DIVISION 1 – GENERAL REQUIREMENTS
01001 General Requirements
01010 Summary of the Work
01047 System Safety Program
01086 Color Codes and Color Standards
01220 Measurement and Payment
01312 Project Meetings
01320 Construction Schedule and Progress Reports
01321 Construction Schedule and Progress Reports for Small Projects
01330 Submittals
01340 Shop Drawings, Product Data and Samples
01345 Construction Photographs
01423 Reference Standards
01430 Contractor’s Quality Assurance
01450 Quality Control
01454 Field Samples and Mock-Ups
01500 Temporary Facilities and Services
01505 Mobilization
01532 Tree and Shrub Protection and Care
01533 Temporary Decking
01560 Environmental Protection
01562 Soil Erosion and Sediment Control
01570 Maintenance and Control of Traffic
01580 Project Signs
01600 Product Requirements
01630 Product Substitution Procedures
01640 Authority Furnished Materials and Equipment
01715 Pre-Construction Inspection
01722 Field Engineering - Surveying
01731 Cutting and Patching
01740 Cleaning
01770 Contract Closeout
01785 Project Record Documents
01786 Operation and Maintenance Instructions
01790 Spare Parts and Maintenance Materials

DIVISION 2 – SITE CONSTRUCTION
02050 Demolition
02072 Removal and Restoration of Miscellaneous Existing Facilities
02100 Site Preparation
02110 Survey Markers and Monuments
02131 Tree Pruning
02140 Dewatering
02150 Underpinning, Support, and Restoration of Structures
02160 Support of Excavation
02220 Grading, Excavating and Backfilling
02221 Utility Excavation and Backfill
02230 Base for Pavements
02242 Soil Stabilization: Portland Cement Treatment
02243 Soil Stabilization: Lime Treatment
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>02246</td>
<td>Geogrid Reinforcement of Sub-Ballast</td>
</tr>
<tr>
<td>02271</td>
<td>Ditch Lining and Slope Protection</td>
</tr>
<tr>
<td>02275</td>
<td>Geogrid Wall Reinforcement</td>
</tr>
<tr>
<td>02316</td>
<td>Geotechnical Instrumentation</td>
</tr>
<tr>
<td>02360</td>
<td>Driven Piles</td>
</tr>
<tr>
<td>02375</td>
<td>Drilled Shaft Foundations</td>
</tr>
<tr>
<td>02376</td>
<td>Overhead Contact System Pole Foundation and Guy Anchor Piers</td>
</tr>
<tr>
<td>02450</td>
<td>General Track Construction</td>
</tr>
<tr>
<td>02451</td>
<td>Sub-Ballast</td>
</tr>
<tr>
<td>02453</td>
<td>Track Ballast</td>
</tr>
<tr>
<td>02455</td>
<td>Track Appurtenances</td>
</tr>
<tr>
<td>02457</td>
<td>Bonded Joints</td>
</tr>
<tr>
<td>02458</td>
<td>Field Rail Welding</td>
</tr>
<tr>
<td>02459</td>
<td>Special Trackwork</td>
</tr>
<tr>
<td>02460</td>
<td>Ballasted Track Construction</td>
</tr>
<tr>
<td>02462</td>
<td>Direct Fixation Track Construction</td>
</tr>
<tr>
<td>02464</td>
<td>Concrete Approach Slab and Track Slab</td>
</tr>
<tr>
<td>02469</td>
<td>Track Demolition and Signal Equipment Removal</td>
</tr>
<tr>
<td>02470</td>
<td>Highway Grade Crossings - Trackwork</td>
</tr>
<tr>
<td>02471</td>
<td>Highway Grade Crossings – Civil Work</td>
</tr>
<tr>
<td>02473</td>
<td>Pedestrian Crossings at Stations</td>
</tr>
<tr>
<td>02476</td>
<td>Grade Crossing Panels</td>
</tr>
<tr>
<td>02511</td>
<td>Bituminous Pavement</td>
</tr>
<tr>
<td>02515</td>
<td>Unit Pavers</td>
</tr>
<tr>
<td>02521</td>
<td>Directional Detectable Pavers and Plates</td>
</tr>
<tr>
<td>02525</td>
<td>Combined Curb and Gutters, Curb Ramps, and Walks</td>
</tr>
<tr>
<td>02550</td>
<td>Concrete Pavement</td>
</tr>
<tr>
<td>02580</td>
<td>Pavement Markings and Delineators</td>
</tr>
<tr>
<td>02590</td>
<td>Traffic Signals</td>
</tr>
<tr>
<td>02660</td>
<td>Water Distribution Systems</td>
</tr>
<tr>
<td>02700</td>
<td>Storm Sewer Systems</td>
</tr>
<tr>
<td>02710</td>
<td>Subway Drainage System</td>
</tr>
<tr>
<td>02711</td>
<td>Aerial Structure Drainage System</td>
</tr>
<tr>
<td>02730</td>
<td>Sanitary Sewer Systems</td>
</tr>
<tr>
<td>02735</td>
<td>On-Site Sanitary Sewer Facility</td>
</tr>
<tr>
<td>02760</td>
<td>Maintenance, Support and Restoration of Existing Utility Facilities</td>
</tr>
<tr>
<td>02780</td>
<td>Underground Electrical and Communications Distribution Systems</td>
</tr>
<tr>
<td>02781</td>
<td>Precast Express Trough</td>
</tr>
<tr>
<td>02782</td>
<td>Express Trough for Aerial Structures</td>
</tr>
<tr>
<td>02830</td>
<td>Chain Link Fencing</td>
</tr>
<tr>
<td>02831</td>
<td>Wooden Screening Fence</td>
</tr>
<tr>
<td>02845</td>
<td>Traffic Control Signs</td>
</tr>
<tr>
<td>02846</td>
<td>Metal Beam Guard Rail</td>
</tr>
<tr>
<td>02847</td>
<td>Right-of-Way Safety Signs</td>
</tr>
<tr>
<td>02848</td>
<td>Precast Parking Bumpers</td>
</tr>
<tr>
<td>02870</td>
<td>Modular Retaining Wall Units</td>
</tr>
<tr>
<td>02871</td>
<td>Prefabricated Block Retaining Wall System</td>
</tr>
<tr>
<td>02872</td>
<td>Mechanically Stabilized Earth Retaining Wall</td>
</tr>
<tr>
<td>02873</td>
<td>Station Furnishings</td>
</tr>
<tr>
<td>02900</td>
<td>Landscaping - General</td>
</tr>
<tr>
<td>02910</td>
<td>Topsoil and Finished Grading</td>
</tr>
</tbody>
</table>
## TABLE OF CONTENTS

02930  Seeding and Sodding – Irrigated Areas  
02931  Seeding and Sodding – Non-Irrigated Areas  
02950  Landscape Planting  
02975  Landscape Irrigation System  
02976  Irrigation Sleeves  
02980  Landscape Maintenance – General  
02981  Landscape Maintenance – Irrigated Areas  
02982  Landscape Maintenance – Non-Irrigated Areas  

### DIVISION 3 – CONCRETE

03100  Concrete Formwork  
03200  Concrete Reinforcement  
03300  Cast-In-Place Concrete  
03305  Portland Cement Concrete  
03350  Concrete Finishing  
03360  Special Concrete Finishes  
03365  Prestressed Concrete  
03430  Structural Precast Concrete  
03450  Architectural Precast Concrete  
03462  Glass Fiber Reinforced Concrete Warning Strips  
03490  Glass Fiber Reinforced Precast Concrete  
03905  Concrete Repair and Restoration  

### DIVISION 4 – MASONRY

04100  Mortar, Grout and Masonry Accessories  
04210  Brick Masonry  
04220  Concrete Masonry Units  
04400  Stone  
04720  Cast Stone  

### DIVISION 5 – METALS

05120  Structural Steel – Bridges  
05124  Overhead Contact System Steel Poles - Wide Flange  
05125  Overhead Contact System Fabricated Metal Supports  
05126  Overhead Contact System Steel Tubular Poles  
05130  Structural Steel - Building  
05135  Architectural Exposed Structural Steel  
05300  Metal Decking  
05310  Permanent Metal Deck Forms  
05415  Cold-Formed Metal Framing  
05430  Slotted Channel Framing  
05500  Metal Fabrications  
05510  Metal Stairs  
05520  Metal Railings  
05700  Ornamental Metal  

### DIVISION 6 – WOOD AND PLASTICS

06100  Rough Carpentry  
06410  Custom Cabinetwork  

### DIVISION 7 – THERMAL AND MOISTURE PROTECTION

07120  Sheet Waterproofing
# TABLE OF CONTENTS

07141 Cold Fluid-Applied Waterproofing  
07150 Dampproofing  
07210 Building Insulation  
07410 Metal Roofing  
07531 Single-Ply Membrane Roofing  
07600 Flashing and Sheet Metal  
07840 Firestopping  
07900 Seals and Sealants

**DIVISION 8 – DOORS AND WINDOWS**  
08115 Hollow Metal Doors and Frames  
08313 Access Doors and Frames  
08413 Aluminum Framed Windscreens  
08710 Door Hardware  
08800 Glass and Glazing  
08835 Decorative Plastic Glazing  
08913 Glazed Aluminum Elevator Enclosures

**DIVISION 9 – FINISHES**  
09253 Gypsum Sheathing  
09260 Gypsum Board Assemblies  
09512 Acoustical Panel Ceilings  
09513 Acoustical Snap-In Metal Pan Ceilings  
09660 Resilient Flooring  
09663 Static Dissipative Resilient Flooring  
09920 Interior Painting  
09970 Coatings for Steel  
09980 Coatings for Concrete and Masonry

**DIVISION 10 – SPECIALTIES**  
10210 Wall Louvers  
10430 Specialty Signs  
10441 Specialty Post and Pole Mounted Signs  
10522 Fire Extinguishers and Cabinets  
10525 Fire Department Key Keeper  
10800 Toilet Accessories

**DIVISION 13 – SPECIAL CONSTRUCTION**  
13100 Corrosion Control  
13101 Corrosion Control Acceptance Tests  
13102 Track-to-Earth Resistance Tests  
13121 Substation Enclosures – Traction Power Substations

**DIVISION 14 – CONVEYING SYSTEMS**  
14240 Hydraulic Elevators

**DIVISION 15 – MECHANICAL**  
15001 Mechanical Systems – General  
15040 Electrical Requirements of Mechanical Work  
15055 Identification of Equipment and Piping  
15060 Piping and Accessories  
15075 Vibration Isolation and Sound Control
# TABLE OF CONTENTS

15160 Pumps
15260 Insulation
15300 Fire Protection Systems
15380 Electric Motor Driven Fire Pump Systems
15400 Plumbing
15458 Water Heaters
15493 Heating Tracing
15600 Heating Systems
15780 Self Contained Air Conditioning Units
15840 Heat Pumps (Air to Air)
15850 Air Handling
15860 Fans
15880 Air Distribution
15911 Louvers and Dampers
15950 Control Equipment
15990 Testing and Balance

## DIVISION 16 – ELECTRICAL

16001 Electrical Systems – General
16030 Testing of Electrical Systems
16040 Identification of Electrical Equipment
16045 Fault and Coordination Power Study – Traction Power Substations
16050 Basic Electrical Materials – Traction Power Substations
16110 Conduit and Raceways
16111 Conduits
16114 Cable Trays
16120 Wires and Cables
16130 Electrical Boxes
16135 Exterior Demarcation Cabinets
16190 Supporting Devices
16311 Mainline Traction Power Substations
16312 Traction Power System Substation Installation
16350 Overhead Contact System Basic Electrical Materials and Methods
16351 Overhead Contact System Grounding and Bonding
16371 Overhead Contact System
16425 Low Voltage Switchboards
16450 Grounding and Bonding
16460 Transformers
16470 Power and Lighting Panelboards
16490 Switches and Receptacles
16500 Lighting Fixtures, Mounting Poles, and Control Devices
16502 Anchor Bolts and Foundations for Lighting Poles
16605 Emergency Lighting Units and Power Supplies
16620 Standby Power Systems
16670 Lightning Protection Systems
16721 Fire Alarm and Detection Systems
16722 Intrusion Alarm and Detection Systems
16750 Stations Communications Devices
16801 Basic Technical Requirements – Communications System
16837 Miscellaneous Components and Products – Communications System
16838 Communications Facilities – Communications System
16839 Communications Interface Cabinet – Communications System
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16841</td>
<td>Communications Cable – Communications System</td>
</tr>
<tr>
<td>16845</td>
<td>Fiber Optic Cable Subsystem – Communications System</td>
</tr>
<tr>
<td>16850</td>
<td>Basic Electrical Materials and Methods – Communications System</td>
</tr>
<tr>
<td>16851</td>
<td>Telephone Subsystem – Communications System</td>
</tr>
<tr>
<td>16852</td>
<td>Public Address Subsystem – Communications System</td>
</tr>
<tr>
<td>16853</td>
<td>Visual Message Board Subsystem – Communications System</td>
</tr>
<tr>
<td>16854</td>
<td>Fire Alarm Subsystem – Communications System</td>
</tr>
<tr>
<td>16855</td>
<td>Intrusion Alarm Subsystem – Communications System</td>
</tr>
<tr>
<td>16856</td>
<td>Closed Circuit Television Subsystem – Communications System</td>
</tr>
<tr>
<td>16857</td>
<td>Control Center Subsystem – Communications System</td>
</tr>
<tr>
<td>16858</td>
<td>SCADA RTU Subsystem – Communications System</td>
</tr>
<tr>
<td>16859</td>
<td>Fare Collection Local Area Network - Communications System</td>
</tr>
<tr>
<td>16860</td>
<td>Grounding and Bonding – Communications System</td>
</tr>
<tr>
<td>16861</td>
<td>Communications Transmission Subsystem – Communications System</td>
</tr>
<tr>
<td>16862</td>
<td>Power Supplies and Distribution – Communications System</td>
</tr>
<tr>
<td>16863</td>
<td>Manuals and Training – Communications System</td>
</tr>
<tr>
<td>16864</td>
<td>Technical Support and Spares – Communications System</td>
</tr>
<tr>
<td>16901</td>
<td>Basic Technical Requirements - Signal System</td>
</tr>
<tr>
<td>16902</td>
<td>Block Design Criteria – Signal System</td>
</tr>
<tr>
<td>16903</td>
<td>Cab Signals - Signal System</td>
</tr>
<tr>
<td>16904</td>
<td>Drawings - Signal System</td>
</tr>
<tr>
<td>16905</td>
<td>External Cable – Signal System</td>
</tr>
<tr>
<td>16906</td>
<td>Power Cable - Signal System</td>
</tr>
<tr>
<td>16911</td>
<td>Power Switch-And-Lock Movements - Signal System</td>
</tr>
<tr>
<td>16915</td>
<td>Motor Control Centers and Starters</td>
</tr>
<tr>
<td>16917</td>
<td>Signals and Indicators – Signal System</td>
</tr>
<tr>
<td>16918</td>
<td>Audio Frequency Main Line Track Circuits - Signal System</td>
</tr>
<tr>
<td>16919</td>
<td>Power Frequency Track Circuits - Signal System</td>
</tr>
<tr>
<td>16920</td>
<td>Train-to-Wayside Communications - Signal System</td>
</tr>
<tr>
<td>16922</td>
<td>CAB Signal and B-Point Loops - Signal System</td>
</tr>
<tr>
<td>16923</td>
<td>Impedance Bonds - Signal System</td>
</tr>
<tr>
<td>16930</td>
<td>Rail Bonding - Signal System</td>
</tr>
<tr>
<td>16932</td>
<td>Automatic Highway Crossing Warning System – Signal System</td>
</tr>
<tr>
<td>16935</td>
<td>Power System – Signal System</td>
</tr>
<tr>
<td>16938</td>
<td>Instrument Houses – Signal System</td>
</tr>
<tr>
<td>16940</td>
<td>Junction Boxes - Signal System</td>
</tr>
<tr>
<td>16953</td>
<td>Instrument Racks - Signal System</td>
</tr>
<tr>
<td>16955</td>
<td>Internal Wire and Cable - Signal System</td>
</tr>
<tr>
<td>16957</td>
<td>Plug Connectors - Signal System</td>
</tr>
<tr>
<td>16958</td>
<td>Relays – Signal System</td>
</tr>
<tr>
<td>16959</td>
<td>Vital Microprocessor Interlocking Systems – Signal System</td>
</tr>
<tr>
<td>16963</td>
<td>Transformers – Signal System</td>
</tr>
<tr>
<td>16969</td>
<td>Local Control Panels – Signal System</td>
</tr>
<tr>
<td>16972</td>
<td>Event Recorders - Signal System</td>
</tr>
<tr>
<td>16976</td>
<td>Grounding of Equipment - Signal System</td>
</tr>
<tr>
<td>16978</td>
<td>Electromagnetic Compatibility – Signal System</td>
</tr>
<tr>
<td>16995</td>
<td>Reliability and Maintainability – Signal System</td>
</tr>
<tr>
<td>16996</td>
<td>Wayside Signs - Signal System</td>
</tr>
<tr>
<td>16997</td>
<td>Miscellaneous Components and Reports Products - Signal System</td>
</tr>
<tr>
<td>16998</td>
<td>Test and Inspection - Signal System</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS

RECORD OF PROFESSIONAL REVISIONS
Table of Contents
Sealed Specification Records

END OF TABLE OF CONTENTS
PART 1 - GENERAL

1.1 GENERAL

A. The General Requirements (Division 1 sections) of these specifications expand on the General and Special Provisions and cover administrative and procedural matters relating to work specified in all the technical sections.

1.2 SPECIFICATIONS

A. Grammatical Mood: These Specifications are written in the imperative mood and abbreviated form. This imperative language of the technical sections is directed at the Contractor unless specifically noted otherwise. Complete incomplete sentences by inserting "shall", "the Contractor shall", and "shall be", and similar mandatory phrases by inference in the same manner as they are applied to notes on the Drawings. Supply the word "shall be" by inference where a colon (:) is used within sentences or phrases. Except as worded to the contrary, fulfill (perform) all indicated requirements whether stated imperatively or otherwise.

B. Brevity: In the interest of brevity these Specifications frequently omit modifying words such as "all" and "any" and articles such as "the" and "an," but the fact that a modifier or an article is absent from one statement and appears in another is not intended to affect the interpretation of either statement.

C. Definitions: For the purposes of this Contract, in addition to General Provisions Paragraphs "Definition" and "Specifications and Drawings", the following terms and their derivative forms shall be accorded the meanings assigned below:

1. Approved: Unless otherwise specified, as approved by the Contracting Officer.

2. Construction Site (Project Site, Worksite, plant, or Site): The area delineated on the Contract plans for the Project and all the areas utilized by the Contractor for the storage and/or processing of materials to be incorporated into the Work that has been approved by the Contracting Officer.

3. Contract Documents: Consist of the Invitation for Bid, the Bid Schedule, and all Exhibits identified on the Invitation for Bid.

4. Construction Staging Area: Property available for use by the Contractor during the construction period for the purpose of storing products and construction equipment and for the purpose of staging work.

5. Contractor: The individual, partnership, or corporation or a combination of any or all jointly undertaking the execution of the Work under terms of the Contract and acting directly or through agents or employees.

6. Defective: An adjective which when used to describe the contractual work effort that does not conform to the Contract Documents, or does not meet the requirements of any inspection, reference standard, test, or approval referred to in the Contract Documents.

7. Drawings: Graphic and pictorial portions of the Contract Documents, showing the design, locations, and dimensions of the Work. Generally including plans, elevations, sections, details, schedules, and diagrams.

a. Synonym: Plans

8. Experienced: The term “experienced” means having successfully completed a minimum of five previous projects similar in size and scope to the work within the Contract for which the experience is required.

9. Gauge: The term "gauge", when used in connection with the measurement of plates, will mean the U.S. Standard Gage; except that when reference is made to the measurement of galvanized or aluminum sheets used in the manufacture of corrugated metal pipe, metal plate culverts, arches, arched metal cribbing and corrugated aluminum pipe, then the term "gauge" will mean that specified in the applicable AASHTO or ASTM standard.

a. When the term "gauge" refers to the measurement of wire in regard to concrete reinforcement, it will mean the wire gauge specified in the applicable AASHTO or ASTM standard.
10. Including/Consisting of:
   a. Including: Introduces a partial, representative listing of things or actions.
   b. Consisting of: Introduces a complete listing of things or actions which constitute the whole.

11. Installer: An Installer is the Contractor or another entity engaged by the Contractor, either as an employee, subcontractor, or contractor of lower tier, to perform a particular construction operation, including installation, erection, application, and similar operations. Installers are required to be experienced in the operations they are engaged to perform.
   a. Trades: Using terms such as "carpentry" does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as carpenter. It also does not imply that requirements specified apply exclusively to tradespersons of the corresponding generic name.

12. Jurisdictional Authorities: State, Federal, and local authorities or agency thereof having jurisdiction over work to which reference is made.

13. Milestone: A principal event specified in Contract Documents relating to an intermediate completion date, time period prior to completion of all work, or final completion of all work.


15. Paragraph: An element of the specification section bearing its own alphanumeric designation.

16. Permanent Drainage Easement: A right to construct and maintain permanent drainage facilities for retention, release, and passage of surface water in a particular area.

17. Permanent Subsurface Easement: A right to construct and maintain permanent subsurface facilities in an underground space.

18. Permanent Utility Easement: A right to construct and maintain utility facilities in a particular area.

19. Review: A general overview, not an approval.

20. Right-of-Way: A term denoting land and property, and interests therein, acquired by the Authority.

21. Similar: Generally the same but not necessarily identical; details shall be worked out in relation to location and relation to other parts of work.

22. Shall/Will/May:
   a. Shall: Indicates action which is mandatory on the part of the Contractor.
   b. Will: Indicates probable action.
   c. May: Indicates permissible action.


24. Specified: Unless otherwise stated, as required by the General Provisions, the drawings, the Specifications, and the Special Provisions for the Project.

25. Supplier: A manufacturer, fabricator, supplier, distributor, material manufacturer, or vendor who contracts with the Contractor or any Subcontractor to furnish materials or equipment to be incorporated in the Work by Contractor or any Subcontractor.

26. Subcontractor: A person, persons, or entity who contracts with the Contractor or any Subcontractor to perform work, provide labor, or to render service on or about the Work.

27. Submit: Unless otherwise specified, transmit to the Contracting Officer for approval, or review and record. Refer to Section 01330, "Submittals", for general requirements for submittals.

28. Temporary Construction Easement Line: Boundary which describes the area not
1.3 CONTRACTOR'S SUPERINTENDENT

A. In furtherance of General Provisions, Paragraph, "SUPERINTENDENCE BY THE CONTRACTOR", the Contractor shall appoint immediately upon award of the Contract, a superintendent who is satisfactory to the Contracting Officer and has the authority to act for the Contractor.

B. The appointment of the superintendent (by the Contractor) shall at all times be subject to the approval in writing of the Contracting Officer (which approval may at anytime be withdrawn). If the Contracting Officer withdraws such approval, the Contractor shall remove the superintendent from the Work and shall not employ him on the Work in any other capacity; and shall replace him by another superintendent as approved by the Contracting Officer.

4.1 MEASUREMENT

A. Unless specifically stated, no separate measurement will be made for the work specified in the various sections under Division 1, "General Requirements".

4.2 PAYMENT

A. No separate payment will be made for the work specified in various sections under Division 1, "General Requirements" except for items specifically designated as separate pay items, but shall be included in the Contract Bid Schedule at the lump sum for "General Requirements". This lump sum price will be full compensation for all materials, labor, tools, equipment, and incidentals necessary for the completion of the work; and for performance of all requirements as described in all sections under Division 1, "General Requirements" and relevant plans and Contract Documents. Payment will be made in the following manner:

1. Twenty-five percent of the lump sum price for General Requirements will be paid in three equal amounts, as part of each of the first three progress payments subject to timely and satisfactory compliance with the requirements of the General Requirements.

2. Seventy-five percent of the lump sum price for the General Requirements will be paid in equal amounts over the remaining duration of the Contract, beginning with the fourth progress payment, subject to compliance with the requirements of the General Requirements including Quality Control, Maintenance of As-Built Drawings, and Schedule Update.

3. The value allocated to General Requirements shall not exceed five percent of the total bid amount.

END OF SECTION 01001
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. The Work under the Contract consists of construction as described in the Contract Documents. Extent and details of the construction site are shown on the Contract drawings. Unless otherwise provided, the Contractor shall furnish all materials, labor, tools, equipment, and incidentals necessary for the proper prosecution and completion of the Work.

B. The Work By Others: In accordance with and in addition to the General Provisions, Paragraph, "OTHER CONTRACTS":

1. The exercise of the right reserved by the Authority to permit other contractors and persons to do work in or about the Contract area during the performance period of this contract does not in any way or to any extent relieve the Contractor from liability for loss and damage to the Work due to or resulting from the Contractor’s operations.

2. These provisions apply to the relations between the Contractor and utility companies performing work in connection with Authority construction. Permit free and clear access to utility companies for their construction.

3. Coordinate interface requirements with other Contractors; schedule and sequence the activities to meet the project schedule and milestones.

1.2 CONTRACT MILESTONE AND PHASED CONSTRUCTION

A. Contract milestones and construction planning requirements, when applicable, are described in the Contract Documents. Schedules prepared under Section 01320 “Construction Schedules and Progress Reports” or Section 01321 “Construction Schedules and Progress Reports for Small Projects”, shall be consistent with contract milestones and construction planning requirements. The work sequence shall be in accordance with the approved Construction Schedule.

B. Suggested construction phasing, when applicable, is described in the Contract Documents.

C. The Contractor shall develop for Authority review and approval a detailed and comprehensive cut-over work plan for the cutover, or connection of the new line section to the existing alignment and systems. The Contractor shall coordinate with the Authority and other contractors or consultants during the development and execution of the cut-over work plan. The cutover work plan shall be submitted to the Authority a minimum of 90 days prior to the requested cutover date. The cutover work plan shall include:

1. Physical work to be implemented.
2. Impacts to rail facilities, systems and operations.
3. Integrated testing plans.
4. Operations and maintenance requirements.
5. Narrative and schedule information identifying work crew members and work shifts.
6. Hourly schedule detailing all work elements and identification of key hold points to be adhered to during the cutover process.
7. Identify contingency resources and the criteria for implementing the contingencies.
8. Identify required outages and measures for the cutover.

D. Perform work to accommodate vehicular and pedestrian traffic during construction as specified in Section 01570 “Maintenance and Control Of Traffic”.

E. Contractor shall notify the Contracting Officer immediately of the Contractor’s inability to meet any of the constraints or milestones described in the Contract.

1.3 GEOTECHNICAL REPORT

A. The Contractor shall use the Geotechnical Report, Exhibit K, in the performance of the Work.

1.4 WORKSITE

A. Location of the Worksite: The Work is located in the DART service area. Exact location of the Worksite, including the area available for Contractor’s operations, access routes, and the right-of-way are shown in the Contract Drawings.

B. Access to the Worksite

1. Plan and execute safe access to the Worksite by construction equipment, vehicles, and personnel in accordance with the Contract.

2. A plan for haul and delivery roads shall be developed by the Contractor and submitted in accordance with Section 01570 "Maintenance and Control of Traffic".
3. The Contractor shall take into consideration the following guidelines for haul and delivery roads plan development:

a. Coordinate access and delivery roads with other contractors active in the area.

b. Minimize nighttime disturbance of hotel, apartment, single family and condominium residents in the area as required in accordance with the specifications for Section 01560 “Environmental Protection” and by the local rules and regulations of the jurisdictional agencies.

c. Minimize daytime disruption to retail and office operations.

d. Refer to Sections 01500 “Temporary Facilities and Services”, 01560 “Environmental Protection”, 01570 “Maintenance and Control of Traffic”, and other applicable provisions of Contract Documents for related requirements.

e. Provide for access by utility companies and their vehicles to and on the Worksit.

f. Provide for access by DART maintenance Personnel and their vehicles to and on the Worksit.

4. The Contractor shall not restrict the portion of the public right-of-way except as noted in these Specifications.

5. The Contractor shall provide access for other contractors during construction.

1.5 CONTRACTOR’S STAGING AREA

A. Refer to the Contract Drawings for specific areas available for Contractor staging areas. Access and egress from the staging area is subject to the approval of the Contracting Officer.

B. Areas Provided by Contractor: Subject to the approval of the Contracting Officer, the Contractor shall provide, with no liability to the Authority, any additional areas and access thereto not shown or described that may be required for temporary construction facilities or storage of materials. Contractor shall construct and maintain all access roads, detour roads, or other temporary work as required by the Contractor’s operation. Refer to Article entitled “Contractor’s Use of Private Property” herein for additional requirements.

C. The boundary of all staging areas shall be located 30 feet or more from the edge of lanes open to the public.

D. The Contractor’s material and equipment shall be stored at the approved Contractor’s staging area or at locations approved by the Contracting Officer. The Contractor shall confine equipment, storage of materials, and operation of workers to those areas approved with no liability to the Authority.

E. When required in the interest of the Work, the Contractor shall arrange offsite parking with a third party at the Contractor’s sole responsibility and risk.

F. Contractor shall provide a security fence for all staging areas used by the Contractor to prevent intrusion into the areas by unauthorized personnel.

G. The Contractor shall be responsible for the staging areas and offsite parking including the security, maintenance, compliance with the applicable Contract provisions, cleaning, and restoration to their original condition.

H. The Contractor’s facility and the Contracting Officer’s facility may be located in one of the staging areas subject to the approval of the Contracting Officer and in accordance with Section 01500, “Temporary Facilities and Services”, of the Specifications.

1.6 WORKSITE AND STAGING AREA

A. The Contractor’s work activities shall be confined within the Right-of-Way, Easements, and Staging areas as depicted on the drawings, unless approved otherwise.

1.7 CONTRACTOR’S USE OF PRIVATE PROPERTY

A. Use by the Contractor of private property including use for storage, staging, parking, or travel across property shall be with no liability to the Authority and shall be subject to the following provisions.

B. The Contractor shall identify its need (including the need of its subcontractors of all tiers) for use of private property and obtain written authorization from property owners. Contractor shall also obtain written authorization from occupants, if appropriate.

C. Contractor shall submit such written authorization for approval by the Contracting Officer. Written authorization shall be in a form acceptable to the Contracting Officer. Refer to Form 01010-A “Temporary Use Agreement”, at the end of this Section as an example of an acceptable form.

D. Such authorization shall typically be submitted a minimum of 21 days prior to Contractor’s use of the property. In all cases, such authorization shall be submitted prior to Contractor’s use of the property.
1.8 WORK HOURS

A. Construction will be limited to the daylight hours of 7:00 a.m. to 9:00 p.m., Monday through Friday, or as approved by the jurisdictional authority.

1.9 PERMITS AND LICENSES

A. Refer to General Provisions, Paragraph “PERMITS AND RESPONSIBILITIES”.

B. Submit copies of permits and licenses prior to proceeding with work.

1.10 NOTIFICATIONS AND COMMUNITY RELATIONS

A. Contractor shall be responsible for coordination with and notifications to adjacent property owners and businesses regarding disruptions due to the Work scheduled in those areas.

B. The Contractor shall designate a contact person to be responsible for coordination and notifications. This contact person shall coordinate with the Authority’s Community Relations Department prior to contact with property owners and businesses.

C. Refer to Section 01570 “Maintenance and Control of Traffic”, for community notification requirements in regard to disruption of normal vehicular and pedestrian traffic flow patterns.

D. Prior to commencement of any part of the Work, give any notices required to be given to adjoining landowners or other parties.

PART 2 - PRODUCTS

Not used

PART 3 - EXECUTION

Not used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”.

END OF SECTION 01010
ATTACHMENT 01010 - A

STATE OF TEXAS
COUNTY OF ________________________________

TEMPORARY USE AGREEMENT

As property owner of the property located at ____________________________________________________________ Address

I do hereby grant ___________________________________________________________ Contractor’s Name and Address

(Contractor) the right to use my property for the purpose of ____________________________________________ Specific Use

In connection with the construction of the Dallas Area Rapid Transit’s project: _______________________________ Specific Name of DART Project

The temporary use of my property shall be for a term of ____ months beginning _________ and ending ______________. Start Date End Date

Contractor agrees that at the end of the term as specified above, all surplus excavation, debris, trash, and litter resulting from said use of my property shall be cleaned up and hauled off the premises and my property shall be restored as nearly as reasonable to its original condition. This agreement does not waive any damages to my remaining property, which were the result of the Contractor’s activities upon this specified property.

Executed this __________ day of __________, 20 ________.

_________________________________________________
Property Owner’s Signature

THE STATE OF TEXAS
COUNTY OF ________________________________

The foregoing instrument was acknowledged before me on the ________________ day of __________________, 20 __________ by _____________________ and acknowledge to me that he-she executed this agreement for the purposes and consideration Name

herein expressed.

Given under my hand and seal of office on this the ________________ day of ______________________, 20 ______________.

_________________________________________________
Notary Public, State of Texas

END OF ATTACHMENT
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section consists of establishing and maintaining a Contractor System Safety Program (CSSP). This safety program shall be developed by the designer and integrated into all Work phases relating to Communications, Traction Electrification, i.e., Overhead Contact System and Traction Power Substations, Signals, and Fare Collection, and these Contract Work elements shall be known collectively as “Systems.” The CSSP requirements shall be applied to subcontractors, suppliers, and vendors.

B. The CSSP shall prescribe a formal approach to hazard control through engineering, design, education, management policy, and supervisory control of conditions and practices. The procurements and guidelines established in MIL-STD-882D, Standard Practice For System Safety, shall be applied to the CSSP.

C. The CSSP shall supplement the fail-safe and fault tolerant design requirements of these Specifications, but shall not, in any way, relieve the Contractor of design responsibility.

1.2 REFERENCED STANDARDS

A. Military Standards

1. MIL-STD-882D – Standard Practice For System Safety

B. Dallas Area Rapid Transit (DART/Authority)

1. DART Light Rail Transit, Systems Safety and Security Program Plan, January 2006, Revision 8 (SSPP)

1.3 OBJECTIVES

A. The primary objective of the CSSP shall be to eliminate hazards from the “Systems” equipment and facilities provided under this Contract. These are hazards which could result in personal injury, damage, or loss of a portion of the subject facilities, see Article 1.6, “Hazard Risk Assessment and Resolution” of this Section. Hazard risk assessment applies both directly and indirectly, (i.e., whether the injury, damage, or loss, were to be caused directly by a subject facility malfunction or indirectly by the resultant unsafe operation of one or more trains.)
c. Approach for evaluating the system safety impacts of these new and different elements.

3. The Authority approved CSSP shall be maintained throughout the life of the Contract.

B. Monthly Progress Reports: Contractor shall submit to the Authority a Monthly System Safety Reports, commencing no later than 60 days after Contract NTP, as a part of the Monthly Progress Report. The Monthly System Safety Reports shall include the following:

1. A list of in-progress System safety tasks and the status of each.
2. Evaluation of design changes on the System safety.
3. A list of open items relevant to System safety.
4. A list of System safety tasks to be accomplished in the next reporting period.
5. An updated schedule showing the significant milestones of the CSSP, with expected dates of completion.

C. Preliminary Hazard Analysis (PHA): Contractor shall submit the PHA in quarterly increments beginning no later than 6 months after Contract NTP. Each submittal shall include the following information:

1. The PHA, in the current state of completion.
2. Perform the PHA and ensure compliance with the relevant portions of the Authority’s SSPP Chapter 5, the CSSP and these Specifications.
3. Identification of changes, additions, or deletions since the previous submittal.
4. Status of all known operating hazards.

D. Operating Hazard Analysis (OHA): Contractor shall submit the OHA in quarterly increments, beginning no later than 6 months after Contract NTP. Each submittal shall include the following information:

1. The OHA, in the current state of completion.
2. Perform the OHA and ensure compliance with the relevant portions of the Authority’s SSPP Chapter 5, the CSSP and these Specifications.
3. Identification of changes, additions, or deletions since the previous submittal.
4. Status of all known operating hazards.

E. Failure Mode Effects Analysis (FMEA): Contractor shall submit the FMEA in quarterly increments, beginning no later than 6 months after Contract NTP. Each submittal shall include the following information:

1. The FMEA, in the current state of completion.
2. Perform the FMEA and ensure compliance with the relevant portions of the Authority’s SSPP Chapter 5, the CSSP and these Specifications.
3. Identification of changes, additions, or deletions since the previous submittal.
4. Status of all known operating hazards.

F. Fault Tree Analysis (FTA): Contractor shall submit the FTA in quarterly increments, beginning no later than 6 months after Contract NTP. Each submittal shall include the following information:

1. The FTA, in the current state of completion.
2. Perform the FTA and ensure compliance with the relevant portions of the Authority’s SSPP Chapter 5, the CSSP and these Specifications.
3. Identification of changes, additions, or deletions since the previous submittal.
4. Status of all known operating hazards.

1.5 REQUIREMENTS

A. Management: Contractor shall be responsible for the CSSP management and operation. The responsibilities and functions of those directly associated with System Safety policies and implementation of the program shall be clearly defined. The authority delegated to this organization and the relationship between line, staff, interdepartmental, project, functional and general management organizations shall be identified. It is not the intent of this Section to prescribe or imply organizational structure, management methodology, implementation procedures, or internal documentation. Pertinent aspects of the CSSP Management shall be reported in the monthly reports.
B. Contractor shall designate an employee as “System Safety Supervisor or Manager” to manage all aspects of the Contractor’s and subcontractors’ CSSP. The requirements for the System Safety Supervisor or Manager shall be:

1. Minimum of three years experience in performing operating hazard analyses and preliminary hazard analyses.
2. Knowledge in “Systems” technology.
3. Knowledge of Light Rail or Transit control system software safety characteristics.
4. Contractor shall submit the designated Safety Manager/Supervisor employee and resume and credentials for Authority approval.

C. Preliminary Hazard Analysis: Contractor shall conduct a complete and comprehensive PHA to identify, classify, evaluate and resolve hazards in the System. The PHA shall include consideration of all “Systems” subsystems, assemblies and components. The PHA shall include the following information:

1. Hazard Index Number
2. Description of the hazard.
3. Effects of the hazard.
4. Initial hazard risk.
5. Controls for the hazard.
6. Final hazard risk.
7. Status of the hazard.

D. Operating Hazard Analysis: Contractor shall conduct a complete and comprehensive OHA.

E. Interface With the Authority System Safety Activities.

1. The Authority will perform System Safety Activities as defined in Authority's SSPP. Included in these activities are PHA and OHA. Contractor shall support these activities by providing:
   a. Technical data related to the Contract requested by the Authority.
   b. Response to System Safety questions for equipment, procedures or other material related to the Contract.
   c. Contractor shall disclose, analyze, explain, and discuss designs with the Authority that impact or potentially impact the safety, operation, or reliability where the Contractor’s designs deviate from the Authority’s current configuration and equipment complement and potentially compel the Authority to review the system safety impact.

F. Interface With the Authority Operations: Contractor employees that are required to work in and around the Authority revenue operations shall attend an Authority sponsored safety class prior to commencing any Work.

1.6 HAZARD RISK ASSESSMENT AND RESOLUTION

A. Hazard Risk is comprised of two elements: severity and frequency. Severity is a qualitative measure of the injury and damage resulting from a mishap. Frequency is a qualitative measure of how often a mishap occurs.

B. Hazard severity shall be classified and assigned a relative quantitative severity in accordance with the Authority’s SSPP Paragraph 5.2.1.

C. Hazard frequency shall be assigned a relative frequency of occurrence in accordance with the Authority’s SSPP Paragraph 5.2.2.

D. Contractor shall take immediate action to control hazards in accordance with the requirements of Authority’s SSPP Paragraph 5.4.

1.7 TASKS AND PROCEDURES

A. The CSSP shall specifically describe the procedures that the Contractor shall follow in order to accomplish CSSP tasks. These tasks shall include the following:

1. Adequately control entire system hazards in the design phase as early as possible.
2. Eliminate from the System any identified false Signal proceed aspects or the evoking of any false proceed aspects.
3. Identify any single failure in the Communication and Control System, Signal System, and Overhead Contact System, Traction Power Substation, Fare Collection or their interfaces that may cause an unsafe condition.
4. Minimize the number of false signal stop aspects and other false communications control indications due to equipment design, installation, or operating procedure.
5. Evaluate design changes and the impact these changes will have on the safety of the complete System.

6. Establish and maintain the required backup data, information and material to assure and support System Safety Certification of the Communications and Control, OCS, and Signals Systems.

PART 2 - PRODUCTS

2.1 CONTRACTOR FURNISHED MATERIALS

A. Contractor shall provide all the materials, tools, equipment, computer time, reference literature and any such required items that are essential to meet the CSSP requirements.

PART 3 - EXECUTION

3.1 PERFORMANCE

A. The System Safety Supervisor / Manager, identified in this Section shall have the following responsibilities:

1. Direct the activities of the CSSP and assigned personnel to complete all required CSSP tasks in accordance with the Contract Documents, while maintaining and staying within schedule and budget.

2. Supervise the Contractor's "PHA" of the Communications, OCS, Traction Power Substation, Fare Collection, and Signal Systems and its individual subsystems and interface areas.

3. Maintain records of all changes to the CSSP. These records shall be available to the Authority upon 48 hours notice.

4. Determine potential changes that could be made in the systems, operating rules, training procedures, equipment, maintenance procedures, physical structure, or other systems outside this Contract to eliminate critical and marginal hazard conditions or to reduce their effect to a negligible status and recommend these changes to the Authority.

5. Implement those safety changes approved or required by the Authority, which fall within these Specifications.

6. Prepare and submit the Monthly System Safety Reports to the Authority as required in Paragraph 1.4.B of this Section.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. In accordance with Section 01001, "General Requirements."

END OF SECTION 01047
PART 1 - GENERAL

1.1 PURPOSE

A. The purpose of this standard is to establish, by means of color-coding, a method for identification of the contents of pipelines; in addition, a uniform color system is given for the painting of safe and hazardous areas of equipment and in buildings.

B. In all cases where identification is essential to safe operation, use English legend and provide framed/mounted color code guides.

1.2 REFERENCE STANDARDS

A. National Electrical Manufacturers Association (NEMA):

   1. NEMA Z535.1 - Safety Color Code

1.3 CONTENTS

A. This standard covers the following color codes, standards, and systems:

   2. Pipeline Identification Color Code.

1.4 CODE SYSTEMS USED

A. The color codes and standards presented herein are based on historical practice and accepted codes of the American National Standards Institute (ANSI), the National Safety Council and the Occupational Safety and Health Administration (OSHA).

1.5 GROUP IDENTIFICATION

A. Because there is a limited number of colors which are readily distinguishable under all conditions of lighting and aging, materials having some property in common are grouped together under one base or ground color. Within each color group, individual designations are indicated by a secondary color applied as a stripe, or used for the color of letters in stencil.

1.6 BASE COLORS

A. The base or ground colors and the groups of materials they represent are presented in Table 01086 - 1.

PART 2 - PRODUCTS

2.1 SAFETY COLOR CODE

A. General Hazard Indication: This Safety Color Code for the use of colors to call attention to physical hazards, the location of safety equipment, and the identification of fire and other protective equipment, is based on NEMA Z535.1.

B. Code Colors:

   1. Red - Fire Protection and Emergency: Use for hydrants and associated piping, firefighting equipment and facilities, also for emergency shut-down controls.
   2. Green - Safety: Use for first aid and personal protective equipment and facilities and for sealing devices on valves.
   3. Yellow - Caution: Use to designate locations of physical hazards which might cause striking against, stumbling, falling, tripping, "caught in between", as well as for traffic marks.
   4. Yellow & Black Stripes - Danger: Use to attract special attention to locations of the physical hazards discussed above.
   5. Orange - Alert: Use to designate dangerous parts of machines or energized equipment which may cut, crush, shock, or otherwise injure, and to emphasize such hazards when enclosure doors or other guards around moving equipment are opened or removed.

C. Examples of some applications of the Safety Color Code:

   1. Red - Fire Protection and Emergency:
      a. Fire alarm boxes.
      b. Fire hydrants.
      c. Fire buckets or pails.
      d. Fire extinguishers and areas on walls or supports on which they are mounted.
      e. Fire exit signs.
f. Fire hose drum shelters.
g. Fire hose cabinets.
h. Fire Doors.
i. Water lines used primarily for fire fighting purposes.

2. Green - Safety:
   a. Gas mask boxes.
   b. First aid kits.
   c. Stretcher.
   d. Safety deluge showers (white and green stripes).

3. Yellow - Caution:
   a. Corner markers for piles of stored materials.
   b. Traffic aisles in shops.
   c. Caution traffic signs in shop and warehouse aisles.
   d. Coverings or guards for guy wires.
   e. Crane hooks.
   f. Suspended fixtures which extend into normal operating areas.
   g. Projecting fixtures such as doorways, traveling conveyer, low beams, and pipes.

4. Black & Yellow Stripes - Danger:
   a. Dangerous curbs.
   b. Bottom risers and top landings of industrial and public stairways.
   c. Exposed and unguarded edges of platforms, pits, and walls.
   d. Lower pulley blocks of cranes.
   e. Car bumpers of fork-lift trucks and cranes.
   f. Pillars, posts, and columns in areas hazardous to personnel (paint to 5 feet above floor).

5. Orange - Alert:
   a. Inside of removable guards for pulleys, shafts, chains.
   b. Inside of enclosed doors for electrical equipment.
   c. Any valves which for safety reasons are required to be locked open.

6. Blue - Precaution: Electrical control units.

PART 3 - EXECUTION

3.1 PIPELINE IDENTIFICATION COLOR CODE

A. Usage:
   1. This Pipeline Identification Color Code is for use on all piping systems.
   2. Label identifications and the use of English legend are mandatory for the content.

B. Non-Descriptive Color:
   1. Aluminum: The only non-descriptive color used or permitted throughout the Contract.
   2. When shown on the Drawings, or when approved by the Contracting Officer, paint the entire length of pipe with aluminum color.
   3. When aluminum color is used as a non-descriptive color, indicate the base color or band color as specified herein.

C. Base or Ground Colors Only: When it is necessary to indicate only the broad group of materials handled, without designating the specific material by a stripe, apply only the base or ground color.

D. Secondary Colors:
   1. Apply the narrow stripe presenting the secondary color which identifies the specific material by painting, or preferably by use of adhesive plastic tapes or snap-on plastic sleeves of the correct color. Tapes or snap-on plastic sleeves manufactured for this purpose are available from many vendors, with colors matching ANSI colors.
   2. In addition, further identify by arrows and legend in English the direction of flow and contents of the pipeline.
E. Color Bands: The location and size of stripes and bands applied to the pipes are recommended as follows:

1. One each side of and adjacent to valves and tees, and other major fittings.

2. Where the pipe enters and emerges from walls, and road and walkway overpasses; on 20 foot centers in equipment rooms.

3. At uniform intervals (20 foot centers) along long sections of the pipe.

4. Adjacent to tanks, vessels, and pumps. When bands are employed in place of painting the entire line, provide these bands 1 foot long. Paint stripes 2 inches wide centered on the band, and space 1 inch apart when two stripes are applied.

F. Examples of Application of the Pipeline Identification:

1. Color Code: Table 01086-2 presents the comprehensive Identification Color Code, listing both band and stripe colors:

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

<table>
<thead>
<tr>
<th>TABLE 01086-1</th>
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</thead>
<tbody>
<tr>
<td>BASE COLORS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color</th>
<th>Class of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Steam (all pressures)</td>
</tr>
<tr>
<td>Yellow</td>
<td>Chemicals (most of these being dangerous, including inhibitors)</td>
</tr>
<tr>
<td>Gray</td>
<td>Crude oil</td>
</tr>
<tr>
<td>Orange</td>
<td>Petroleum gases, naphthas, gasolines, solvents, jet fuels including mineral spirits and lighter fluid</td>
</tr>
<tr>
<td>Oxide Red</td>
<td>Kerosene, diesel oils, waxy distillages, and heavier non-volatile petroleum products.</td>
</tr>
<tr>
<td>Black</td>
<td>Fuel oils, asphalt, slop oils, residual oils, still bottoms.</td>
</tr>
<tr>
<td>Blue</td>
<td>Water (designated types and temperatures).</td>
</tr>
<tr>
<td>Green</td>
<td>Air, nitrogen, oxygen, Freon</td>
</tr>
<tr>
<td>Red</td>
<td>Fire protection materials and equipment.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 01086-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIPELINE COLOR CODES</td>
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</table>

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>Identification</th>
<th>Color Code</th>
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<tbody>
<tr>
<td>Steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>400 psi and over</td>
<td>White</td>
<td>1-yellow</td>
</tr>
<tr>
<td>150 psi to 400 psi</td>
<td>White</td>
<td>1-red</td>
</tr>
<tr>
<td>Below 150 psi</td>
<td>White</td>
<td>1-green</td>
</tr>
<tr>
<td>Hot Water (150°F and over)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw</td>
<td>Blue</td>
<td>2-black</td>
</tr>
<tr>
<td>Condensate</td>
<td>Blue</td>
<td>2-white</td>
</tr>
<tr>
<td>Treated (any process)</td>
<td>Blue</td>
<td>2-oxide red</td>
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<table>
<thead>
<tr>
<th>Water (below 150°F)</th>
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<tbody>
<tr>
<td>Raw</td>
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<tr>
<td>Chilled</td>
</tr>
<tr>
<td>Condensate</td>
</tr>
<tr>
<td>Treated (any process)</td>
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<td>Sewage</td>
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<table>
<thead>
<tr>
<th>Fire Protection</th>
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<tbody>
<tr>
<td>Water, Foam or Other Fire-extinguishing Material</td>
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</table>

<table>
<thead>
<tr>
<th>Fuels</th>
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</thead>
<tbody>
<tr>
<td>Gasoline (regular)</td>
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<tr>
<td>(premium)</td>
</tr>
<tr>
<td>Gasoline (white)</td>
</tr>
<tr>
<td>LP Gas</td>
</tr>
<tr>
<td>LP Gas (refrigerated)</td>
</tr>
<tr>
<td>Diesel Oil (white)</td>
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<td>Diesel Oil (black)</td>
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<tr>
<td>Fuel Oils Black</td>
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<td>Asphalt Black</td>
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<tr>
<td>Slop and Waste Oils</td>
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<table>
<thead>
<tr>
<th>Lube and Crude Oils</th>
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<tbody>
<tr>
<td>Lube Oils</td>
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<table>
<thead>
<tr>
<th>Chemicals</th>
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<tbody>
<tr>
<td>Acids</td>
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<tr>
<td>Ammonia</td>
</tr>
<tr>
<td>Caustics</td>
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<tr>
<td>Chlorine</td>
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<tr>
<td>Inhibitors</td>
</tr>
<tr>
<td>Hydrogen</td>
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<tr>
<td>Gas (fuel and sour)</td>
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<tr>
<td>Gas (sweet)</td>
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<tr>
<td>Air (industrial)</td>
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<td>Oxygen</td>
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<tr>
<td>Carbon Dioxide</td>
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<td>Freon</td>
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END OF SECTION 01086
PART 1 - GENERAL

1.1 DESCRIPTION

A. In addition to the General Provisions Paragraphs, "MEASUREMENT AND PAYMENT OF SCHEDULED ITEMS" and "PAYMENTS", this Section includes specifications for measurement and payment as they apply to the Work, and includes provisions applicable to lump sum prices, unit prices, and allowances, as indicated.

B. Measurement methods specified in the individual Sections of these Specifications shall govern if they differ from methods specified in this Section.

1.2 LUMP-SUM MEASUREMENT

A. The term "lump sum" when used as an item of payment, will mean complete and fixed price for the work prescribed for that portion of the contract work under the item described in the contract.

B. The quantities may be shown on the Contract Drawings for items for which lump sum is the method of measurement. If shown, the quantities are shown for the convenience of the Contractor. Contractor shall verify quantities for purposes of bidding and construction. The Contractor will not be entitled to additional compensation if the quantities shown vary from those actually required.

C. Breakdown of costs of lump sum items:

1. If the Contractor requests progress payments for lump-sum items or amounts in the Bid Schedule, such progress payments will be made in accordance with a well-balanced, detailed breakdown of costs of lump sum items for payment purposes, prepared by the Contractor and submitted to the Contracting Officer for approval.

2. Such breakdown for each applicable lump-sum item shall show fixed definable and measurable quantities where possible and unit prices therefor as developed and assigned by the Contractor to the different features of the work and major subdivisions thereof. The summation of extensions of quantities and unit prices and related costs shall equal the amount of the lump-sum Contract Price or lump sum bid item indicated in the Bid Schedule.

3. Following the Contracting Officer’s approval, progress payments will be made in accordance with the Contractor’s breakdown and from the approved progress schedule, reflecting the progress which occurred during the payment period as approved by the Contracting Officer.

1.3 MEASUREMENT OF QUANTITIES FOR UNIT PRICES

A. Measurement will be in accordance with the General Provisions Paragraph, "MEASUREMENT AND PAYMENT OF SCHEDULED ITEMS".

B. Measurement Standards: Work paid for at a unit price per unit measurement will be measured in accordance with United States Standard Measures except as otherwise specified.

1. The term "pound" when used in the measurement or payment of any material or work, will mean 16 ounces avoirdupois, based on computed or scale weight.

2. The term "ton" when used in the measurement or payment of any material or work, will mean the short ton consisting of 2000 pounds avoirdupois. When applicable, materials measured in pounds will be converted to tons.

C. Measurement, General: Unless otherwise specified, the following shall apply:

1. Structures will be measured according to neat lines shown on the Contract Drawings or as ordered in writing, unless otherwise specified. Concrete and masonry will be measured and accurately computed by dividing the work into simple geometrical figures and adding their volumes or areas.

2. Allowance will not be made for surface laid over a greater area than shown on the Contract Drawings, or for any material moved from outside the area of the cross section and lines shown on the Contract Drawings except when specifically authorized by the Contracting Officer.

D. Measurement by Area: Unless otherwise specified, the following shall apply: Longitudinal measurements for area computations will be made horizontally. Transverse measurements will be the neat dimensions shown on the Contract Drawings or ordered in writing by the Contracting Officer.

E. Measurement by Volume: Unless otherwise specified, the following shall apply: In computing volumes of excavation, embankment or borrow, methods utilizing electronic computation, planimeters, or other accepted engineering procedure having general acceptance in the engineering profession will be used. When the measurement is based on the cross sectional area, the average end area method will be used.

F. Linear Measurement: Unless otherwise specified, the following shall apply: Items which are measured by the linear foot, such as guardrail, underdrains, etc., will be measured parallel to the base or foundation upon which such structures are placed, unless
Measurement per Each: The term "each" when used as an item of payment such as project markers and Right-of-Way monuments will mean complete payment for the work prescribed for that item.

Measurement by Weight: Unless otherwise specified, items measured on a linear basis will be measured at the centerline of item in place.

Bituminous Materials: Bituminous materials, where specified to be paid for separately, will be measured by the ton, unless specified or directed otherwise. Bituminous materials delivered in tank trucks or tank feeders shall be weighed on scales, as approved by the Authority.

Timber: Where specified to be paid for separately by the board foot, timber will be measured by the board foot actually incorporated in the structure. Measurement will be based on nominal widths, and the thickness and the extreme length of each piece.

Measurement will be based on nominal widths, and the thickness and the extreme length of each piece.

1.4 VALUES OF UNIT PRICES

A. The number of units and quantities contained in the Bid Schedule as estimated quantities are approximate only, and final payment will be made for the actual number of units and quantities, which are incorporated in the Work and required by the Contract, as, measured by the Contracting Officer.

B. In the event that work or materials or equipment are required to be furnished to a greater or lesser extent than is indicated in the Contract Documents, such work or materials or equipment shall be furnished in greater or lesser quantities in accordance with General Provisions Paragraph, "VARIATION IN ESTIMATED QUANTITY".

1.5 ALLOWANCES

A. Description: Allowances specified in the Contract Documents and indicated in the Bid Schedule shall cause the work so covered to be furnished, performed, and completed for such sums as are acceptable to the Contracting Officer and shall include the cost to the Contractor of all materials and equipment to be delivered and installed under the specified allowances.

B. Specific Allowances: Specific allowances, if any, included in the Contract are indicated in the Bid Schedule.

C. Administration:

1. The allowances specified in the Contract Specifications and indicated in the Bid Schedule are exclusive of any work indicated in the Contract Documents for which payment is included under other specifically designated items in the Bid Schedule.

2. Contractor Accountability of Allowance Work Performed: Contractor shall maintain a separate account of all incurred, segregable, direct costs for the work allocable to the item requirements. Only allowable and allocable direct costs will be reimbursed; there shall be no compensation for any other related costs including but not limited to overhead indirect costs, commission or profit. These amounts shall not subject to retainage.

1.6 CONTRACT PAYMENTS

A. Payments will be in accordance with the General Provisions Paragraph, "PAYMENTS".

B. Full Compensation:
1. The Contract lump sum and unit prices paid for the various items and classifications of work shall include full compensation for furnishing labor, supervision, materials, tools, equipment, transportation, services, and incidentals, and for performing work necessary for completing the construction or installation of the item or work classification, complete in place, unless stated otherwise. Prices paid shall include all miscellaneous components, accessories, and appurtenances; shop drawings, working drawings, and other submittals; and testing and inspection, unless stated otherwise.

   a. The term "complete in place", when used in regard to measurement and payment, means the completion of the contract item, including the furnishing of materials, equipment, tools, labor, supervision and work incidental thereto, unless otherwise specified.

2. Refer to with the General Provisions Paragraph, "MEASUREMENT AND PAYMENT OF SCHEDULED ITEMS" for payment for cost of work not specifically provided for by a pay item in the Bid Schedule.

C. Refer to the breakdown of costs of the lump sum price for General Requirements required under this Section: If in any month, the Contractor fails to comply with any portion of the General Requirements that has value to the Authority which will not be fulfilled by the untimely performance of that aspect of the work, the entire monthly payment for General Requirements will be deducted from the Contract Amount. If such work is completed or submitted late within a particular month, the payment will be prorated at the option of the Contracting Officer and a percent of the payment (in accordance with the proration) will be deducted from the Contract Amount. Examples of aspects of the work which have value to the Authority only or primarily in their timely execution for each month are submittal of properly prepared Schedule Update, proper execution of Contractor's Quality Control Plan, and maintenance of complete and correct Working (As-Built) Drawings and Specifications.

1.7 REJECTED, EXCESS, OR WASTED MATERIALS

A. Quantities of material wasted or disposed of in a manner not called for under the Contract; rejected loads of material, including material rejected after it has been placed by reasons of the failure of the Contractor to conform to the provisions of the Contract; material not unloaded from the transporting vehicle; material placed outside the lines indicated on the Contract Drawings or established by the Contracting Officer; or material remaining on hand after completion of the Work, will not be paid for, and such quantities shall not be included in the final total quantities. No additional compensation will be permitted for loading, hauling, and disposing of rejected material.

1.8 CERTIFICATION OF AS-BUILTS

A. The Contractor shall submit with each pay request, a certification that all Request for Information (RFI’s), Change Orders or Supplemental Agreements, clarifications, revisions and field surveyed data have been documented on the Working (As-Built) Drawings and Specifications sets in accordance with the contract requirements. Working (As-Built) Drawings and Specifications shall be certified correct and complete by the Contractor’s Quality Control Representative at the time invoices are submitted for progress payments.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”

END OF SECTION 01220
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the general requirements and procedures regarding the project meetings.

1.2 TYPES OF MEETINGS
A. Pre-Construction Conference: Prior to the start of construction.
B. Initial Coordination Meeting: Prior to the start of construction
C. Initial Coordination Utility and Jurisdictional Agency Meetings: As needed.
D. Contractor Coordination Meeting (Weekly Progress Meeting): Held weekly.
E. Mutual Understanding Meeting: Held after the Contractor’s Quality Control Plan is approved, refer to Section 01450, Quality Control.
F. Contractor’s Quality Control (CQC) Meetings: Held weekly.
G. Ad-Hoc Meetings: As required throughout prosecution of the Work. To address immediately any matter or situation that has a bearing on the quality or completion of the Contract Work.

1.3 PRE-CONSTRUCTION CONFERENCE
A. The Contracting Officer will arrange a Pre-Construction Conference to orient the Contractor. The date of the conference will be as soon as practical after Notice of Award.
B. Attendees: Contracting Officer, other Authority representatives, and representatives of the Authority’s designers, utilities, and other jurisdictional authorities. Contractor’s Attendees: A responsible officer of the Contractor, the Project Manager, proposed Contractor’s Quality Control Representative (CQCR), Superintendent, Safety Supervisor, and other personnel as necessary.
C. Agenda:
   1. Project Organization and Discussion of Responsibilities.
   2. Design Overview
   3. Contract Documents
   4. Insurance and Bonds
   5. Quality Control
   6. Safety
   7. Environmental Protection
   8. DBE/MDE/WBE Requirements
   9. Operations Coordination
   10. Maintenance Coordination
   11. Utility Coordination
   12. Community Relations
   13. Neighborhood Job Opportunity Program

1.4 INITIAL COORDINATION MEETING
A. The Contracting Officer will arrange and conduct the Initial Coordination Meeting with the Contractor. The agenda will be forwarded to the Contractor soon after Notice to Proceed.
B. Contractor’s attendees shall include the Project Manager, CQCR, Superintendent, Safety Supervisor, and other personnel as necessary.
C. Agenda:
   1. Authority’s Project Organization
   2. Contractor’s Project Organization
   3. Partnering
   4. Quality Control
   5. Proposed Construction Methods
   6. Scheduling
   7. Communications Procedures
   8. Meetings
   9. Submittals
   10. Project Cost Control
   11. Differing Site Conditions
   12. Design Site Conditions
   13. Claims
   14. Project Completion
16. Payment Procedures

1.5 INITIAL COORDINATION UTILITY AND JURISDICTIONAL AGENCY MEETINGS

A. The Contracting Officer will arrange and conduct meetings with the Contractor and affected entities. The purpose of these meetings will be to establish an early working relationship between the Contractor and affected utilities and jurisdictional agencies and establish coordinated activities during the construction phase.

B. Agenda:

1. Review the Agreements with each party.
2. Representative contact and their authority for each party present.
3. Permit, insurance, safety requirements.
4. Scheduling of work.
5. Inspection and acceptance of work.

1.6 MONTHLY PROGRESS STATUS UPDATE MEETING

A. This meeting shall be held prior to the formal submittal to verify progress and review the approved schedule against actual progress and to establish a basis for the monthly payment estimate.

B. Agenda Topics

1. Agreement on Update Information: The Contracting Officer will review the Contractor submitted logic sort of last month’s printout as a draft. Either prior to or during the meeting, the update information listed below shall be agreed upon. This agreed-upon update information shall then be entered into the CPM Schedule.
   a. Actual start dates on activities started this period.
   b. Actual completion dates on activities finished this period.
   c. Remaining duration’s for activities which have started but are not completed.
2. Status of Project Milestones: Review project milestones with gains or slippages noted.
3. Schedule Slippages: Review any slippages in critical activities or on project milestones.

4. CPM Changes for Next Update: List and categorize any agreed changes to the schedule as shown below:
   a. Minor logic changes.
   b. Changes in the duration of any activity.
   c. Incorporation of any Change Orders and/or Contract Modifications into the schedule and their impact upon project milestones.
   d. Personnel loading changes.

5. Potential Delays: Review the planned activities (starting, in-progress, and completing) for the next period, highlighting any foreseeable delaying factors. Resolve problems that may have already affected the schedule, with the specific action to be taken by each party.

1.7 CONTRACTOR COORDINATION MEETING

A. This meeting shall serve as a forum to establish and maintain close coordination of work activities through an overview of the next month’s activities, provide details regarding the upcoming work week; and discussing the activities of the following work weeks in more general terms. The agenda shall include the following, as appropriate:

1. Review and approval of minutes of previous meeting.
2. Project safety issues.
3. Environmental protection and hazard related issues.
5. Community relations.
6. Review of work progress since previous meeting.
7. Activities in progress or scheduled for upcoming week including subcontracted work.
8. Manpower, material, and equipment restrictions.
9. Access and availability of work sites.
11. Corrective measures to regain project schedule.
12. Status of shop drawings, working drawings, and other submittals.

13. Review of offsite fabrication, inspection, and delivery schedules.


15. Interfaces and dependencies with preceding, concurrent, and follow-on contractors.

16. Quality assurance and quality control issues.

1.8 CONTRACTOR’S QUALITY CONTROL MEETING

A. This meeting shall be held to review Contractor’s and Authority’s quality control and quality assurance activities and results, review discrepant items, review deficiencies and non-conformances, discuss prevention and correction, identify work which requires as-built drawings, to agree on weather days, and discuss any other concerns which may be related to quality control. DART Quality has the option to attend these meetings.

1.9 MEETING ADMINISTRATION PROCEDURES

A. Unless advised otherwise, meetings will be held in the office of the Contracting Officer.

B. Except for ad-hoc meetings, the day and time for regularly scheduled meetings will be established at the Pre-construction Conference. Requests for changes in date and time of meeting by either party will require a minimum of 24 hours advance notice.

C. Except as otherwise specified, the Contracting Officer will prepare the meeting minutes and distribute them to attendees within five working days following the date of the meeting and within three working days following the date of the Monthly Progress Status Update Meeting.

D. Contractor shall submit any exceptions to the meeting minutes within 48 hours of receipt.

E. Contractor’s Quality Control Representative (CQCR) shall document CQC meetings and provide copies of the minutes to the Contracting Officer within two days after the meeting.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - METHOD OF MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”.

END OF SECTION 01312
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section together with Appendices A, B, and C specifies requirements and procedures for the Contractor to prepare Construction Schedule, Schedules of Values, Schedule Reports, Schedule Data Files, and related reports. The purpose of the schedules and reports shall be to:

1. Ensure adequate planning and timely execution of the work by the Contractor.
2. Establish a model to be used as a basis for determining satisfactory progress and completion of the Project.
3. Facilitate coordination and interfacing of the Contractor's work with others as needed.
4. Assist the Contracting Officer in monitoring progress.
5. Verify the approximate amount of the monthly progress payment to be made to the Contractor.
6. Evaluate proposed changes to the Contract and subsequent impacts to the schedule.

B. Contractor shall be required to provide and maintain at a minimum the following:

1. Monthly Requirements:
   a. Construction Schedule.
   b. Schedule of Values.
2. Weekly Requirements: Provide for Contractor Coordination (Weekly Progress) Meetings:
   a. Narrative Summary.
   b. Three Week Look Ahead (using the P6 Baseline Schedule) with updated data disk.

1.2 REFERENCED STANDARDS

A. The following publications are cited as references for the CPM scheduling technique described in this Contract:


1.3 CONSTRUCTION SCHEDULING PROCEDURE

A. Scheduling technique known as the Critical Path Method (CPM) will be used by the Contractor in complying with these Specifications. The Precedence Diagramming Method (PDM) shall be used in preparing the CPM diagrams and calculations.

B. Contractor shall prepare the Construction Schedule, Schedule Reports, and Schedule Data Files using products of Primavera Systems, Inc., specifically: Primavera Project Planner for Windows (latest version). Any versions of the specified scheduling software used by the Contractor shall be compatible with the versions employed by the Contracting Officer.

C. Construction Schedule, Schedule of Values, Review Bar Chart, and Schedule Data Files shall be produced in the formats described in Part 2 "PRODUCTS".

1.4 IN-HOUSE CAPABILITY

A. Within 14 calendar days after Notice of Award, submit a statement of network analysis capability to the Contracting Officer verifying that either the Contractor's organization has "in-house" capability qualified to satisfy the requirements of this specification or that the Contractor employs a consultant or firm which is so qualified. Contractor shall verify capability by providing a description of construction projects to which the Contractor or his consultant has successfully applied CPM network analysis. Include a minimum of two projects, with references, valued at least half of the value of this contract and which were controlled throughout the duration of the project by means of periodic systematic review, update and revision of a CPM network schedule.

B. The use of an outside consultant is at the Contractor's expense and does not relieve the Contractor of responsibility for complying with this section.

C. Contractor shall maintain on the project site, a full time dedicated scheduler whose sole responsibility is scheduling and who is qualified in CPM scheduling techniques and familiar with the Authority's CPM scheduling software. The dedicated scheduler shall have the primary responsibility for monitoring status, updating progress and revising the Contract Schedule to reflect current contract status.

1.5 SUBMITTALS

A. Construction Schedule:

1. Preliminary Construction Schedule:
   a. Contractor shall prepare a Preliminary Construction Schedule, which shall show in detail the Work activities for the first 3 months of the Work and a summary by
area/subarea of all remaining activities for the entire Contract.

b. Preliminary Construction Schedule shall consist of no less than 200 activities (refer to Appendix A) and shall be presented in the form of a Bar Chart.

c. Each activity, which is not a milestone, submittal, or information, on the Preliminary Construction Schedule shall be allocated a dollar value that coincides with the Schedule of Pay Items, the summation of which shall equal the Grand Total shown on the Schedule of Pay Items.

d. Preliminary Construction Schedule shall be submitted within 14 calendar days after the effective Notice to Proceed.

2. Secondary Construction Schedule:

a. Contractor shall expand the Preliminary Construction Schedule to create a Secondary Construction Schedule that will show in detail all work activities and corresponding costs and resource requirements including labor by type, major equipment, as required per activity for the entirety of the Contract.

b. Secondary Construction Schedule shall be divided into activities which are reasonable, realistic and feasible; and shall be representative of the separable portions of the work and shall comply with the policies of Activity Definition and Duration as outlined in Appendix A to this section.

c. Graphic representations and tabular reports shall be generated using the formats and quantities stipulated in PART 2 “PRODUCTS” using the software specified in Paragraph 1.3.B.

d. Secondary Construction Schedule is to be submitted within 25 calendar days after the effective Notice to Proceed.

3. Review Conference

a. In preparation for a Baseline Construction Schedule, and as part of the submittal process, the Contractor and Contracting Officer shall jointly review the Secondary Construction Schedule within 7 days after submittal to insure Contract compliance.

b. Revisions requested by the Contracting Officer with respect to schedule presentation shall be implemented and resubmitted for approval within 7 days after the Review Conference.

c. Contractor shall furnish within 7 days after the Review Conference a written narrative defining the Contractor’s determination of durations. The narrative shall describe the number of laborers, weather incorporation, the number of work days per week, and major construction equipment.

4. Baseline Construction Schedule:

a. A Secondary Construction Schedule incorporating any revisions as requested by the Contracting Officer as a result of the Review Conference shall be submitted 45 calendar days after Notice to Proceed for approval by the Contracting Officer.

b. Upon approval by the Contracting Officer, the Secondary Construction Schedule, as defined in Paragraph 1.5.A.2.a, shall constitute the Baseline Construction Schedule. Approval by the Contracting Officer is for conformance to the requirements of the contract documents only. Approval does not relieve the Contractor of any of its responsibility for the accuracy or feasibility of the Baseline Construction Schedule, or the Contractor’s ability to meet milestone dates and the contract completion date.

c. Baseline Construction Schedule and subsequent updates shall be generated using the formats and quantities stipulated in PART 2 “PRODUCTS” using the software specified in Paragraph 1.3.B.

d. Contractor shall discuss in detail the Baseline Construction Schedule with all subcontractors and major suppliers as it relates to their respective work.

e. Baseline Construction Schedule will be used as a basis for verifying future progress payments and to measure the Contractor’s overall performance on a monthly basis.

5. Update of Baseline Construction Schedule:

a. Baseline Construction Schedule, hereinafter referred to as the "Construction Schedule," shall be updated on a monthly basis until Contract completion except with respect to contract modifications or approved revisions to the Construction Schedule which will require interim submittals of the Construction Schedule as deemed necessary by the Contracting Officer.
b. Updated Construction Schedule shall be calculated using "retained logic" and shall depict progress of work and payments corresponding to the established "status" date as mutually agreed upon by the Contractor and Contracting Officer.

c. Actual progress shall be reflected in the following terms and subject to approval by the Contracting Officer:

1) Activities started and/or completed.

2) Percentage of resources expanded.

3) Estimated remaining duration for each activity in progress.

4) Budgeted dollar amount and actual dollar amount per activity based on percent complete per resource.

d. Contractor shall certify in writing that the updated Construction Schedule has been discussed in detail with all subcontractors and major suppliers as it relates to their respective work and a copy submitted to the Contracting Officer.

e. Updates to the Construction Schedule, as agreed upon by the Contracting Officer shall be submitted with requests for progress payment, commencing with the third payment request. Failure to meet the requirements of this paragraph shall result in the withholding of payments for the General Requirements.

f. Monthly reports shall be provided to the Contracting Officer with the request for progress payment by the 15th day of each month or by a date mutually agreed to by the Contractor and the Contracting Officer (See b above) and shall contain the latest updated progress information from the previous update.

g. Request for progress payment, narrative report, and the construction schedule shall cover a 1-month period from the end of the last period day 25 of the current month or as mutually agreed.

B. Schedule of Values:

1. Preliminary Schedule of Values:

a. Contractor shall prepare a Preliminary Schedule of Values to show the allocation of Pay Items to individual activities defined in the Preliminary Construction Schedule. 12 digit cost accounts by pay item number with Categories shall be assigned as indicated in Appendix B. The sum of the dollar amounts assigned to each activity shall equal the Grand Total shown on the Schedule of Pay Items.

b. Preliminary Schedule of Values shall outline at a minimum:

1) The "Title" of each activity as defined in the Construction Schedule.

2) The Pay Items used to determine the total dollar amount of each activity.

3) The total dollar value of each activity.

c. Preliminary Schedule of Values is to be submitted with the Preliminary Construction Schedule ten days after Notice to Proceed.

2. Secondary Schedule of Values:

a. Contractor shall update the Preliminary Schedule of Values to create a Secondary Schedule of Values that will allocate a dollar value (cost) for each activity of the CPM Schedule. Each activity cost allocation shall include a labor, equipment, and material cost and a prorata contribution to overhead and profit. The sum of activity costs shall be equal to the total Contract Sum.

b. Secondary Schedule of Values is to be submitted in the format and quantities stipulated in PART 2, "PRODUCTS".

c. Secondary Schedule of Values is to be submitted with the Secondary Construction Schedule, 25 days after Notice to Proceed.

3. Review Conference:

a. In conjunction with the Review Conference for the Secondary Construction Schedule, the Contracting Officer shall also review for approval the items delineated on the Secondary Schedule of Values.

b. If, in the opinion of the Contracting Officer, the Secondary Schedule of Values lacks sufficient detail to support an activity's value, the Contractor will be required to submit documentation substantiating the value of those activities in question.
1) Documentation shall be in the format defined in Appendix B to this section. This documentation shall be submitted within 3 working days after the Review Conference.

2) Based on the documentation provided for in the preceding paragraph, dollar amount allocations will be considered unbalanced if an activity on the Construction Schedule has been assigned a disproportionate share of the dollar amounts.

c. Any adjustment to the dollar amounts of activities as deemed necessary by the Contracting Officer shall be implemented and resubmitted for approval within 7 days after the Review Conference.

4. Baseline Schedule of Values:

a. Secondary Schedule of Values incorporating any dollar amount adjustments as requested by the Contracting Officer as a result of the Review Conference, and subsequent review of any additional dollar amount documentation as described under Sub-section 1.5.B.3 shall be submitted with the Secondary Construction Schedule, 45 days after the effective Notice to Proceed for approval by the Contracting Officer.

b. Upon approval, the Secondary Schedule of Values as defined in Paragraph 1.5B.4.a. shall constitute the Baseline Schedule of Values.

5. Update of the Baseline Schedule of Values:

a. Contractor shall update the Baseline Schedule of Values to reflect approved contract modifications and/or revisions affecting activity dollar amounts.

b. Submit Updates to the Baseline Schedule of Values to the Contracting Officer for approval.

c. Updates to the Baseline Schedule of Values, as approved by the Contracting Officer, shall be submitted with the corresponding updates to the Construction Schedule.

D. Three-Week Look Ahead:

1. Contractor shall prepare a Three-Week Look Ahead on a weekly basis.

2. Three-Week Look Ahead shall be submitted to the Contracting Officer for review no later than 24 hours prior to the Contractor Coordination Meeting.

3. Three-Week Look Ahead shall be created in P6 format or other acceptable formats approved by DART from the latest accepted Construction Schedule.

a. Additional detail shall be added to the Construction schedule if the Three-Week Look Ahead requires additional detail.

b. No activity ID number or Description shall be changed.

c. Additional detail shall be added by changing the activity type to hammock and creating the detail within the hammock.
E. Qualifications of Scheduler: Refer to Article entitled “In-House Capabilities” herein for submittal requirements.

PART 2 - PRODUCTS

2.1 FORMATS

A. This section defines the acceptable formats for which the Construction Schedule, Schedule Data Files, Schedule of Values, Weekly Narrative Summary, and Review Bar Chart shall be submitted:

2.2 CONSTRUCTION SCHEDULE

A. Bar-Chart:

1. Bar-Charts shall be produced in 8-1/2 inch by 11 inch format with sufficient clarity and readability so the Contracting Officer can readily monitor and follow progress for all portions of the Contract.

2. Bar-Charts shall contain the following information for each activity in the activity column:
   a. Identification Number.
   b. Activity Description (“Title”).
   c. Original Duration.
   d. Remaining Duration.
   e. Percent Complete.
   f. Total Float.
   g. Calendar.
   h. Early Start and Early Finish Date (“Bars”).
   i. Free Float.

3. Bar-Charts are to be sorted according to the area/sub-area and Early Start/Early Finish.

4. Critical path shall be clearly shown on the Bar-charts. Critical activities shall be defined as activities with "total float" of less than one day and being the longest path associated to physical work.

5. One Bar-Chart shall be submitted in accordance with Paragraph 1.5.A, “Construction Schedule”

B. Schedule Narrative Reports:

1. Schedule Narrative Reports shall comment on the following updated information for each changed activity:
   a. Logic.
   b. Codes.
   c. Early Dates.
   d. Actual Dates.
   e. Calendar.
   f. Original Duration.
   g. Resources.

1) Labor Resources.
2) Equipment Resources.
3) Whether work will be performed on a single, double or triple shift, and whether it is to be done on a 5, 6 or 7 day work week basis.

h. Budgeted Dollar amount per activity.

2. Narrative Report shall be sorted Area/Sub-Area activity ID.

3. One copy of the Schedule Narrative Report shall be submitted in accordance with Paragraph 1.5.A

2.3 SCHEDULE DATA FILES

A. A copy of data files in PRX back-up format for the Construction Schedule and subsequent approved updates of the Construction Schedule shall be submitted on a CD-ROM or DVD. Each submitted schedule shall have a unique P6 “project name”. These data files are hereinafter referred to as the Schedule Data Files.

B. Schedule Data Files shall be submitted with the corresponding hard copy of the Construction Schedule and subsequent approved updates to the Construction Schedule.

C. Schedule Data Files shall be considered the property of the Authority upon receipt.

2.4 SCHEDULE OF VALUES

A. Schedule of Values shall be presented using the outline in Table 01320 – 1

B. Schedule of Values shall be arranged and subtotaled to match the format followed by the bid “Schedule”.

C. Include manload for Baseline and Update Baseline Construction Schedules.

D. One copy of the Schedule of Values shall be submitted in accordance with Paragraph 1.5.B
2.5 WEEKLY NARRATIVE SUMMARY

A. Weekly Narrative Summary shall be generated and one copy provided to the Contracting Officer in accordance to Paragraph 1.5.B in this section.

B. Weekly Narrative Summary shall be typed and on 8-1/2 inch by 11 inch paper.

2.6 THREE-WEEK LOOK AHEAD

A. Information on the Three-Week Look Ahead shall relate to physical progress during the preceding week, plans for the current week and for succeeding 2 weeks. The Three-Week Look Ahead shall depict the time frame corresponding to the weekly progress meetings and shall be accompanied by a data disk with the updated monthly Construction Schedule. The most updated construction schedule can be provided, even if same as before.

B. Three-Week Look Ahead shall depict the following information in the column field

1. Identification Number.
2. Activity Description.
3. Original Duration,
4. Remaining Duration.
5. Percent Complete.
6. Total Float.
7. Calendar.
8. Early Start and Early Finish Date. (bars).

C. Area, Sub-Area and Early Start Dates shall sort the activities.

D. One copy of the Three-Week Look Ahead shall be generated in accordance with Paragraph 1.5.D.

PART 3 - EXECUTION

3.1 PERFORMANCE CONDITIONS

A. Baseline Construction Schedule does not relieve the Contractor of responsibility for the accuracy and feasibility of the Construction Schedule. However, to the extent the Baseline Construction Schedule is reasonable, it shall become a part of the Contract and defines the obligations of the Contractor to achieve a timely Contract completion.

B. Failure by either the Contractor or Contracting Officer to include any element of work required for performance of the Contract in the Construction Schedule shall not excuse the Contractor from its obligation under the Contract to complete all work with the Contract completion time.

C. Contractor shall be responsible in accordance with the General Provisions Paragraph, “PERMITS AND RESPONSIBILITIES” for obtaining all necessary permits and licenses unless otherwise indicated. Should the Contractor’s work be delayed because a necessary permit was not obtained, the Contractor shall reschedule work and/or employ additional labor and equipment as is necessary to complete the work by the date required at no additional cost to the Authority.

D. Contractor shall furnish sufficient forces, plant and equipment, and shall work such hours, including overtime operations, as necessary and approved by the Contracting Officer, to ensure the execution of work in accordance with the current monthly update of the Construction Schedule.

1. If, in the opinion of the Contracting Officer, the Contractor is failing to achieve the Contractual Milestone Dates, as required in the current monthly update, the Contractor shall submit a recovery plan, in the form of a Three Week Look Ahead, PRX back-up file and narrative, for the Contracting Officer’s approval within 3 days of notification.

2. The recovery plan is dependent on the cause for loss of time and may require the Contractor to increase the number of shifts; days of work; institute or increase overtime operations; and/or increase the amount of construction plant and equipment without additional cost to the Authority.

E. It shall be the responsibility of the Contractor to maintain progress so as not to delay the work of other Authority Contractors participating in the Project.

F. If the Contractor delays the work of other Authority Contractors, the Contractor shall, with the approval of the Contracting Officer, increase the number of shifts; days of work; institute or increase overtime operations; and/or increase the amount of construction plant and equipment without additional cost to the Contract so as not to impede the work of others.

G. Float time is not for the exclusive use of, or benefit of, either the Authority or the Contractor.

3.2 UPDATES, REVISIONS, AND CHANGES

A. In the event actual progress on critical activities (activities with total float less than one day and on the longest path); or on activities with less than 15 percent total float (refer to Appendix D for mathematical computation) is observed to deviate from the Baseline Construction Schedule by 1 week behind (5 working days), the Contractor shall provide, within 3 working days after notification by the Contracting Officer, a recovery plan for completing the work in accordance with Paragraph 3.1.D.

B. Updates to the Construction Schedule to reflect progress to date shall not be considered a revision to the Baseline Construction Schedule. However, the Contractor shall submit to the Contracting Officer for
approval a revised Construction Schedule in the formats and quantities stipulated in PART 2, “PRODUCTS”, if one or more of the following conditions occur:

1. Changes which reflect adjustments to activities and related dollar amounts.

2. Contractor elects to change any sequence of activities from the previously approved update to the Construction Schedule. Contractor shall notify the Contracting Officer in writing, stating the necessity for proposed revisions and receive the Contracting Officer’s approval prior to making any such revisions.

3. When, in the opinion of the Contracting Officer, the status of work is such the Baseline Construction Schedule is no longer representative for planning and evaluation of the Contractor’s work.

3.3 TIME EXTENSIONS

A. Requests, if any, for extensions of time resulting from Excusable or Compensable changes issued by the Contracting Officer shall be accompanied by a full schedule analysis. The analysis shall include an updated Baseline Construction Schedule reflecting proposed changes; a narrative explaining the impacts and any dollar amounts associated with the extension. The requests shall be submitted in accordance with the General Provisions, Paragraph, “CHANGES”.

B. Construction Schedules revised as a result of the foregoing conditions are to be submitted in the formats and quantities stipulated in PART 2, “PRODUCTS”.

3.4 EARLY COMPLETION

A. An early completion schedule is one which anticipates completion of all or specified parts of the work ahead of the corresponding Contract Time. Since Contract float belongs to the project, the Contractor shall not be entitled to any extension in Contract Time, or recovery for any delay incurred because of extensions in an early completion date, until all contract float is used or consumed and performance or completion of the work extends beyond the corresponding Contract Time. Contractor shall adjust or remove any float suppression techniques, e.g. preferential sequencing (crew movements, equipment use, form reuse, etc.), extended durations, imposed dates, scheduling of Work not required for a Contract Time as required Work, and others, as a prerequisite to a request for an increase in Contract Price or Contract Time. Use of restraint dates should be minimized and require approval by the Contracting Officer.

3.5 NON-COMPLIANCE

A. Failure of the Contractor to comply with the requirements of this section may result in withholding of progress payments or in termination of the Contractor’s right to proceed with the Work, or any separate part thereof, in accordance with the Contract.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”.

<table>
<thead>
<tr>
<th>ITEM NO. (FROM BID PER ACTIVITY SCHEDULE)</th>
<th>PAY ACTIVITY ITEM ID</th>
<th>ACTIVITY TITLE</th>
<th>ESTIMATED QUANTITY</th>
<th>TOTAL DOLLAR AMOUNT</th>
</tr>
</thead>
</table>

TABLE 01320 – 1
ACTIVITY DEFINITION AND DURATION POLICY

I. ACTIVITY DEFINITIONS

A. Construction activities shall be defined as work activities that require time and resources (manpower, equipment, and/or material) to complete. The description shall be a concise representation in sufficient detail to identify the work to be performed. The use of “start,” “continue,” “complete,” or similar words is not acceptable.

B. The Construction Schedule shall contain sufficient detail of activities to include the following:
   1. Procurement, fabrication, delivery, installation, and test activities for major materials and equipment.
   2. Submittal and approval of shop and working drawings and material samples.
   3. Commissioning, training, and Operations & Maintenance (O & M) manuals.
   4. Access and availability to work areas.
   5. Delivery of any Authority-furnished equipment.
   6. Interfaces and dependencies with preceding, concurrent and follow-on contractors.
   7. Work to be performed by subcontractors.

C. As part of the process of defining activities, the activities shall be coded in such a manner as to reflect the Work Breakdown Structure defined in Appendix C of this section.

D. Each construction activity shall have only one responsible party performing the work.

II. MILESTONES (EVENTS)

A. Milestones in the Contract Documents spell out conditions regarding necessary progress of work, construction planning milestones, and completion time which shall be incorporated into the Construction Schedule.

B. Section 01010, "Summary of the Work", contain prerequisites for interfacing with other Authority contractors which shall be incorporated into the Construction Schedule.

III. ACTIVITY DURATIONS

A. The construction process shall be divided into activities and durations which are reasonable, realistic, and feasible; and shall be representative of the separable portions of the Work.

B. In the event there is other concurrent non-Authority construction occurring within the defined regional parameters of this Contract which may impact the efficiency with which the requirements of this Contract are met, the Contractor is to take this into consideration when determining the duration of activities defining the Construction Schedule.
The following outline is to be used for further delineation of those items listed on the Schedule of Values for which the Contracting Officer requests more detailed information for the determination and substantiation of fair allocations of costs per activity.

<table>
<thead>
<tr>
<th>ACTIVITY ID NO.</th>
<th>ESTIMATED QUANTITY</th>
<th>UNITS</th>
<th>ACTIVITY DESC. (“TITLE”)</th>
<th>UNIT BID PRICE</th>
<th>ALLOCATED COST PER ACTIVITY</th>
</tr>
</thead>
</table>

**Cost Category**
- L = Labor:
- E = Equipment:
- M = Material:
- C = Subcontractor:
- O = Overhead:
- P = Profit:
APPENDIX C
TO
SECTION 01320

WORK STRUCTURES

I. WORK STRUCTURE
   A. In order to achieve a standardized coding structure, the following activity code definitions are required as a minimum:
      1. DART Project Code.
      2. DART Function Code.
      3. DART Contract Number.
      4. Pay Item Number.
      5. Area of Work.

II. ACTIVITY CODES DICTIONARY

<table>
<thead>
<tr>
<th>Name</th>
<th>Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROJ</td>
<td>9</td>
<td>DART Project Code</td>
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<tr>
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<td>4</td>
<td>DART Function Code</td>
</tr>
<tr>
<td>CONT</td>
<td>10</td>
<td>DART Contract Number</td>
</tr>
<tr>
<td>PAY</td>
<td>6</td>
<td>Pay Item Number</td>
</tr>
<tr>
<td>AREA</td>
<td>6</td>
<td>Area of Work</td>
</tr>
<tr>
<td>SUBA</td>
<td>4</td>
<td>Sub-Area of Work</td>
</tr>
</tbody>
</table>

Note: Procurement should be an “AREA” and Submittal, Submittal Review by Contractor, DART Approval and Delivery should all be “SUB AREAS” of work.

III. ACTIVITY CODE DEFINITIONS
   A. DART Project Codes (PROJ): As Assigned by the Authority.
   B. DART Function Codes (FUNC): As Assigned by the Authority.
   C. DART Contract Number (CONT): As Assigned by DART Contracts Department.
   D. Pay Item Number (PAY): As per the associated item number in the Bid Schedule.
   E. Area of Work (AREA): As assigned by Contractor.
   F. Sub-Area of Work (SUBA): As assigned by Contractor.

END OF SECTION 01320
PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section includes specifications for the preparation, updating, revision, and submittal of the Construction Schedule, Three Week Look Ahead, Schedule of Values, and Progress Reports.

1.2 CONSTRUCTION SCHEDULING SOFTWARE
A. Contractor shall use products of Primavera Systems, Inc., specially: Primavera Project Planner for Windows (latest version). Any versions of the specified scheduling software used by the Contractor shall be compatible with the version employed by the Authority.

1.3 SUBMITTALS
A. Submit three copies of items required under this Section, with the exception of schedules.

B. Schedules, including Preliminary Baseline Construction Schedule and Three Week Look Ahead, shall be submitted as one hard copy and one electronic copy as specified herein. The electronic copy shall be a full schedule "backup" in P6. Only a PRX file will be accepted.

C. Submit preliminary Construction Schedule as specified under “Submittal of Preliminary Baseline Construction Schedule” herein.

D. Submit Monthly Summary Report and updated Construction Schedule and Schedule of Values with each monthly progress payment application.

E. Submit Three Week Look Ahead at Contractor’s Coordination (Weekly Progress) Meetings. Submit revised Construction Schedule and analyses as required.

F. Submit revised Construction Schedule and analyses as required.

PART 2 - PRODUCTS

2.1 SCHEDULE FORMS
A. The Authority will provide criteria on schedule code definitions at a meeting between the Contractor’s scheduler and the Authority. This meeting will be initiated by the Contractor and take place no later than 5 days after Notice to Proceed (NTP). The schedule format and structure will be presented and explained at this meeting.

B. Updated schedules shall be submitted as a back-up (PRX) copy in “P6 Concentric” format on a CD with an attached hard copy as explained below.

C. Prepare the Construction Schedule and Three Week Look Ahead in the form of a Gantt (Bar) chart.

2.2 CONTENT OF SCHEDULES
A. Submittal of Preliminary Baseline Construction Schedule:

1. Contractor shall prepare a Preliminary Baseline Construction Schedule for all work and submit it within 10 days after NTP. The schedule shall be coded as defined in the activity codes provided. The schedule shall cover the entire contractual duration and contain sufficient numbers of activities to cover all work in detail.

2. The Construction Schedule shall consist of activities having durations no greater than 14 days and costs no greater than $50,000.

3. Refer to Paragraph entitled “Construction Progress (hard copy)” herein for detailed requirements.

4. The Contracting Officer will review the preliminary schedule and return with comments within 10 days after receipt. Contractor shall incorporate comments and return within one week. When the Contracting Officer has accepted the schedule as fulfilling all of the contractual requirements, it will then be accepted as the Baseline Construction Schedule.

B. Construction Progress (hard copy):

1. Show activities required for construction in the bar-chart area, organized by Area, Early Start, and Early Finish.

2. Show the following data in the activities column: Activity I.D., “Early Start” and “Early Finish” dates, original duration, remaining duration, calendar and total float.

C. Schedule for Submittals of Shop Drawings, Product Data and Samples. Show:

1. Activities for Contractor’s submittals.

2. Activities for DART approved submittals.

D. The Three Week Look Ahead shall relate to the physical progress during the preceding week and plans for the succeeding three weeks (three week look-ahead) in detail. The Data Date for the Weekly Update shall be on Sunday. If the monthly update coincides with the weekly, then only submit the monthly for that week.

1. If the Three Week Look Ahead does not contain sufficient detail to schedule work, then change the activity in question to a hammock activity and create detail activities in support of the hammock.

E. Develop the Schedule of Values using the Bid Schedule. Each pay item in the Schedule of Values shall be represented within an activity or activities in the baseline schedule by a corresponding cost as a resource. This shall be defined in “Define Resource”, represented by the appropriate pay item number.

2.3 PROGRESS REVISIONS

A. The data date for the monthly updated Construction Schedule and the date of the submittal of the request for payment application shall be the 25th of the month or a mutually agreed date.

B. Indicate progress of each activity to the data date.

C. Show changes occurring since previous submission of schedule.

1. Major changes in scope (requires changes to baseline schedule).

2. Activities modified since previous submission.

3. Revised projections of completion.

4. Other identifiable changes.

D. The Monthly Progress Report shall contain activities sorted by area. Provide a narrative report by area, as needed to define:

1. Problem areas, anticipated delays and the impact on schedule.

2. Corrective action that will be taken by the Contractor to get the project back on schedule. This item is required whenever the progress of the job is impacting the contractual milestone dates.

3. The effect of changes on schedule or on sub-contractors.

PART 3 - EXECUTION

3.1 PERFORMANCE CONDITIONS

A. The Approved Construction Schedule does not relieve the Contractor of responsibility for the accuracy and feasibility of the Construction Schedule. However, to the extent the Approved Construction Schedule is reasonable, it shall become a part of this Contract and defines the obligations of both the Contractor and the Authority to achieve a timely Contract completion.

B. Failure by either the Contractor or Contracting Officer to include any element of work required for performance of the Contract in the Construction Schedule shall not excuse the Contractor from its obligation under the Contract to complete all work within the Contract completion time.

C. Contractor shall furnish sufficient forces, plant and equipment, and shall work such hours, including overtime operations, as necessary and approved by the Contracting Officer, to ensure the execution of work in accordance with the current monthly update of the Construction Schedule.

1. If, in the opinion of the Contracting Officer, the Contractor is failing to achieve the start and/or finish dates of the Approved Construction Schedule as presented in the current monthly updates, the Contractor shall submit a recovery plan for the Contracting Officer’s approval within five working days of notification.

2. The recovery plan may require the Contractor to increase the number of shifts; days of work; institute or increase overtime operations; and/or the amount of construction plant and equipment without additional cost to the Authority.

D. It shall be the responsibility of the Contractor to maintain progress so as not to delay the work of other Authority Contractors participating in the Project.

E. If the Contractor delays the work of other Authority Contractors, the Contractor shall, with the approval of the Contracting Officer, increase the number of shifts; days of work; institute or increase overtime operations; and/or the amount of construction plant and equipment without additional cost to the Contract so as not to impede the work of others.

F. Float time is not for the exclusive use of, or benefit of, either the Authority or the Contractor.
3.2 UPDATES, REVISIONS, AND CHANGE ORDERS

A. Updates to the Construction Schedule to reflect progress to date shall not be considered a revision to the Approved Construction Schedule. However, the Contractor shall submit to the Contracting Officer for review a revised Construction Schedule in the formats and quantities stipulated in PART 1, if one or more of the following conditions occur:

1. Approved change orders which reflect adjustments to activities.

2. Contractor elects to change any major sequence of activities affecting the critical path or significantly change the previously approved update to the Construction Schedule. Contractor shall notify the Contracting Officer in writing, stating the necessity for proposed revisions and receive the Contracting Officer’s approval prior to making any such revisions.

3. When, in the opinion of the Contracting Officer, the status of work is such the Approved Construction Schedule is no longer representative for planning and evaluation of the Contractor’s work.

B. Acceptance of the revised Approved Construction Schedule by the Contracting Officer is a condition precedent to approval of progress payments.

3.3 TIME EXTENSIONS

A. Requests, if any, for extensions of time resulting from changes issued by the Contracting Officer shall be accompanied by a full schedule analysis. The analysis shall include an updated Approved Construction Schedule reflecting proposed changes; a narrative explaining the impacts and any dollar amounts associated with the extension; and, if applicable, an updated Scheduled Earnings Curve. The requests shall be submitted in accordance with the General Provisions, Paragraph, “CHANGES”.

B. Construction Schedules revised as a result of the foregoing condition, shall be submitted in the formats and quantities stipulated in PART 1.

C. Since Contract float belongs to the project, the Contractor shall not be entitled to any extension in Contract Time, or recovery for any delay incurred because of extensions in an early completion date, until all contract float is used or consumed and performance or completion of the work extends beyond the corresponding Contract Time. Contractor shall adjust or remove any float suppression techniques, e.g. preferential sequencing through imposed logic (crew movements, equipment use, form reuse, etc.), extended durations, imposed dates, scheduling of Work not required, and others, as a prerequisite to a request for an increase in Contract Price or Contract Time. Use of restraint dates should be minimized and require approval by the Contracting Officer.

3.4 EARLY COMPLETION

A. An early completion schedule is one which anticipates completion of all or specified parts of the work ahead of the corresponding Contract Time.

3.5 NON-COMPLIANCE

A. Failure of the Contractor to comply with the requirements of this section may result in withholding of progress payments or in termination of the Contractor’s right to proceed with the Work, or any separate part thereof, in accordance with the Contract.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”.
APPENDIX A TO SECTION 01321

WORK STRUCTURES

I. WORK STRUCTURE

In order to achieve a standardized coding structure, the following activity code definitions are required as a minimum:

1) DART Project Code
2) DART Function Code
3) DART Contract Number
4) Pay Item Number

II. ACTIVITY CODES DICTIONARY

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<td>6</td>
<td>Pay Item Number</td>
</tr>
</tbody>
</table>

III. ACTIVITY CODE DEFINITIONS

1) DART Project Codes (PROJ): As Assigned by the Authority.
2) DART Function Codes (FUNC): As Assigned by the Authority.
3) DART Contract Number (CONT): As Assigned by DART Contracts Department.
4) Pay Item Number (PAY): As per the associated Item number in the Bid schedule.

END OF SECTION 01321
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the general requirements and procedures for preparing and submitting construction information and data for approval or information. Other requirements for submittals are specified under applicable Sections of the Standard Specifications and Contract Specifications. Requirements herein concern submittals directly related to the Work (non-administrative). Refer to General Provisions Paragraph, "SPECIFICATIONS AND DRAWINGS", for related requirements.

B. Project progress schedules and status reports are specified in Section 01320, “Construction Schedule and Progress Reports” or Section 01321, “Construction Schedule and Progress Reports for Small Projects”.

C. General requirements and procedures for preparing and submitting Shop Drawings, product data, and samples are specified in Section 01340, “Shop Drawings, Product Data, and Samples”. Field samples and mock-ups are a special form of sample too large to be transmitted in the specified manner for transmittal of sample submittals. Refer to Section 01454, “Field Samples and Mock-Ups”.

D. Submittals related to the Contractor’s quality program are specified in Section 01450, “Quality Control”.

E. Submittals required to complete the Contract closeout are specified in Section 01770, “Contract Closeout”.

F. Preparation and submission of project record documents are specified in Section 01785, “Project Record Documents”.

G. Preparation and submission of equipment and systems operation and maintenance manuals are specified in Section 01786, “Operation and Maintenance Instructions”.

1.2 SUBMITTAL CONTROL DOCUMENT

A. Submit a Submittal Control Document within 30 days after Notice to Proceed (NTP). Submittal Control Document shall be presented in a form acceptable to the Contracting Officer in both electronic and hard copy versions and shall be updated and sent to the Contracting Officer on a monthly basis noting deviations, if any. The completed Submittal Control Document shall be subject to final review and approval by the Contracting Officer. Once the Submittal Contract Document is finalized, the Contractor shall adhere to the outlined schedule.

B. Identify all submittals which are required by the Contract Documents and determine the date on which each submittal will be submitted in conformance with the schedules specified in Section 01320, “Construction Schedule and Progress Report” or Section 01321, “Construction Schedule and Progress Reports for Small Projects”.

C. Submittal Control Document shall consist of a completed submittal schedule and list of products for all items requiring the Contracting Officer’s review and approval, as follows:

1. Description of submittal (i.e. shop drawing) and of the item including name of manufacturer, trade name and model number.


3. Intended submission/resubmission date(s).

4. Order release date.

5. Lead-time to delivery/anticipated delivery date(s).

6. Highlight any items for which expedited review is requested to meet the project schedule.

D. Refer to Section 01450, “Quality Control”, for Submittal Status Log requirements.

1.3 GENERAL SUBMITTAL PROCEDURES

A. Obtain the Contracting Officer’s approval of shop drawings, product data, and other submittals before any work involving such submittal is performed. Initiate actions for procurement, fabrication, or construction only after obtaining the Contracting Officer’s approval of the relevant submittals. Materials for which samples are required shall not be used in the Work until approved in writing by the Contracting Officer. Changes in products for which drawings, product data, or samples have been submitted will not be permitted unless those changes have been accepted and approved in writing by the Contracting Officer.

B. Contractor shall be responsible for accuracy, completeness, and scheduling of submittals so as to facilitate the review and approval by the Contracting Officer.

C. Printed quantities: Submit the following minimum quantities, unless specified under applicable Sections of the Standard and Contract Specifications:
1. Drawings: One reproducible and 3 copies of each drawing.

2. Calculations: 4 copies of Contractor’s or manufacturers’ calculations, including design calculations for bridge structures.

3. Catalog Cuts: 4 originals, minimum, of manufacturers’ catalog cuts or entire catalogs.

4. Instructions: 4 copies of manufacturers’ printed installation, erection, application, and placing instructions.

5. Samples: 4 of each sample item specified in the various Specification Sections, except for color range samples and unless otherwise specified or requested.

6. One original and 3 copies of inspection reports, test reports, certificates of compliance, delivery tickets, batch tickets and bills of materials.

7. Survey Data: As specified in Section 01722, “Field Engineering - Surveying”.

8. Guarantees, Warranties, and Bonds: 1 executed original, if specified.

9. Where submittals are submitted to the Contracting Officer for information or record purposes, submit 2 copies.

10. Where permits and licenses and other such documents are obtained in the Authority's name, submit the original and 1 copy.

D. Electronic quantities (applies to all submittals): Submit the following minimum quantities. Submit greater quantities when specified.

1. All submittals shall be delivered to the Authority in an electronic format in both their native software format and in PDF format. Digital electronic files shall be provided to the Authority on CD ROM disk or DVD and each CD ROM or DVD shall:
   a. Provided in a protective cover with an exterior label.
   b. Contain an index of the CD ROM or DVD’s contents that lists each file name along with a file description.
   c. Include PDF’s of the submittal reports, files or drawings.

E. Contracting Officer will return 2 sets of submitted items including the reproducible for shop drawings to the Contractor with the following exceptions:

1. Submittals for record of the Authority will not be returned.

2. One of the 6 catalog cuts or catalogs will be returned to the Contractor after review. Submit additional copies if more than one are desired.

F. Review Period: Transmit submittals sufficiently in advance of construction requirements to permit no less than 21 days for review and appropriate response by the Contracting Officer.

1. Contractor shall be responsible for determining whether or not certain governmental entities and utilities require longer review periods. Where longer review periods are required, the Contractor shall schedule the Work accordingly, so that the progress of the Work is not adversely impacted.

G. Submittal Form: Include only 1 item per submittal, with form attached to each copy of the submittal, do not group different submittal items under one submittal form and number. Accompany submittals with a Contracting Officer approved submittal form containing the following information attached to each copy of submittal:

1. Sequential submittal number and date.

2. Contract title and number.

3. “To:” and “From”: Including the Contractor’s name, address, and telephone number.

4. Supplier’s, manufacturer's, or Subcontractor’s name, address, and telephone number.


6. Category and Type of Submittal.

7. Purpose.

8. Description.

9. Signature of Submitter.

H. Submittal Numbering:

1. Assign sequential numbers to each submittal using the related Specification Section number for the first 5 digits and a 3-digit number for each submittal, all initial
SUBMITTALS

1. Submittals will be issued as Rev. 0 (i.e. 03300-001-Rev.0, 16001-030-Rev. 0).

2. Assign revision numbers (i.e. 03300-001-Rev. 1, 03200-030-Rev. 3) to all re-submittals and cross-reference to previous submittals.

I. Provide Contractor's Certification Stamp worded exactly as shown on Figure 01330-2 herein, and stamp and sign each submittal.

J. Professional Seal Required: Submittals involving engineering expertise, such as excavation support structures, falsework for concrete, Systems design progression, load calculations and when required by the individual Specification Sections shall be sealed and signed by a professional engineer, currently registered in the State of Texas, for the discipline involved. Furnish information sufficient to completely explain the facility, product, machine, or system described and its intended manner of use. When professional certification is required by the Contract requirements, the Authority is entitled to rely upon the accuracy and completeness of such calculations and certifications.

K. Space for Contracting Officer's Disposition Stamp: Include a 4 inch square blank space, on each submittal for the Contracting Officer's disposition stamp. On drawings, provide this space in the lower right corner, just above the title block.

L. Maintain at the Worksite a complete up-to-date, organized file of all past and current submittals including an index and locating system that identifies the status of each submission. Refer to Section 01450, “Quality Control”, for Submittal Status Log requirements.

1. Quality Control Set: Maintain the returned final set of samples at the construction site in suitable condition and available for quality control comparisons by the Contracting Officer.

2. Refer to Section 01785, “Project Record Documents”, for maintenance of record and as-built documents.

M. Submittal Delivery: Ship submittals prepaid or deliver by hand directly to the Contracting Officer or elsewhere as required by the Contracting Officer.

N. Changes in Approved Submittals: Changes in approved submittals will not be permitted unless those approved submittals with changes have been resubmitted and approved, in the same manner as the original submittal.

O. Supplemental Submittals: Supplemental submittals initiated by the Contractor for consideration of corrective procedures shall contain sufficient data for review. Make supplemental submittals in the same manner as initial submittals.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. Contractor's Review:

1. Examine and check the submittal for accuracy, completeness, and compliance with the Contract before delivery to the Contracting Officer. Each submittal shall be reviewed, stamped (refer to Figure 01330-2), and signed as reviewed and approved by the Contracting Officer prior to submission. Approval represents that the Contractor has determined and verified materials, field measurements (as verified by surveying) and field construction criteria related thereto, and has checked and coordinated the information contained within such submittals with the requirements of the Work and the Contract.

a. Submittals without this stamp may be returned to the Contractor for re-submittal.

2. If the submittal is designated to be approved by another governmental agency or utility and to be sent to the Contracting Officer for information, approval by the governmental agency or utility shall take place before submission to the Contracting Officer.

3. Contractor shall coordinate each submittal with the requirements of the Work, ensuring that each submittal of one trade is compatible with other submittals of that trade and with the submittals of other trades. Ensure submittal is complete with all relevant data required for review.

4. Approval does not relieve the Contractor from responsibility for furnishing materials of proper dimensions, quantity and quality; from responsibility for errors and omissions in the samples, mock-ups, sample panels, product data and shop drawings, calculations, etc.; from responsibility for deviations from the Contract Documents, nor from responsibility for complying with the requirements of this Contract.

5. Contractor's liability to the Authority, in case of deviations in the submittals from the requirements of the Contract Documents, is not relieved by the Contracting Officer's review and approval of submittals containing deviations, unless the Contracting Officer expressly approves the deviations by issuing a Change. If the Contractor fails to describe such variations, the Contractor is not relieved of the
6. If submittals show variations from the Contract requirements due to standard shop practice or for other reasons, describe such variations on the first page of submittal. If acceptable, the Contracting Officer may approve such variations, subject to the proper adjustment in the Contract under General Provisions, paragraph entitled “CHANGES”.

7. Contractor shall be responsible for the correctness of the submittals, for shop fits and field connections, and for the results obtained by the use of such submittals.

B. Distribution of Submittals after Review: Distribute prints or copies of approved submittals, bearing the Contracting Officer's or designated approval authority's stamp and signature, to the Contractor's field office and the Contracting Officer's field office; to affected and concerned Subcontractors, Suppliers, and fabricators; and to affected and concerned members of the Contractor's workforce.

1.5 CONTRACTING OFFICER'S REVIEW

A. In addition to the requirements of General Provisions Paragraph, "SPECIFICATIONS AND DRAWINGS", the Contracting Officer's actions with regard to shop drawings, working drawings, samples, mock-ups, sample panels, miscellaneous and other submittals are as hereinafter specified.

B. Contracting Officer will review and approve or take other appropriate action upon the Contractor's submittals only for the limited purpose of avoiding impacts on any other work and properties and of checking for conformance with information given and the design concept expressed in the Contract requirements. The Contracting Officer's action will be taken as to cause no delay in the Work or in the activities of the Contractor. Review of such submittals is not conducted for the purpose of determining the accuracy and completeness of other details such as dimensions and quantities, or for substantiating instructions for installation or performance of equipment or systems, all of which remain the responsibility of the Contractor as required by the Contract. The Contracting Officer's review will not constitute approval of safety precautions or, unless specifically stated by the Contracting Officer of any construction means, methods, techniques, sequences, or procedures. The Contracting Officer's approval of a specific item does not indicate approval of an entire assembly of which the item is a component.

C. Failure of any material to pass the specified tests is sufficient cause for refusal to consider, under this Contract, further samples of the same brand, make, or source of that material. The Contracting Officer reserves the right to disapprove any material or equipment that previously has proved unsatisfactory in service.

D. Contractor's submittals will be stamped with the date of receipt and with the Contracting Officer's Review/Disposition Stamp, see Figure 01330-1. The stamp will be marked, and the stamp will be signed and dated. Contracting Officer will indicate its reviews of submittals and the action taken (approvals and non-approvals) by means of its Review/Disposition Stamp. The stamp marks will have the following meanings:

1. APPROVED: Work may proceed, provided it complies with the Contract.

2. APPROVED AS NOTED (CORRECT AND RESUBMIT): Work may proceed, provided:
   a. It complies with the Contract as well as the corrections on the submittal; and the Contractor resubmits within 15 days corrected copies of the shop drawing, working drawing, or miscellaneous submittal for final approval; and
   b. Work performed by the Contractor prior to receiving final approval will be at the Contractor's risk.

3. APPROVED AS NOTED (CONFIRM): Work may proceed provided it complies with the Contract as well as the corrections on the submittal; and the Contractor confirms in writing within 15 days to the Contracting Officer prior to the commencement of work that the submittal have been duly noted and corrected as required.

4. DISAPPROVED: Work not recognized as being able to proceed.
   a. Make corrections required by the Contracting Officer. Resubmit without delay.
   b. Handle re-submittals in the same manner as first submittals. Refer to Paragraph entitled “Submittal Numbering” under Article “General Submittal Procedures” for revision numbering.
   c. On re-submittals, direct specific attention in writing on re-submitted shop drawings, working drawings, samples, mock-ups, sample panels, or miscellaneous submittals to revisions other than the corrections of previous submissions.
5. APPROVED and APPROVED AS NOTED (CONFIRM) shall not be construed:

a. As permitting any departure from the Contract requirements;

b. As relieving the Contractor of responsibility for errors and omissions, including details, dimensions, and quantity of materials; or

c. As approving departures from details furnished by the Contracting Officer.

E. Review stamps or other approval methods of the various designated approval authorities may not be the same as those of the Authority. Contractor shall work with the various designated approval authorities and shall obtain approvals in the clearest and most straightforward manner possible.

1.6 MISCELLANEOUS DOCUMENTATION

A. Certificates of Conformance or Compliance for Materials or Products: Refer to Section 01450, “Quality Control”, for detailed requirements.

B. Certificates: When specified, submit certificates to demonstrate proof of compliance regarding qualifications of personnel, manufacturers, fabricators, and installers specified in the individual specification section. Certificates shall be signed by an official authorized to certify on behalf of the issuing organization with the name and address of the Contractor, the project name, and location.

C. Certified Test Reports: Refer to Section 01450, “Quality Control”, for detailed requirements.

D. Certified Test Reports of Previous Testing: Where specified, submit certified test reports of previous testing of like items, if approved under similar Authority contracts. Include the following:

1. Certification that materials meet or exceed specified test requirements.

2. Name and address of testing laboratory.

3. Dates of tests to which reports apply.

4. Certification that materials provided are the same as those tested.

E. Calculations: When certified calculations are specified, they shall be certified by a Professional Engineer registered in the State of Texas.

F. Survey Data: Refer to Section 01722, “Field Engineering – Surveying”.

G. Plans such as Traffic Control Plans and Demolition Plans, submit as specified in individual specifications sections.

H. Progress Photographs: Furnish progress photographs as specified in Section 01345, “Construction Photographs”.

I. Record (As-Built) Drawings and Specifications: Refer to Section 01785, “Project Record Documents”.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01330
SUBMITTALS

FIGURE NO. 01330-1
Review/Disposition Stamp

_____ APPROVED
_____ APPROVED, AS NOTED
☐ CORRECT AND RESUBMIT ☐ CONFIRM
_____ DISAPPROVED

Approval does not relieve the Contractor from responsibility for any errors or omissions in these submittals and/or shop drawings or from the responsibility for complying with the requirements of this Contract (except as otherwise provided under the provisions of the "Specifications and Drawings" clause of this Contract).

Dallas Area Rapid Transit

Date: ____________________________
By: ____________________________

FIGURE NO. 01330-2
Contractor's Certification Stamp

Contractor's Certification

"Having checked this submission, we certify that it conforms to the requirements of the Contract in all respects, except as otherwise indicated."

Company Name: ____________________________
Signature: ____________________________
Print Name: ____________________________
Title: ____________________________
Date: ____________________________
SECTION 01340
SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the general requirements and procedures for preparing and submitting Shop Drawings, Product Data, and Samples required by individual Specification Sections. Additional requirements are specified in the individual Specification Sections.

B. Refer to Section 01330, “Submittals”, for general requirements for submittals.

C. Refer to Section 01785, “Project Record Documents”, for requirements for submittal of final approved drawings and catalog cuts upon completion of the Work.

D. Certificates of Compliance: Refer to Section 01450, “Quality Control”.

1.2 DEFINITIONS

A. Shop Drawings: As defined in the General Provisions Paragraph, “SPECIFICATIONS AND DRAWINGS”, is an inclusive term and may include descriptive literature and test data. The term “Shop Drawings,” as used herein, includes fabrication, erection and installation, application, layout, and setting drawings, lists or schedules of materials and equipment, manufacturer’s standard drawings, wiring and control diagrams, all other drawings as may be required to show that the materials, equipment, and systems, and the positions thereof, comply with Contract requirements.

B. Product Data: The term “product data,” as used herein, includes manufacturer-prepared descriptive literature, catalog sheets, brochures, performance data, test data, printed diagrams, schedules, illustrations, and other information furnished by the Contractor or the various product and materials suppliers to illustrate and describe a product, material, system, or assembly for some portion of the Work.

C. Samples: The term “samples,” as used herein, are physical examples which illustrate materials, fixtures, appliances, equipment, colors, textures, finishes, and work quality, and establish the standards of quality and utility by which the Work will be judged for acceptance.

D. Working Drawings: Working drawings are Contractor prepared plans for temporary structures and facilities such as decking, temporary bulkheads, support of excavation, support of utilities, groundwater control systems, underpinning and for such other items of work as may be required for construction but which do not become an integral part of the completed Project.

1. Working drawings shall comply with the requirements for shop drawings.

2. Submit appropriate design calculations to support working drawings.

3. Working drawings and calculations shall be signed and sealed by the Contractor’s engineer who shall be a Professional Engineer licensed in the State of Texas.

E. Certificate of Compliance: Refer to Section 01450, “Quality Control”, for definition.

1.3 SUBMITTALS

A. Refer to Section 01330, “Submittals”, for submittal procedures.

1.4 SHOP DRAWINGS

A. General: Provide shop drawings complete, detailed, and dimensioned and including the following:

1. Fabrication, erection, layout, and setting drawings.

2. Complete list of materials.


4. Manufacturer's drawings.

5. Wiring and control diagrams, as applicable.

6. Drawings prepared by the Contractor for permanent structures, equipment, and systems designed by Contractor in accordance with Contract requirements.

7. Additional requirements specified in the individual Specification Sections.

B. Size of sheet: 22 inches by 34 inches or 11 inches by 17 inches as approved. Refer to Section 01330, “Submittals” for the space requirement for Contracting Officer’s Review/Disposition Stamp. The title block in the lower right hand corner shall display the following:

1. Contract number, name of project, and title of the drawing.

2. Date of drawing or revision.

3. Name of Contractor and subcontractor submitting the drawing.
4. Clear identification of contents and location of the work.
5. Title and number of Specification section.
6. Drawing Number.
7. Names of individuals who designed and checked drawings (Completed “Designed By” and “Checked By” boxes).

C. Each drawing shall include details necessary for the procurement, installation, maintenance, and repair of all components or facilities equipment provided. Change notices that are attached to drawings shall not constitute revised drawings. Each drawing shall include all changes and be upgraded to reflect the latest configuration.

1.5 LIST OF MATERIALS SOURCES

A. Refer to Section 01450, “Quality Control”, for requirement for submittal of a list of Contractor's sources of materials and equipment requiring approval, certification, or testing.

1.6 PRODUCT DATA

A. Contractor shall modify manufacturers' standard diagrams, charts, illustrations, brochures, calculations, schematics, catalog cuts, and other descriptive data to delete information which is not applicable to the Contract. Contractor shall supplement standard information with additional information applicable to this Contract, and indicate dimensions, clearances, performance characteristics, capacities, wiring and piping diagrams, and controls. Wherever applicable, clearly indicate field-measured dimensions.

B. Contractor shall modify the manufacturer’s printed installation, erection, application, and placing instructions to delete information which is not applicable to the Contract.

C. Submittals shall include the following:

1. Contract number and project name.
3. Title and number of applicable Specification Section.
4. Applicable standards, such as ASTM or Federal specification numbers.

1.7 SAMPLES

A. Contractor shall furnish to the Contracting Officer samples required by the Contract Documents.

B. Mark samples, tag, or otherwise properly identify as specified in these Specifications. Provide each tag or sticker with a clear space for the stamps of the Contractor and the Contracting Officer. Label each sample as follows:

1. Contract number and name of project.
2. Name of Contractor and subcontractor.
3. Material or equipment represented.
4. Place of origin.
5. Name of producer and brand, if any.
6. Location in project. Furnish samples of finish materials with additional markings identifying them under the schedules.

7. Sequentially number using related section numbers as described in Section 01330, “Submittals” under “Submittal Numbers”.

C. Quantities: The following specifies exceptions to the quantity of samples specified in Section 01330, “Submittals”, under the Article entitled “General Submittal Procedures”.

1. Where requested, or in case a range of color, gaining, texture, and other characteristics may be anticipated in finished products, furnish a number of samples of the specified materials to indicate the full range of such characteristics which will be present in the finished products and which will be considered one sample set. Such products delivered or erected without prior acceptance by the Contracting Officer are subject to rejection and removal or replacement.

2. Provide full sets of optional samples where the Contracting Officer's selection is required.

D. Prepare samples to match the Contracting Officer's sample where so indicated.

E. Provide samples of materials that are generally furnished in containers bearing the manufacturers' descriptive labels and printed application instructions. If these are not submitted in standard containers, supply such labels and application instructions.

F. Approval of a sample shall be only for the characteristics and use named in the submittal and approval, and shall not be construed to change or modify any Contract requirement.

G. Before submitting samples, the Contractor shall assure itself that the materials or equipment will be available in the quantities required in the Contract, as neither change nor substitution will be permitted after a sample has been approved.
unless the Contracting Officer in writing approves such change or substitution.

H. Samples of material from local sources taken for testing shall be taken by or in the presence of the Contracting Officer or approved designee. Samples taken otherwise shall not be considered for testing.

I. Approved samples not damaged in testing may be incorporated in the finished work if marked for identification and approved by the Contracting Officer. Materials incorporated in the Work shall match the approved samples.

J. Send approved samples, mock-ups, and sample panels not destroyed in testing, nor accepted as a part of the built-in work, to the Contracting Officer. Samples, mock-ups, and sample panels which fail testing or are not approved by the Contracting Officer will be disposed of, unless the Contractor requests, at the time of submittal, that they be returned to the Contractor at Contractor's expense.

K. The Contracting Officer may take for testing samples of material delivered to the site or installed in place. Failure of samples to meet Contract requirements shall annul previous approvals of the item tested.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01340
SECTION 01345
CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.1 DESCRIPTION
A. Work specified in this section includes employing a qualified photographer to take construction record photographs periodically during the course of the Work.

1.2 PHOTOGRAPHY
A. The quality of the work must meet the following intended uses:
   1. Visual survey of pre-construction conditions including historic properties.
   2. Construction progress record.
B. Views required:
   1. Vantage points will be determined by Contracting Officer who shall be notified at least 72 hours in advance of Photographer’s scheduled visit to the construction site.
   2. At successive periods of photography, take at least one photograph from the same overall view as previously.
C. Pre-construction photographs will include photographic recording of specific details on historic and other properties as directed by the Contracting Officer. Include minimum of 40 color photographs. Comply with requirements of Section 01715, “Pre-Construction Inspection”.
D. Construction progress: Each month during the Contract, take an average of 40 color photographs within the construction area as directed by the Contracting Officer.

1.3 NEGATIVES AND PRINTS
A. All negatives shall become the property of the Authority. If a digital camera is used, resolution shall be at least 1080 X 1080 dpi and, in addition to prints, the images shall be provided on a format acceptable to the Authority.
B. Type: color prints:
   1. Minimum film size: 35 millimeter or a digital camera of suitable resolution.
   2. Provide minimum of 4.1 mega pixels for digital cameras.

1.4 IDENTIFICATION
A. Include the following information on the face of each print:
   1. Orientation of view, station.
   2. Date and time of exposure.

1.5 DELIVERY AND COORDINATION:
A. Deliver two sets of 3 inch x 5 inch processed prints, filed in three ring notebooks or bound books as suitable, to the Contracting Officer within 7 days of the date of photography. If a digital camera is used, also include electronic files of photographs on CD-ROM. In addition, deliver one set of twenty 8 inch x 10 inch prints as selected by the Contracting Officer from the 3 inch x 5 inch submitted.
B. Photographer shall furnish additional prints, if required, to Contracting Officer at commercial rates applicable at the time of purchase. The Contracting Officer reserves the right to take possession of the negatives at any point during the Contract duration.
C. The Authority obtains all rights for publication.

PART 2 - PRODUCTS
Not Used.

PART 3 - EXECUTION
Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. In accordance with Section 01001, “General Requirements”.

END OF SECTION 01345
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for construction industry standards of industry associations, trade associations, societies, organizations, and regulatory agencies as they are invoked and used in these Standard Specifications.

1.2 REFERENCE STANDARDS

A. The Contract Documents contain references to various standard specifications, codes, practices, and requirements for materials, equipment, work quality, installation, inspections, and tests, which references are published and issued by the organizations, societies, and associations listed herein by abbreviation and name. Such references are hereby made a part of the Contract Documents to the extent specified in General Provisions Paragraph, “MATERIALS AND WORKMANSHIP”.

B. Whenever a referenced standard contains administrative requirements, including measurement and payment provisions, such as the standard specifications of various government entities, utility districts, and other agencies, such administrative requirements shall not apply to the Work of this Contract. References to such standards shall be applicable to the pertinent technical provisions only.

1.3 REFERENCED STANDARDS FILE

A. The Contractor shall have access to the reference standards. Referenced standards shall be made readily available, when requested, for use by the Contracting Officer and the Contractor's staff in carrying out the quality assurance and quality control programs specified in the Contract Documents, and to assure compliance with the requirements of the codes, specifications, test methods, practices, and other standards referenced in the Contract Documents.

1.4 ABBREVIATIONS

A. Wherever in the Contract Documents an organization's abbreviation or acronym is used, it shall be understood to mean the full name of the respective organization as specified in the various Specification Sections, and as follows:

1.5 REFERENCES TO STANDARDS

A. In conjunction with the requirements of General Provisions Paragraph, "MATERIALS AND WORKMANSHIP", the listings below are acceptable standards to be used by the Authority, unless specified otherwise.

B. Technical References - Interpretation of Documents:

1. With reference to codes, regulations, reference standards, and specifications, perform work conforming to the edition current as of the date of Notice to Proceed (NTP), unless otherwise specified.

2. Where reference standards and specifications conflict with local jurisdictional requirements, the more stringent standard shall govern, unless otherwise approved.

C. In this Contract, if the Contractor wishes to use standards other than those referenced, submit a comparison of the proposed standard and the referenced standards. Demonstrate in the comparison that the Authority is being given material equal to or better than that specified, at no extra cost, and certify the comparison as being accurate by an engineer licensed in Texas.

D. Reference to manufacturer's printed specifications for specified products shall mean most current edition of the Specifications as of the date of the Notice to Proceed, unless otherwise noted.

E. References are made to recognized standards by use of the acronyms listed below.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Aluminum Association</td>
</tr>
<tr>
<td>AABC</td>
<td>Associated Air Balance Council</td>
</tr>
<tr>
<td>AAMA</td>
<td>Architectural Aluminum Manufacturers Association</td>
</tr>
<tr>
<td>AAN</td>
<td>American Association of Nurserymen, Inc.</td>
</tr>
<tr>
<td>AAR</td>
<td>Association of American Railroads</td>
</tr>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway &amp; Transportation Officials</td>
</tr>
<tr>
<td>ABPA</td>
<td>Acoustical and Board Products Association</td>
</tr>
<tr>
<td>ACI</td>
<td>American Concrete Institute</td>
</tr>
<tr>
<td>ACIL</td>
<td>American Council of Independent Laboratories</td>
</tr>
<tr>
<td>ACP</td>
<td>American Concrete Pipe Association</td>
</tr>
<tr>
<td>AFBMA</td>
<td>Anti-Friction Bearing Manufacturing Association</td>
</tr>
<tr>
<td>Reference Standard</td>
<td>Description</td>
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<td>-------------------</td>
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<tr>
<td>AGA</td>
<td>American Gas Association</td>
</tr>
<tr>
<td>AHA</td>
<td>American Hardboard Association</td>
</tr>
<tr>
<td>AI</td>
<td>The Asphalt Institute</td>
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<tr>
<td>AIA</td>
<td>American Insurance Association</td>
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<tr>
<td>AISC</td>
<td>American Institute of Steel Construction, Inc.</td>
</tr>
<tr>
<td>AISI</td>
<td>American Iron and Steel Institute</td>
</tr>
<tr>
<td>AITC</td>
<td>American Institute of Timber Construction</td>
</tr>
<tr>
<td>AMCA</td>
<td>Air Moving and Conditioning Association</td>
</tr>
<tr>
<td>ANCII</td>
<td>American Standard Code for Information Exchange</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
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<tr>
<td>AOAC</td>
<td>Association of Official Analytical Chemists</td>
</tr>
<tr>
<td>APA</td>
<td>American Plywood Association</td>
</tr>
<tr>
<td>APTA</td>
<td>American Public Transit Association</td>
</tr>
<tr>
<td>AREMA</td>
<td>American Railway Engineering and Maintenance-of-Way Association</td>
</tr>
<tr>
<td>ARI</td>
<td>Air-Conditioning and Refrigeration Institute</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASNT</td>
<td>American Society for Non-Destructive Testing, Inc.</td>
</tr>
<tr>
<td>ASTM</td>
<td>ASTM International (Formerly known as American Society for Testing and Materials)</td>
</tr>
<tr>
<td>AWI</td>
<td>Architectural Woodwork Institute</td>
</tr>
<tr>
<td>AWPA</td>
<td>American Wood-Preservers’ Association</td>
</tr>
<tr>
<td>AWPB</td>
<td>American Wood Preservers Bureau</td>
</tr>
<tr>
<td>AWPI</td>
<td>American Wood Preservers Institute</td>
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<tr>
<td>AWS</td>
<td>American Welding Society, Inc.</td>
</tr>
<tr>
<td>AWWA</td>
<td>American Water Works Association, Inc.</td>
</tr>
<tr>
<td>BHMA</td>
<td>Builders Hardware Manufacturers Association</td>
</tr>
<tr>
<td>BIA</td>
<td>Brick Institute of America</td>
</tr>
<tr>
<td>CDA</td>
<td>Copper Development Association, Inc.</td>
</tr>
<tr>
<td>COE</td>
<td>Corps of Engineers (U. S. Dept. of the Army)</td>
</tr>
<tr>
<td>CPMB</td>
<td>Concrete Plant Manufacturers Bureau</td>
</tr>
<tr>
<td>CRSI</td>
<td>Concrete Reinforcing Steel Institute</td>
</tr>
<tr>
<td>CTI</td>
<td>Ceramic Tile Institute</td>
</tr>
<tr>
<td>CS</td>
<td>Commercial Standard of NBS (U. S. Dept. of Commerce)</td>
</tr>
<tr>
<td>DHI</td>
<td>Door &amp; Hardware Institute</td>
</tr>
<tr>
<td>EIA</td>
<td>Electronic Industry Association</td>
</tr>
<tr>
<td>ETL</td>
<td>Electrical Testing Laboratories</td>
</tr>
<tr>
<td>FED</td>
<td>Federal Construction Regulations</td>
</tr>
<tr>
<td>FGMA</td>
<td>Flat Glass Marketing Association</td>
</tr>
<tr>
<td>FM</td>
<td>Factory Mutual Engineering Corp.</td>
</tr>
<tr>
<td>FRA</td>
<td>Federal Railroad Administration</td>
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<tr>
<td>FS</td>
<td>Federal Specifications</td>
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<tr>
<td>FTA</td>
<td>Federal Transit Administration</td>
</tr>
<tr>
<td>GA</td>
<td>Gypsum Association</td>
</tr>
<tr>
<td>GRI</td>
<td>Geosynthetic Research Institute</td>
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<tr>
<td>HI</td>
<td>Hydronics Institute</td>
</tr>
<tr>
<td>HMI</td>
<td>Hoists Manufacturers Institute</td>
</tr>
<tr>
<td>HPMA</td>
<td>Hardwood Plywood Manufacturers Association</td>
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<tr>
<td>IBC</td>
<td>International Building Code</td>
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<tr>
<td>IECC</td>
<td>International Energy Conservation Code</td>
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<tr>
<td>IPC</td>
<td>International Plumbing Code</td>
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<tr>
<td>ICEA</td>
<td>Insulated Cable Engineering Association</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronic Engineers</td>
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<tr>
<td>IES</td>
<td>Illuminating Engineer Society (Same as IEEE)</td>
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<tr>
<td>ISA</td>
<td>Instrument Society of America</td>
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<tr>
<td>ITE</td>
<td>Institute of Transportation Engineers</td>
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<tr>
<td>Reference Standards</td>
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<tr>
<td>LIA</td>
<td>Lead Industries Association</td>
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<td>LPI</td>
<td>Lightning Protection Institute</td>
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<td>MIA</td>
<td>Marble Institute of America</td>
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<tr>
<td>MLSFA</td>
<td>Metal Lath/Steel Framing Association</td>
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<td>MSS</td>
<td>Manufacturers Standardization Society of Valve and Fittings</td>
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<td>NAAMM</td>
<td>The National Association of Architectural Metal Manufacturers</td>
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<td>NACE</td>
<td>National Association of Corrosion Engineers</td>
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<tr>
<td>NBGQA</td>
<td>National Building Granite Quarries Association, Inc.</td>
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<tr>
<td>NBS</td>
<td>National Bureau of Standards (U. S. Dept. of Commerce)</td>
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<tr>
<td>NCMA</td>
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<td>NCPWB</td>
<td>National Certified Pipe Welding Bureau</td>
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<td>Prestressed Concrete Institute</td>
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<td>Railway Tie Association</td>
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<td>TMUTCD</td>
<td>Texas Manual of Uniform Traffic Control Devices</td>
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<td>Texas National Resource Conservation Commission (TCEQ as of January 2003.)</td>
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PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. Costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01423
**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. This Section includes specifications for the Contractor's quality assurance of erection and installation of materials, equipment, systems, and assemblies, and construction of the Work, as indicated. The requirements specified herein are in addition to quality assurance requirements specified in other Sections of these Specifications.

B. Contractor's Quality Control Plan, quality control requirements, and Authority's Testing and Inspection are specified in Section 01450, "Quality Control".

C. Field samples and site mockups are specified in Section 01454, “Field Samples and Mockups”.

**1.2 WORK QUALITY**

A. Shop and field work shall be performed by mechanics, craft-persons, artisans, and workers skilled and experienced in the fabrication and installation of the work involved. The Work shall be performed in accordance with the Contract Documents and the reviewed and accepted submittals including Shop Drawings.

B. Work shall be erected and installed plumb, level, square, and true, or true to indicated angle, and in proper alignment and relationship to the work of other trades. Finished Work shall be free from defects and damage.

**1.3 MANUFACTURERS' SPECIFICATIONS AND INSTRUCTIONS**

A. Unless otherwise indicated or specified, manufactured materials, products, processes, equipment, systems, assemblies, and the like shall be erected, installed, or applied in accordance with the manufacturers' instructions, directions, or specifications. Said erection, installation, or application shall be in accordance with printed instructions furnished by the manufacturer of the material or equipment concerned for use under conditions similar to those at the jobsite.

B. Any deviation from the manufacturers' printed installation instructions and recommendations shall be explained and acknowledged as correct and appropriate for the circumstances, in writing, by the particular manufacturer and will require the Contracting Officer's approval prior to implementation. The Contractor will be held responsible for installations contrary to the respective manufacturers' instructions and recommendations.

**1.4 SPECIALIST APPLICATOR/INSTALLER**

A. Materials, equipment, systems, and assemblies requiring special knowledge and skill for the application or installation of such materials, equipment, systems, or assemblies shall be applied or installed by the specified product manufacturer or its authorized representative or by a skilled and experienced Subcontractor qualified and specializing in the application or installation of the specified product.

B. When required in the applicable specifications section, utilize an installation Subcontractor approved by the product manufacturer, as applicable.

**1.5 MANUFACTURERS' FIELD SERVICES**

A. When required in the applicable specifications section, the Contractor shall have the manufacturer of a product, system, or assembly provide appropriate field or job service at no additional cost to the Authority. The Contractor shall have the manufacturer inspect and approve in writing the application or installation work. If required under the applicable specifications section, the manufacturer's representative shall also provide test reports attesting that completed work is in compliance with specified requirements.

B. The Contractor shall make all necessary arrangements with the manufacturer of the products to be installed to provide onsite consultation and inspection services to assure the correct application or installation of the product, system, or assembly.

C. The manufacturer's authorized representative shall be present at the time any phase of this work is started.

D. The Contractor shall have the manufacturer's authorized representative inspect and approve all surfaces over which, or upon which, the manufacturer's product will be applied or installed.

E. The Contractor shall have the manufacturer's representative make periodic visits to the site as the work progresses as necessary for consultation and for expediting the work in the most practical manner.
1.6 FINISHED TOLERANCES

A. Except as specified otherwise in the individual Specifications Sections, finished tolerances shall conform with the following requirements:

1. Walls: Finished wall surfaces shall be plumb and shall have a maximum variation of 1/8 inch in 8 feet when a straightedge is laid on the surface in any direction, and no measurable variation in any 2-foot direction.

2. Ceilings: Finished ceiling surfaces shall present true, level, and plane surfaces, with a maximum variation of 1/8 inch in 8 feet when a straightedge and water level are laid on the surface in any direction, and no measurable variation in any 2-foot direction.

3. Concrete Floors: Tolerances for concrete floors and pavement are specified in Section 03350, “Concrete Finishing”.

4. Finished Floors: Where floor drains occur, slope finished floor to the drain at the rate of 1/8 inch per foot or as otherwise indicated on the Contract Drawings.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. Costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01430
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications which describe the responsibilities for quality control of the Work including inspections and control testing by the Contractor. This Section describes the use of certificates of compliance. This Section also includes the Authority’s inspections and quality assurance testing.

B. Requirements specified herein are in accordance with and augment General Provisions Paragraph, “INSPECTION OF CONSTRUCTION”. The Contracting Officer and other Authority personnel will identify discrepancies and nonconformances through daily oversight and the Authority’s quality audits subject to the limitations stated in General Provisions Paragraph, ”INSPECTION OF CONSTRUCTION”.

C. Wherever it is required to obtain the approval of the Authority’s Quality Manager, it shall be understood that this approval shall be obtained through the Contracting Officer.


1.2 REFERENCED STANDARDS

A. ASTM International (Formerly American Society for Testing and Materials) (ASTM)

1. ASTM E329 Standard Specifications for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

B. DART Quality Program Plan (QPP)


1. ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories

E. American National Standard Institute (ANSI):


F. Institute of Electrical and Electronic Engineers (IEEE):


3. IEEE Standard 1012 – Software Verification and Validation

1.3 DEFINITIONS

A. Acceptance Tests: Test conducted for the purpose of accepting or approving products and performance of the Contractor.

B. Certificate of Compliance: Written statement, signed by a qualified party, attesting that the items or services are in accordance with specified requirements and accompanied by additional information to substantiate the statement.

C. Certificate of Conformance: Written statement, signed by a qualified party, certifying that the items or services are in accordance with specified requirements.

D. Certified Test Reports: Reports of tests signed by a qualified professional attesting that tests were performed in accordance with the test method specified, that the test results reported are accurate, and that items tested meet or fail to meet the stated minimum requirements. Include calibration certificates, if required.

E. Certified Inspection Reports: Reports signed by Contractor’s Quality Control Representative (CQCR) attesting that the items inspected meet the specification requirements other than any exceptions included in the report.

F. Contractor Quality Control (CQC) Plan (System): Written description of proposed actions to control and assure quality. CQC Plan defines applicable quality policy for the project and applicable quality procedures. CQC Plan shall be established and maintained by the Contractor to ensure compliance with the Contract requirements. No portion of the Plan may be delegated to subcontractors or suppliers without the prior approval of the Contracting Officer.

G. Corrective Action: Corrective action identifies action to be taken to correct immediate defects and correct the root cause to prevent recurring defects. Corrective action addresses systemic or chronic problems. Corrective action includes procedures for investigating the cause of nonconforming work.
QUALITY CONTROL

and procedures for analysis to detect and eliminate potential causes of nonconforming work.

H. Factory Tests: Tests made on various products and component parts prior to shipment to the job site.

I. Procedure: Procedures as used in regard to Contractor’s quality control shall be understood to mean written instructions for implementing various components of quality control and its management. Procedures shall identify what is to be done, who will do it, and how, where, and when it will be done.

J. Quality Control Inspection: Examining, testing, analysis, or sampling products or workmanship, including when appropriate, raw materials, components, and intermediate assemblies, to determine conformance to stated requirements.

K. Manufacturer’s Certificate of Conformance or Compliance: Certificate signed by an authorized manufacturer’s official attesting that the material or equipment delivered meets the Specification requirements.

L. Nonconformance: A discrepancy in characteristic, documentation, or procedure which affects form, fit, or function and renders the quality of an item unacceptable or indeterminate in regard to meeting relevant project requirements. Examples of nonconformance include physical defects, test failures, incorrect or inadequate documentation, or deviation from prescribed processing, inspection, or test procedures.

M. Person: Associations, companies, corporations, educational institutions, firms, government agencies at the federal, state, and local level, partnerships, and societies, as well as divisions thereof, and individuals.

N. Product: A type or a category of manufactured goods, constructions, installations, and natural and processed materials or those associated services whose characterization, classification, or functional performance determination is specified by standards.

O. Quality Control Tests: Tests conducted and performed by the Contractor for the purpose of monitoring the quality of products and performance of the Contractor.

P. Testing Laboratory: Any person, as defined above, whose functions include testing, analyzing, or inspecting “products”, as defined above, or evaluating the designs or specifications of such “products” according to the requirements of applicable standards. Refer to Article 1.8 entitled “Qualifications of Contractor’s Testing Facility” herein for additional information.

Q. Consensus Standard: An artifact or process that is a de-facto standard by written agreement between the Contractor and the Authority where the de-facto standard’s content and applicability are established prior to application and is applied in place of a recognized U.S. national standard.

R. Measurement Standard: A metrology reference standard device used to calibrate measuring and test equipment (M&TE) or other measurement standards where a measurement standard has a National Institute of Standards and Technology (NIST) traceability property such that comparative measurement or value of a measurement standard is related to stated references through an unbroken chain of comparisons all having stated uncertainties.

S. Quality Assurance Audit: An examination of the Authority approved Contractor CQC Plan implementation to determine its compliance with and conformance to the CQC Plan and related documents.

T. Software Quality: A software product’s totality of features and characteristics that determine its ability to satisfy stated needs and conformity to these Specifications. The degree to which a software system meets these Specifications.

U. Software Quality Assurance (SQA): SQA is the planned and systematic set of activities that ensure that software process including all activities involved in design, coding, testing, and maintaining products including software, associated data, documentation and all supporting and reporting paperwork conform to requirements, standards, and procedures.

V. Software System Test: The activity of testing integrated hardware and software systems to verify whether the system meets the customer requirements and these technical Specifications.

W. Software Validation: Formal process to confirm that software components are consistent with customer requirements, functional requirements, and these Specifications.

1.4 CONTRACTOR’S QUALITY CONTROL (CQC) PLAN (SYSTEM) - OVERVIEW

A. Contractor shall develop; establish; implement; maintain; and evaluate an organization and system herein called the Contractor’s CQC Plan to perform inspections and tests to ensure compliance with the contract.

B. CQC Plan shall include inspections and tests for items of work of subcontractors and/or suppliers. CQC Plan shall also include retesting in the event of failure. CQC Plan shall include activities associated with quality required in the technical provisions of the Specifications for design and construction operations, including onsite and offsite fabrication and materials.

C. CQC Plan shall include procedures to verify that the quality related activities are performed. Procedures shall include assignment of CQC responsibilities to qualified, Authority-approved individuals and
organizations and documentation of the quality related activities to provide evidence and accountability of quality in the finished project.

D. Obtain DART Quality approval of the CQC Plan prior to its implementation. No revisions to the Plan will be allowed without prior approval of DART Quality. Unless specifically authorized by the Authority, in writing, construction shall not be started until the CQC Plan (including all personnel associated with implementation of the plan) is approved.

1. Contractor may identify quality control measures for early activities in its CQC Plan. With the Contracting Officer’s written approval, Contractor may proceed with early activities prior to approval of overall CQC Plan.

E. DART Quality will monitor the implementation of the CQC Plan.

F. CQC Plan shall address the ANSI/ISO/ASQ Q9001, Section 4.0, and “Quality Management System – Requirements” and shall be implemented to satisfy the needs of the Contractor and the Authority. It shall address: the objectives for service quality; the approach to be adopted in pursuit of quality objectives; and define the role of the quality personnel responsible for implementing the quality policy. CQC plan shall be based on the technical and manufacturing aspects of the engineering design and materials supplied on this job and the inspection and quality procedures for the design, construction, and installation of materials for this project.

1.5 CQC PLAN ELEMENTS

A. The CQC Plan shall address the requirements listed herein.

B. Management Responsibilities:

1. Quality Policy: Contractor shall define and document, in writing, a quality policy that will communicate, implement, and maintain that policy at all levels of its organization as well as to subcontractors and/or suppliers. This commitment to quality shall belong to the highest level of the Contractor’s management. The CQC Plan shall define quality goals and objectives.

2. Contractor’s Quality Control Representative (CQCR): Contractor’s management shall designate a full-time Contractor’s Quality Control Representative who shall have defined authority and responsibilities for ensuring that the quality policy is implemented and maintained. A letter appointing the CQCR, signed by an officer of the firm, shall outline the CQCR’s duties, responsibilities and authority, to include the authority to direct removal and replacement of any nonconforming work. CQCR shall report to that officer of the firm who signed the letter appointing the CQCR. Refer to the Article 1.7 entitled “Qualifications of Contractor’s Quality Control Staff” for CQCR qualifications.

a. Contractor’s Alternate – Quality Control Representative (ACQCR): A letter appointing the ACQCR, signed by an officer of the firm, delegating the CQCR’s responsibilities including the authority to direct removal and replacement of nonconforming work. ACQCR will report to the officer of the firm who signed the letter. Refer to the Article 1.7 entitled “Qualifications of Contractor’s Quality Control Staff” for Alternate CQCR qualifications.

3. Obtain DART Quality approval of the CQC Plan prior to beginning construction activities. The Contract time will not be extended for failure to propose an acceptable CQCR.

4. Upon receipt of a written notification that any Contractor’s Quality Control Personnel (CQCP) failed to perform that individual’s duties, a replacement shall be provided immediately. Contractor will not be entitled to any additional time or compensation if replacement of personnel is required.

5. Personnel List and Organization Chart: The Plan shall further identify all persons responsible for CQC functions and shall define in writing their responsibilities, authority, and interrelationship of these people. Personnel involved with quality related activities shall be identified and their interrelationship with management defined. This relationship shall be shown on an organization chart. Personnel responsible for ensuring quality shall be independent of those directly related for the work being performed and shall have no other work activities assigned except for ensuring quality. Personnel shall be free from the pressure of costs, construction scheduling, and production, and shall have the necessary independent authority to perform their roles effectively.

C. Documented Quality Plan (System): CQC Plan shall establish and maintain a documented quality plan to ensure that project quality objectives are met. No part of the Contractor’s quality control responsibilities may be delegated to subcontractors or suppliers without prior approval of the Contracting Officer. Quality requirements shall be extended to both the subcontractors and suppliers. This shall be done by written procedures and instructions for activities affecting quality in any required design, procurement, manufacturing, and construction as applicable for the work being
performed. Procedures and instructions shall be developed for control of process including inspection; testing; nondestructive examination; maintenance of calibration equipment; disposition of nonconforming work (processes and/or products); corrective action; maintenance of quality records; reviewing shop drawings, samples, certificates, or other submittals; quality audits; and training.

D. Design Control: Contractor shall, when required by the Contract, establish and maintain procedures to control and verify design efforts required for the Project to ensure that design criteria and regulations are satisfied (e.g. MSE Walls). The design control shall ensure that the design requirements are understood; plan the design interfaces and design verification activities; execute the design verification activities; and control any design changes through the project completion.

E. Document Control: Contractor shall establish and maintain procedures for control of project documents and data. The document control process shall ensure that relevant documents are current and available to users who require them.

1. Contractor shall establish and maintain procedures for quality records. These procedures shall identify which records will be kept, responsibility for production and collection, and responsibility for indexing, filing, storage, protection, maintenance, and disposition of quality records. Contractor shall certify that these records are current and accurate within each payment application. Failure to maintain these records shall be grounds for the Contracting Officer to withhold progress payments for the General Requirements.

2. CQC records shall be prepared, maintained, and filed in accordance with approved procedures. These records shall be kept in approved fire-safe storage cabinets that preclude damage, loss, or deterioration.

F. Purchasing: Contractor shall establish and maintain procedures for ensuring that services (subcontractors and/or manufacturers) or products comply with the Contract requirements. Contractor shall ensure that suppliers have a quality program appropriate to the work being performed and in accordance to the Contract requirements. The procedure shall ensure that purchasing documents are reviewed and approved by a designated authority prior to release.

G. Product Identification and Traceability: Contractor shall establish and maintain procedures for identifying and controlling items of production (batch, materials, parts, and components) to prevent the use of incorrect or defective items and to ensure that only correct and acceptable items are used or installed in accordance with the Contract requirements.

H. Process Control: Contractor shall establish and maintain procedures for identifying and planning the production and installation processes that shall be performed under controlled conditions as identified by the Contract requirements. Special processes, the result of which cannot be verified by subsequent inspection and testing of the product, shall be specifically identified and be continuously monitored. This shall also apply to both subcontractors and suppliers.

I. Inspection and Testing: Contractor shall establish and maintain procedures for inspection and testing. Inspection and testing shall be planned and executed as necessary to verify quality. Procedures shall be specified, referenced to Contractor’s schedule activity code numbers, implemented, and the results documented for receiving incoming products, for work in progress, and for final inspection and testing. For schedule activity code provisions, refer to Section 01320, “Construction Schedule and Progress Reports”, or Section 01321, “Construction Schedule and Progress Reports for Small Projects”, as applicable.

1. List of Tests: Contractor shall prepare a list of all tests the Contractor is to perform to meet the requirements of the Contract. The list shall give the test name, specification paragraph, if applicable, containing the test requirements, and the personnel and laboratory responsible for each type of test. The tests listed shall include, in addition to those specified, those required by manufacturers and those required at successive stages of the performance of the Work occurring in the field to document progressive quality of the Work such as compaction tests in various lifts in backfilling of a trench or the subgrade prior to construction of a facility.

   a. Identify those tests that require the presence of the CQC Officer during testing and the CQC Officer’s signed approval.

   b. Preliminary Schedule: Include a preliminary schedule for coordination with the Authority’s testing laboratory. Indicate tests to be performed by Contractor testing laboratory. Include at least 24 hours for on-site work and 48 hours for off-site work advance written notice to the Contracting Officer for collection of test samples, conducting field tests, and similar work by the Authority’s testing laboratory. Include at least 30 days advance written notice to the Contracting Officer for off-site inspections.

2. Establish procedures for inspection of incoming materials. Notify Contracting Officer of delivery and location of incoming material to facilitate Contracting Officer’s
3. Utilize 3-phase inspection process including preparatory, initial, and follow-up inspections.

   a. Preparatory Inspection and Meeting: Perform preparatory inspection before beginning any work on any definable segment of work. Participants will include a representative of the Contracting Officer and shall also include a member of the Contractor’s quality control staff assigned to inspect the work, the supervisor in charge of the work, and individuals responsible for accomplishing the work. Included in a preparatory meeting shall be a review of the Contract requirements, the review of approved shop drawings and other submittal data, the review of safety requirements, assurance that required control testing is to be provided, a physical examination to ensure that materials and equipment conform to approved shop drawings and submittal data, and assurance that required preliminary work has been completed. Participants shall discuss what will constitute a representative segment for purposes of the initial inspection of the particular item of work and shall come to a mutual agreement. If no mutual agreement is be made, the Contracting Officer will define the representative segment. This inspection and meeting shall be conducted and documented by the CQCR.

   b. Perform an initial inspection as soon as a representative segment of the particular item of work is accomplished. Include in the initial inspection the following: performance of scheduled tests, examination of the quality of workmanship, a review for omissions or dimensional errors, and approval or rejection of the initial segment of the Work.

   c. Perform follow-up inspections daily and include continued testing and examinations to ensure continued compliance with the Contract requirements. Follow-up inspections shall be identified with schedule activity code numbers in accordance with Section 01320, “Construction Schedule and Progress Reports”, or Section 01321, “Construction Schedule and Progress Reports for Small Projects”, as applicable.

4. Contractor shall provide Quality Control and Acceptance tests as necessary to ensure compliance with the contract. Where testing laboratory services are supplemented by the Authority, as described in the Article 1.11 entitled “Authority’s Testing and Inspection” herein, the Contractor shall coordinate and cooperate with the testing laboratory and furnish samples of materials, design mix, equipment, tools, storage, and assistance as requested.

5. Laboratory Reports: Notwithstanding that the testing laboratory provided by the Authority may be used, the Contractor shall provide reports which cite the Contract requirements, the test or analysis procedures used, the actual test results, and include a statement that the item tested or analyzed conforms or fails to conform to the Specification requirements. Stamp each report conspicuously on the cover sheet in large red letters a minimum of 1/2-inch high “CONFORMS” or “DOES NOT CONFORM” to the Specification requirements as the case may be. Submit test reports signed by a representative of the testing laboratory authorized to sign certified test reports.

   a. Reports in Regard to Nonconformance: Include with submittal of the signed original, an additional copy of tests which indicated nonconformance to the Contract requirements and the CQCR’s written explanation of proposed or actual corrective measures taken. When corrective measures are taken, submit a copy of the laboratory report indicating conformance, along with a copy of the nonconforming report and a description of the corrective action taken.

6. Tabulation of Tests: Maintain an up-to-date tabulation of all tests performed in connection with the Contract, including conforming, nonconforming and repeated test results. Tabulation of tests shall include logs of each test performed, such as mandreling of conduits and ground resistance tests. Each nonconforming test listed shall indicate the status of the nonconforming test result, either by indicating the resolving test laboratory report number, or by indicating that it still remains nonconforming or open. Certify the current tabulation(s) as complete, and deliver directly to the Contracting Officer with each payment application. Failure to maintain and provide these records shall be grounds for the Contracting Officer to withhold progress payments for General Requirements and to require the replacement of the CQCR responsible for these records. Prior to final closeout,
provide a tabulation of tests performed in connection with the Contract, including conforming, nonconforming, and repeated test results. Certify the tabulation(s) as complete, and deliver directly to the Contracting Officer.

7. Inspection and Test Record Numbering: Reports shall be numbered sequentially and traceable to Contract number, location, lot, part, and retest number, as applicable. Coordinate with the requirements specified under “List of Tests” and “Tabulation of Tests” herein.

8. Ensure inspections, measurements, and tests are performed under appropriate environmental conditions.

J. Inspection, Measuring, and Testing Equipment: Contractor shall establish and maintain procedures for identifying, controlling, calibrating, and maintaining inspection, measuring, and test equipment required to carry out inspection and testing. Procedures shall include maintenance of calibration records. Such equipment shall be identified, controlled, calibrated, and maintained in conformance to requirements established by ISO/IEC 17025. Such equipment shall be recalibrated in a timely manner. This shall apply to the Contractor and Contractor’s subcontractors and suppliers.

1. In maintaining calibration, use reference standards traceable to the U. S. National Institute of Standards and Technology, if no documented standard exists in ISO/IEC 17025.

2. Establish calibration intervals based on equipment manufacturer’s recommendations, usage, accuracy, and maintenance history. In every case, calibration shall be performed at intervals not to exceed 1 year.

3. Mark equipment indicating calibration status of the piece of equipment. Mark in a manner readily visible to operator but will not hamper operation of equipment.

4. Perform calibrations under appropriate environmental conditions.

5. Re-inspect and re-test equipment proven to be out of calibration.

6. Establish handling procedures for equipment to prevent damage that may cause inaccurate readings. Safe guard equipment to prevent adjustments that would invalidate calibration settings.

K. Nonconformances and Deficiencies: Contractor shall establish and maintain procedures for correcting and controlling nonconforming work and for the investigation of the cause of nonconforming work and the corrective action needed to prevent a recurrence. Such procedures shall ensure that work is not inadvertently used or installed. Such procedures shall include analysis to detect and eliminate potential causes of nonconforming work.

1. Nonconforming materials, equipment, components, parts, and work shall be identified, documented, and (when possible) segregated.

2. Procedures shall also include disposition of items noted as Deficiency during inspections. Procedures shall take into account the following requirements in regard to Deficiencies.

a. Deficiencies shall be transferred to a Nonconformance Report when the deficiency is not corrected and is sufficiently severe to cause the product or service or associated product or service not to satisfy its intended usage requirements.

b. Deficiencies shall be transferred to a Nonconformance Report when the deficiency will affect follow-on work.

c. Deficiencies shall be transferred to a Nonconformance Report when required by the Contracting Officer.

3. Nonconforming items will be classified as follows by the Contracting Officer:

a. Reject: The item is unsuitable for its intended use and economically or physically incapable of being repaired/rewilded.

b. Rework: The item can be brought into conformance with original requirements.

c. Repair: The item can be made acceptable for its intended purpose; however, it may not meet all requirements.

d. Use-As-Is: The item will be used without modifications; and will meet engineering functional requirements for performance and fit.

4. Upon rework or repair of those items classified as “Rework” and “Repair”, obtain the Contracting Officer’s inspection and approval prior to Nonconformance Report closure.

5. When and as determined by the Contracting Officer, a credit will be made to the Authority from those funds due to the Contractor for those for items dispositioned as “Repair” or
1.6 SUBMITTALS

A. Submit 3 copies of the following through the Contracting Officer to DART Quality for review and approval:

1. CQC Plan as defined herein within 14 days after the Notice to Proceed. Include samples of Contractor’s proposed Quality Control forms.

2. Qualifications of proposed Contractor’s Quality Control Personnel.

3. Matrix correlating the CQC Plan with the list at the end of the Section, Attachment 01450-1, showing the CQC Plan’s compliance with the requirements of this Section.

4. Qualifications of proposed Contractor’s testing laboratory including the name, address, and certification of compliance with ASTM E329, together with the scope of proposed services. Should the Contractor desire to use more than 1 firm for quality control testing, the required information shall be submitted for each such proposed firm.

B. Refer to Article 1.10 entitled “Specific Duties of the Contractor’s Quality Control Representative” for CQCR’s submittals.

1.7 QUALIFICATIONS OF CONTRACTOR’S QUALITY CONTROL STAFF

A. Contractor shall provide a full time CQCR supplemented by sufficient CQCP necessary to be physically at the job site at all times during work progress to provide continuous inspection of the work. For example, if the Contractor is performing work at separate locations or during more than 1 shift, an inspector shall be present at each location and during each shift to ensure that the work being performed meets the requirements specified by the Contract. The initial listing of staff in no way relieves the Contractor of meeting quality control requirements of the contract.

B. Qualification requirements for CQCP listed herein are minimum qualifications. Only individuals with qualifications, which meet the referenced standards, as applicable, shall be proposed. Each individual’s qualifications shall be detailed to show actual related experience in performing similar duties and responsibilities. If any proposed individual fails to meet the standard qualifications, that individual shall be withdrawn from consideration immediately.

C. CQCR shall have a minimum of 8 years verifiable construction experience in the type of construction prevalent for the contract being bid and who has developed the specialized knowledge, skills, and abilities to effectively perform the duties and responsibilities specified herein. Experience shall include 4 years managing a quality assurance/quality control program similar to the program specified herein. CQCR shall be a part of the Contractor’s staff, or an approved consultant working for the Contractor (not part of the staff of a subcontractor performing the work).

M. Training: Contractor shall establish and maintain procedures for training and documenting of personnel to perform any activity or job they are not qualified to perform. Only personnel qualified through experience and/or training shall perform activities that will affect quality for this Contract.

N. Include as part of the CQC Plan, a listing of outside organizations such as testing laboratories, architects, and consulting engineers to be employed by the Contractor. The listing shall include a description of the services these firms will provide, and list the authorized representatives for each organization that can sign reports. The services of such outside organizations may include the documentation of inspection activities of materials received; reports verifying the quantities of materials received; reports verifying factory tests completed on the materials received, as applicable; any physical damage of materials received; and other documentation of materials as required.

1. Include documentation of the accreditation of Contractor’s Testing Facilities. Refer to Article 1.8 entitled “Qualifications of Contractor’s Testing Facilities” herein.

O. Sources of Material: Include as part of the CQC Plan, a list of Contractor’s sources of materials to be incorporated in the work, which require approval, certification, or testing. This list shall make clear for which materials the Contractor proposes to use manufacturer’s certificates of conformance of compliance. Refer to Submittal Status Log specified herein for related requirements.

P. Sample forms are available for the Contractor’s use in the DART Quality Program Plan (QPP).

1.6 SUBMITTALS

A. Submit 3 copies of the following through the Contracting Officer to DART Quality for review and approval:

1. CQC Plan as defined herein within 14 days after the Notice to Proceed. Include samples of Contractor’s proposed Quality Control forms.

a. Sources of Materials: Submit list within 30 days of Notice to Proceed.
D. ACQCR shall have a minimum of 5 years of verifiable construction experience of a similar type of construction. Designate the ACQCR to act for the CQC (and notify the Contracting Officer) only when the CQC is officially absent from the job site. ACQCR cannot act for the CQC for a period longer than 10 consecutive calendar days in a 6-month period, without prior written approval from the Contracting Officer and DART Quality.

E. Inspectors shall have 4 years of verifiable experience on construction projects fulfilling similar type of positions.

1.8 QUALIFICATIONS OF CONTRACTOR’S TESTING FACILITIES

A. Contractor shall provide its own testing facilities or engage the services of an independent testing laboratory to perform tests and inspections at the Contractor’s cost.

B. Contractor-provided testing laboratory, whether such laboratory is part of the Contractor’s organization or an independent testing laboratory, shall hold and maintain an active accreditation in accordance with ASTM E329 throughout the course of the Contract.

C. Contractor shall notify the Contracting Officer if the accreditation status of its testing laboratory changes during the course of the Contract.

1.9 QUALITY CONTROL REQUIREMENTS

A. In accordance with the General Provisions Paragraph, "INSPECTION OF CONSTRUCTION", inspect and test the Work and maintain records of the inspections and tests. Obtain approvals, except those required for field installations, field applications, and field tests, before delivery of materials and equipment to the Project Site.

1. Factory Tests: Arrange for factory tests when required under the Contract and as required by the Contracting Officer.

2. Factory Inspection: Arrange for factory inspection when required under the Contract or as required by the Contracting Officer.

3. Field Inspections and Tests by the Contractor: Furnish equipment, instruments, qualified personnel, and facilities necessary to inspect the Work and perform all tests required to be conducted by the Contractor.

4. Field Inspections and Tests by the Authority: Provide assistance, equipment, instruments, qualified personnel, and facilities as required by the Contracting Officer for field inspections and tests conducted by the Authority in accordance with the following Article, “Authority’s Testing and Inspection” and the General Provisions Paragraph, “INSPECTION OF CONSTRUCTION”.

5. Samples: Prepare samples and submit in accordance with Section 01330, "Submittals".

B. Mutual Understanding Meeting: Within 5 calendar days after the CQC Plan is approved, but before construction operations are started, meet with the Contracting Officer and discuss the quality control requirements. The purpose of the meeting is to develop a mutual understanding relative to details of the system, including forms to be used for recording the quality control operations, inspections, tests, approvals, certifications, administration of the system, coordination with jurisdictional authorities, and Authority surveillance. As a minimum attendees shall include DART Quality, CQC, and representatives of affected entities. Refer to Section 01312, “Project Meetings”, for related requirements.

C. Contracting Officer shall have access to all work areas during the Contractor’s working time and shall have the right to monitor the methods and procedures used for construction related activities and/or CQC testing.

D. Certified Test Reports: Before delivery of materials and equipment, submit for approval certified copies of the test reports required in the technical sections. Accompany test reports with certificates from the manufacturer certifying that the material and equipment proposed to be supplied is of the same type, quality, manufacturer, and make as that tested.

E. Manufacturer’s Certificates of Conformance or Compliance: Contractor may use certificates of compliance for certain materials and products in lieu of the specified sampling and testing procedures. However, the Authority reserves the right to refuse to permit the use of certain materials on the basis of a certificate of compliance. The Authority will accept manufacturer’s certification furnished by the Contractor on items of materials and equipment incorporated into the Work only when this method will assure full compliance with the provisions of the Contract.

1. Certificates shall be originals; preprinted certifications will not be acceptable unless approved by the Contracting Officer. Certificates shall be signed by an authorized representative of the producer or manufacturer and shall state that the material complies with Contract requirements and the name and address of the Contractor, project name, and location.

2. Submit certificates with each lot of material delivered on the day the materials are delivered to the site. The lot certified shall be clearly identified by the certificate.
3. The certificate shall identify the materials or equipment being certified and give the information specified for submittals in Section 01330, “Submittals”. The certificate shall also identify the referenced standard as applicable, the name and address of the organization performing the tests, the date of the tests, and the quantity of material shipped. Certificates for a material shall state the date(s) of shipment or delivery to which the certificates apply.

4. Certificate of compliance shall be accompanied by a certified copy of test results or shall state that such test results are on file with the producer or manufacturer and shall be furnished to the Authority on request.

5. Materials used on the basis of a certificate of compliance may be sampled and tested by the Contracting Officer at any time. The fact that material is used on the basis of a certificate of compliance shall not relieve the Contractor of its responsibility for incorporating material in the Work which conforms to the requirements of the Contract, and any such material not conforming to such requirements will be subject to rejection, whether in place or not.

F. If Contractor fails to take Corrective Action in response to Corrective Action Reports, the Authority may terminate the right to proceed with the work or the separate part of the work in accordance with the General Provisions Article entitled “Default” or may remove the CQCR.

G. Refer to Section 01722, “Field Engineering - Surveying”, for requirements to provide surveying for both layout and for the subsequent verification that the work constructed complies with the dimensions and locations as shown.

1.10 SPECIFIC DUTIES OF THE CONTRACTOR’S QUALITY CONTROL REPRESENTATIVE

A. CQCR shall perform duties listed herein.

B. Meetings: Refer to Section 01312, “Project Meetings,” for the CQCR responsibilities in regard to Contractor’s Quality Control (CQC) meetings.


D. Prepare daily CQC reports identifying prime and subcontractor personnel and equipment on the site, idle equipment and personnel, material deliveries, weather conditions, work accomplished, inspections and tests conducted, results of inspection and tests, nature of defects found, causes for rejection, and corrective actions taken. Work shall be identified with schedule activity code numbers in accordance with Section 01320, “Construction Schedule and Progress Reports”, or Section 01321, “Construction Schedule and Progress Reports for Small Projects”, as applicable. Nonconforming tests and other nonconformances shall be noted on the daily CQC report. Daily CQC report shall note any questionable work identified by the Contracting Officer or other Authority representatives (called a Deficiency Notice). Daily CQC reports shall include the following certification: “On behalf of the Contractor, I certify that this report is complete and correct, and materials and equipment used and work performed during this reporting period are in compliance with the Contract Documents, to the best of my knowledge, except as noted above”. This certification shall be signed on behalf of the Contractor by the authorized CQCR.

E. CQCR shall submit the following for Contracting Officer’s review and use:

1. Test reports, certifications and other testing and inspection documentation. Deliver signed original to the Contracting Officer within 7 days. Refer to specific requirements in Article 1.5 entitled “CQC Plan Elements”, under Paragraph “Laboratory Reports”.

a. Deliver a copy of preliminary field inspection and testing reports to the Contracting Officer on the day of inspection and testing. Copy shall be either a photocopy of the handwritten report or a printout if report is prepared electronically in the field.

b. Reports, including preliminary reports, shall identify inspections as preparatory, initial, or follow-up.

2. Daily CQC reports. Submit by 9 am the following working day.

3. Updated copy of Tabulation of Tests performed with each payment application. Also submit as part of closeout submittals; refer to Section 01770, “Contract Closeout”.

4. Daily “next day activity list.” Submit at the end of normal work hours for the work to be performed the next day.

5. Written responses to Nonconformance Reports, Corrective Action Reports, and Audit Finding Reports. Submit within the time frame designated in the applicable report.
6. Original copies of reports dealing with nonconforming work.

F. Responsibilities in Regard to Submittals:

1. Verify that submittals required by the various sections of the Specifications have been certified by the Contractor as specified in Section 01330, “Submittals”, and that submittal quality control procedures have been followed in accordance with the CQC Plan.

2. Maintain at the Worksite an up-to-date Submittal Status Log showing the status of submittals required by the Contract. A sample format of an acceptable log is available on request. While the use of this sample format is not required, any other format shall contain the same information as shown on the sample. Submittal Status Log shall be based upon and be consistent with the Submittal Control Document specified in Section 01330, “Submittals”. Failure to update and maintain this log accurately shall be grounds for the Contracting Officer to withhold progress payments from the lump sum for “General Requirements”.

G. Next Day Activity List: Provide a daily “next day activity list” identifying work to be performed for the next day. This shall include a list of tests and inspections that will be required to ensure that the work complies with the requirements of the inspections. List shall identify inspections as preparatory, initial, or follow-up. List shall identify tests and corrective work to be performed in regard to Deficiencies and Nonconformance Reports.

H. Prepare a written response to any Nonconformance Reports (NCR), Corrective Action Reports (CAR), and Audit Finding Reports (AFR) that the Contracting Officer identifies to the Contractor.

I. Refer to Section 01220, “Measurement and Payment”, for CQC responsibilities in regard to certifications of as-buils.

1.11 AUTHORITY’S TESTING AND INSPECTION

A. The Authority will employ and pay for services of a certified testing laboratory that complies with ASTM E329 for the purpose of periodically performing quality assurance (QA) tests (solely for the Authority’s purposes) of the worksite, plant, or laboratory to verify performance of the Contractor. Performance of quality assurance tests by the Authority does not relieve the Contractor of the responsibility of performing quality control inspection and testing to verify that work meets Contract requirements.

1. Copies of non-conforming tests will be furnished to the Contractor to ensure that nonconforming work is corrected.

2. Contractor shall bring nonconforming work into conformance and perform retest of failed test. When the nonconforming work has been successfully tested by the Contractor’s testing laboratory, the Contractor shall then notify the Authority regarding when the Authority’s testing laboratory can perform retest. The testing laboratory that performed the failed test will perform the retests.

B. Repeat Quality Assurance Tests and Inspection by the Authority: In the event of a quality assurance test or inspection performed by the Authority fails, the Contractor shall be responsible for payment of cost for repeat quality assurance tests and inspections after each correction made to non-conforming materials and workmanship until tests and inspections by the QA testing laboratory or inspections of the Authority have certified that the materials, equipment, and workmanship conform to the contract requirements.

C. Coordination:

1. Under the general direction of the Contracting Officer, the Contractor shall cooperate and coordinate with the Authority’s testing laboratory to perform the tests specified by the Contract or required by the Contracting Officer to verify that the Contractor quality control measures and/or performance are adequate to provide a product which conforms to the contract requirements.

2. Refer to coordination and preliminary scheduling requirements specified in Article 1.5 entitled “CQC Plan Elements” under Paragraph “Preliminary Schedule” herein. To avoid delays to the progress of the Work, the Contractor shall submit written notice to the Contracting Officer at least 24 hours in advance for on-site work and 30 days in advance for off-site work of the time Authority-furnished testing laboratory field services are required. Contractor shall coordinate with the Contracting Officer in obtaining the required field services. Contractor shall provide assistance as necessary and as directed by the Contracting Officer to enable the Authority-furnished testing laboratory to perform the tests as specified.

1.12 AUTHORITY’S QUALITY AUDITS

A. The Authority may perform quality audits of the Contractor’s, subcontractor’s, and supplier’s quality records and performance. Contractor shall ensure that quality control records and places of work are open and available to the Authority for inspection during normal working hours.

1. Contractor shall reply to any findings resulting from such audit within 10 working days. Reply shall describe what caused any
deficiencies, what corrective actions are being taken, who is responsible for corrective actions, and when corrective actions will be complete.

B. Contractor, subcontractor, or supplier being audited shall be available during the audit as required by the audit team.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, "General Requirements".

END OF SECTION 01450
ATTACHMENT 01450-1

CQC Plan Element and its Paragraph No. within Section 01450

1.5B.1. Quality Policy

1.5B.2. Contractor’s Quality Control Representative (CQCR): Include letter appointing the CQCR

1.5B.5. Personnel List and Organization Chart: Define responsibilities, authority, and interrelationships

1.5C. Documented Quality Plan (System)

1.5D. Design Control

1.5E. Document Control

1.5F. Purchasing

1.5G. Product Identification and Traceability

1.5H. Process Control

1.5I. Inspection and Testing

1.5I.1. List of Tests

1.5I.1.b. Preliminary Schedule

1.5I.2. Procedures for inspection of incoming materials

1.5I.5. Laboratory Reports

1.5I.5.a. Reports in Regard to Nonconformance

1.5I.6. Tabulation of Tests

1.5I.7. Inspection and Test Record Numbering System

1.5J. Inspection, Measuring, and Testing Equipment

1.5K. Nonconformances and Deficiencies

1.5L. Quality Audits

1.5M. Training

1.5N. Listing of outside organizations

1.5N.1. Contractor’s Testing Facilities: Include documentation of accreditation

1.5O. Sources of Materials

END OF ATTACHMENT
PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section includes specifications for providing the field samples and site mock-ups required by the individual Specifications Sections.

1.2 FIELD SAMPLES AND MOCK-UPS
A. Field samples and mock-ups shall be prepared at the jobsite by the Contractor as specified in the various Sections of these Specifications. Affected finish work shall not be started until the Contracting Officer has approved the field samples and jobsite mock-ups in writing.
B. Preserve approved field samples and mock-ups for comparison purposes until the affected work is completed and accepted by the Authority. Finished work shall match the approved field samples and mock-ups.

1.3 SUBMITTALS
A. Comply with the requirements for samples, and process a transmittal form for each mock-up or sample panel as a record of the activity.
B. Transmit documentation regarding the mock-up and sample panels as specified for submittals.
C. Refer to Section 01330, “Submittals”, for Contracting Officer’s review and approval.

1.4 QUALITY ASSURANCE
A. NONCONFORMANCE
1. Completed work which does not exactly match approved field samples and mock-ups will be rejected, and shall be replaced with work which does exactly match the approved field samples and mock-ups at the Contractor's expense.
2. If the Contractor elects to start work before the Contracting Officer has approved the related field samples or mock-ups, the Contractor does so at the risk of having the work rejected by the Contracting Officer without compensation.

PART 2 - PRODUCTS

2.1 MATERIALS
A. As specified in individual Specification Sections.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Construct and prepare field samples and jobsite mock-ups at designated locations at the jobsite or on the structure as directed by the Contracting Officer.

1. Take photographs of the existing conditions and substrates before beginning the field sample or mock-up.
2. Contractor shall have product manufacturers inspect and approve field samples and mock-ups, which involve their materials, for proper application or installation of the materials in accordance with their respective instructions and recommendations for the conditions or circumstances involved in the application or installation.
3. Contractor shall make arrangements with the respective product manufacturers to provide job or field service as specified in Section 01430, “Contractor’s Quality Assurance”.

B. Construct or prepare as many additional samples and mock-ups as may be required, as determined by the Contracting Officer, until desired features, textures, finishes, and colors are obtained. Approved samples and mock-ups shall serve as the standards of quality for the various affected units of work.

3.2 REMOVAL AFTER COMPLETION
A. Field samples and mock-ups not incorporated into the final construction shall be removed from the jobsite and structures after completion and acceptance of the affected work or as otherwise specified or directed by the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. Separate measurement or payment will not be made for work required under this Section. Costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01454
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work specified in this section includes furnishing, installing, maintaining, and subsequently removing temporary facilities (including services required during construction) for use by the Contractor and the representatives of the Authority.

B. This section supplements the General Provisions Paragraph, "OPERATIONS AND STORAGE AREAS".

C. Work in or near Airports: Equipment type and heights, sign heights, hours of construction and sequencing, illumination and signal work in or near airports shall meet clearance and lighting restrictions of the Federal Aviation Administration and airport owner.

1.2 REFERENCED STANDARDS

A. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1926 – Safety and Health Regulations for Construction

2. 29 CFR 1926 Subpart F – Fire Protection and Prevention

B. Texas Department of Transportation (TxDOT)

1. Texas Manual on Uniform Traffic Control Devices (TMUTCD)

1.3 SUBMITTALS

A. Submit working drawings showing the proposed locations and sizes of staging area, offices, storage areas, shops, security fencing, stationary equipment, and similar facilities.

B. Submit floor plans for proposed Contracting Officer’s facility.

C. Submit a plan for temporary fire protection system.

1.4 UTILITY CONNECTIONS

A. Provide and maintain temporary utility services necessary for the performance of the Work and related operations. At the completion of the Work, remove all temporary utility services and terminate connections to main service lines in a manner acceptable to the utility companies.

B. Erect temporary partitions and closures as necessary to protect the existing facilities and the users/occupants thereof from weather and environmental nuisances caused by construction, such as dust and noise.

C. Provide temporary drainage from the Worksite in accordance with Section 01562, "Soil Erosion and Sediment Control".

1.6 TEMPORARY ELECTRICAL SERVICE

A. Provide power distribution throughout the Worksite as required to facilitate construction operations. Provide terminations for each voltage supply complete with circuit breakers, disconnect switches and other electrical devices as required to protect the power supply system.

B. Furnish, install, and maintain a temporary lighting system as required by the building trades installed in accordance with OSHA requirement to satisfy the requirements of safety and security. Provide temporary lighting system to afford illumination in all areas.

C. Install all temporary equipment and wiring for power and lighting in accordance with the applicable provisions of the governing codes.

D. Provide power centers for electrically operated and controlled construction facilities including tools, equipment, testing equipment, and interior construction lighting and ventilation equipment. Locate power centers so that power is available at any desired point with no more than 100 feet extension. Provide, as a minimum, one power center per floor level.

E. When the permanent electrical power and lighting systems are in operating condition, they may be used for temporary power and lighting for construction purposes if approved by the Contracting Officer in writing.

F. At the completion of the construction work or at such time after the Contractor makes use of the permanent electrical installation, remove temporary electrical service equipment, including restoration of existing source of supply.

1.7 TEMPORARY WATER SERVICE

A. Furnish water necessary for construction purposes and assure continuous water supply to the site for emergencies. Make temporary connections to existing mains; provide temporary meter; and make all arrangements and pay charges for the temporary water service including cost of installation and maintenance thereof.
B. When the permanent water supply and distribution system has been installed, it may be used as a source of water for construction purposes if approved by the Contracting Officer in writing.

C. At the completion of the construction work or at such time after the Contractor makes use of the permanent water installation, remove temporary water service equipment and piping, including restoration of the existing source of supply.

1.8 TEMPORARY ENCLOSURES

A. Provide temporary weather tight enclosures and temporary heating as required during construction to make the building weather tight and to protect the work from damage, and as necessary to ensure suitable working conditions for the construction operations.

B. Provide adequate ventilation (as required) to prevent accumulation of excess moisture in the building.

C. When the permanent air circulation system, or suitable portion thereof, is in operating condition, it may be used without refrigeration or chilling if approved in writing by the Contracting Officer. If such use is approved:

1. Provide temporary filters to adequately filter air being distributed through the duct work to the supply outlets; place disposable filters in front of all exhaust duct work.

2. Thoroughly clean the interior of the air handling units and ductwork prior to requesting acceptance of the Work.

D. Upon conclusion of the temporary period, remove all temporary piping, or other equipment and pay all costs in connection with repairing any damage caused by the installation or removal of temporary equipment; and thoroughly clean and recondition those parts of permanent heating and air circulation systems used for temporary service and install new filters.

E. Build where shown and as required by property owner, closed, dustproof, weatherproof, and burglar-proof temporary partitions and closures of suitable materials to isolate the Site from remainder of the structure. Comply with local building code requirements.

F. Provide emergency exits, with appropriate hardware.

G. Provide temporary protection against dust and damage.

H. Remove temporary protective installations upon completion of work and restore area.

1.9 TEMPORARY CONSTRUCTION OPENINGS

A. Provide openings in slabs, walls and partitions where required for moving in large pieces of equipment of all types. Close and restore all openings and finish them after the equipment is in place. Structural modification, if required, shall be performed in accordance with Section 01731, “Cutting and Patching”.

1.10 FIRE PROTECTION

A. Submit a plan for a temporary fire protection system for use during the term of the Contract, which is subject to approval by the Contracting Officer. This plan includes provisions for fire protection systems and equipment as required by OSHA 29 CFR 1926 Subpart F.

B. Store gasoline and other flammable liquids in Underwriters' Laboratories listed safety containers in conformance with the recommendations of the National Fire Protection Association (NFPA). Do not allow such storage, within buildings located on the site. Refer to Section 01560, “Environmental Protection”, for related requirements.

C. Take adequate precautions against fire throughout all operations. Keep flammable material to an absolute minimum and properly handle and store. Do not permit fires in any part of the Work. Do not store flammable/combustible materials within 50 feet of stored flammable liquids.

D. Perform construction work, including cutting and welding and protection during construction, in accordance with the published standards of the Factory Mutual Association and the National Fire Protection Association. Provide a sufficient number of Authority-approved non-freeze portable fire extinguishers distributed about the project.

E. At the earliest possible date, complete and make operable, the permanent standpipe system, as applicable, and incorporate into temporary fire protection system. At that time, furnish sufficient hose to provide adequate coverage as determined by the local Fire Department.

F. Make arrangements for periodic inspection by local fire protection authorities and insurance underwriters' inspection personnel; cooperate with and aid authorities and promptly carry out their recommendations.

1.11 MATERIALS HOIST AND OTHER EQUIPMENT

A. Provide material hoists (as required) for normal use by all trades and employ skilled operators. Provide all necessary guards, signals, and safety devices required for safe operations. Provide suitable runways from the hoists to each level where work is being done. The safe load capacity shall be shown on each hoist and a label showing safe operating procedures.
B. Furnish and maintain temporary ramps, scaffolds, and chutes; and other construction plants and equipment as required, for proper execution of the Work under the Contract.

C. For the construction and operation of the material hoist and other construction aids, conform to all applicable Federal, State, and Local safety codes and regulations.

1.12 CONTRACTOR’S FACILITY

A. In accordance with the General Provisions Paragraph, "OPERATIONS AND STORAGE AREAS", submit working drawings showing the proposed locations and sizes of staging area, offices, storage areas, shops, security fencing, stationary equipment, and similar facilities.

B. Contractor’s plant and equipment:

1. Submit a plan of the proposed plant layout for approval within 20 calendar days after receipt of NTP (Notice to Proceed). Do all necessary construction in connection therewith in a manner satisfactory to the Contracting Officer.

2. Provide and maintain sufficient construction plants and equipment at points where work is in progress to adequately meet demands of the Work and with ample margin for emergencies or overload. Provide plants and equipment of adequate size, capacity, and numbers, to the satisfaction of the Contracting Officer, to permit a rate of progress which will ensure completion of Work within the time specified in the Contract. The Contracting Officer has the right to order testing of all plants and equipment, and to reject or condemn any plant, apparatus, or staging which, in his opinion, is unsafe, improper, or inadequate. Whether the Contracting Officer exercises this authority or not, the Contractor is not relieved of his responsibility for the safe, proper, and lawful construction, maintenance, and use of such plant, apparatus, or staging. Rework condemned plants or equipment to an acceptable condition or remove from site and replace within 5 days from the date of instruction of the Contracting Officer.

3. The location of stationary equipment and the location of miscellaneous mobile equipment are subject to approval of the Contracting Officer.

C. Security: It is the responsibility of the Contractor to provide and maintain security of his facilities, utilities, plant, and equipment and the work during the entire contract period.

1.13 CONTRACTOR’S STAGING AREAS

A. Refer to Section 01010, “Summary of the Work”, for provisions regarding Contractor’s Staging Areas.

1.14 CONTRACTING OFFICER’S FACILITY

A. Provide, maintain, and service office facilities for the use of the Contracting Officer and staff in administrating the Contract (herein called “office”). The office shall be installed, ready for operation, within 20 days of Contractor receiving the Notice-to-Proceed. Obtain approval of the location of the office from the Contracting Officer. Unless directed otherwise, maintain office on location through completion of the Contract and for 30 calendar days after final completion after which remove office which shall become the Contractor’s property.

B. Permits and Inspections: Arrange for and comply with all necessary local permits and inspections including any incidental costs.

C. The office shall be secured and security shall be provided and maintained by the Contractor during the entire Contract period.

D. The office including entrance, toilet facilities, and parking shall be accessible by disabled individuals and shall comply with Americans with Disabilities Act (ADA) requirements.

E. The office shall have water service; electrical service; heating, ventilation and air conditioning (HVAC); and telephone service.

1. The telephone service shall consist of six telephones with five voice lines and one facsimile (fax) line. The T1 Line service will be provided by DART from the Contracting Officer’s facility to DART’s 1401 Pacific location.

F. During the entire Contract period, maintain the office, including janitor service on a daily basis, and supply consumables such as toilet paper, soap, paper towels, paper cups, light bulbs, etc., for the equipment provided.

G. Provide all-weather paved access to the office and an all-weather parking area with space for 15 vehicles adjacent to the office.

H. The office shall include separate toilet facilities for men and women. The toilet facilities shall be outfitted with water closet, lavatory, utility cabinets, hot and cold water supply, mirror, soap dispenser, paper towel holder, adequate light, HVAC, and a lockable door.

I. The offices and exterior doors shall all be keyed and lockable.

J. Floors shall be covered with flooring material such as resilient tile or sheet linoleum or wall-to-wall...
carpet. Floors shall withstand a load of 125 psf. Wall surfaces shall be neatly painted.

K. The level of lighting to be provided in the office shall be at least to the levels noted in the following:

1. Desktop: 100 footcandles.
2. Toilet Facilities: 60 watt incandescent fixture.

L. Wall receptacles: 120 Volt 2-ampere duplex receptacles, located at ten foot intervals around the perimeter of the office.

M. Computer Network Capability:

1. The computer network server room size shall be a minimum of 6 foot by 6 foot with a keyed and lockable heavy-duty door (opening outward). Keys shall be submitted to the Contracting Officer for delivery to DART Project Management IS Coordinator. The room shall have one wall covered with plywood (5/8 inch minimum). If one wall is an exterior wall that one shall be used (windows covered). The wood shall completely cover the wall with access holes created for switches and plugs. Provide the server room with its own HVAC vent and return and furnish with one utility table (30 inches by 60 inches, 30 inches high). Provide network relay rack (19 inches by 72 inches) for network computer equipment.

2. The Contracting Officer’s Facilities shall be cabled with Category level 5 cabling originating from the computer network server room and going to each desk location as well as a location for the network printer. Each individual cable end shall be terminated with an RJ-45 jack box using the EIA 568B wiring scheme and the computer network server room shall terminate cables to a 24 port category 5 patch panel. The data patch panel shall be wall mounted using a hinged stand off bracket and shall use the EIA 568B wiring scheme. Cable runs shall be routed underneath the floor up to the specified station. Prior to installation, a detailed layout diagram will be provided by the DART Proj/Mgt. IS Coordinator. Connections shall be tested and verified.

N. Office Square Footage and Layout:

1. Provide a minimum 2100 square foot office consisting of 5 lockable offices, 1 secretary and reception space, an open office work area (with 60 feet of low partitions arranged as directed) for inspectors, and 1 meeting room. Office shall also include computer network server room and toilet rooms as specified herein.

2. The meeting room shall be large enough to accommodate up to 18 people at any one time. The meeting room shall be furnished with a meeting table that can accommodate 18 persons, 18 side chairs, one white board (mounted) and 1 tack board.

3. The office shall have 2 coat closets; 1 coat closet equipped with rods, 10 plastic hangers, and 1 floor broom with dust pan.

O. Furnishings and Equipment: Furniture and equipment shall be new and as approved by the Contracting Officer. In addition to furniture and equipment specified elsewhere under this Article “Contracting Officer’s Facility”, furnish and equipment the office facilities follows:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First aid kit, industrial-type</td>
</tr>
<tr>
<td>-</td>
<td>Fire extinguishers, quantity as required</td>
</tr>
<tr>
<td>5</td>
<td>Desks, 24 inches by 60 inches, six lockable drawers</td>
</tr>
<tr>
<td>5</td>
<td>Utility tables (30 inches by 60 inches by 30 inches high)</td>
</tr>
<tr>
<td>6</td>
<td>Swivel chairs on casters with adjustable height tilt seat and arm rests</td>
</tr>
<tr>
<td>12</td>
<td>Side chairs (in addition to meeting room chairs)</td>
</tr>
<tr>
<td>9</td>
<td>Waste baskets</td>
</tr>
<tr>
<td>1</td>
<td>Secretarial chair and desk</td>
</tr>
<tr>
<td>1</td>
<td>Drafting table, slant top, 36 inches by 72 inches minimum size, equipped with swivel type lamp and stool on casters.</td>
</tr>
<tr>
<td>5</td>
<td>File cabinets, four-drawer lockable;</td>
</tr>
<tr>
<td>5</td>
<td>File cabinets, four-drawer lockable fireproof</td>
</tr>
<tr>
<td>5</td>
<td>Bookcases, three-shelf (34 inches wide by 12-1/2 inches deep)</td>
</tr>
<tr>
<td>2</td>
<td>Plan storage racks, rolling-type (six sticks each)</td>
</tr>
<tr>
<td>2</td>
<td>Storage cabinet (36 inches by 18 inches by 6 feet) with lock</td>
</tr>
<tr>
<td>2</td>
<td>Plan tables, 3 foot by 6 foot</td>
</tr>
<tr>
<td>-</td>
<td>40 feet of overhead shelving, arranged as directed</td>
</tr>
<tr>
<td>1</td>
<td>Refrigerator, 16 cubic foot minimum size</td>
</tr>
<tr>
<td>1</td>
<td>Microwave oven</td>
</tr>
<tr>
<td>1</td>
<td>Electric sanitary water cooler</td>
</tr>
<tr>
<td>1</td>
<td>Electric wall clock (9 inch minimum diameter)</td>
</tr>
<tr>
<td>3</td>
<td>Electric printing calculators</td>
</tr>
</tbody>
</table>
P. Provide the following equipment complete with supplies including toner and paper and maintenance for the duration of Contract. Refer to the Contract Specifications for additional criteria for this equipment.

1. Fax machine with dedicated phone line.
2. Auto feed copy machine with scanning capabilities.

1.15 SANITARY

A. Sanitary Provisions: Provide toilet facilities for men and women available at all times. Locate portable facilities, insofar as practicable, secluded from public view. Keep toilet facilities clean and sanitary and in compliance with regulations of jurisdictional agencies.

1.16 ACCESS TO ADJACENT PROPERTY

A. Conduct construction operations in such a manner as to cause as little inconvenience as possible to owners of property affected by such operations. Refer to Section 01570, “Maintenance and Control of Traffic”, for access requirements.

B. Refer to Section 01010, “Summary of the Work”, for Contractor’s use of private property requirements.

1.17 ACCESS TO FIRE HYDRANTS AND FIRE ALARM BOXES

A. Whenever the Work is being carried on, give free access to each fire hydrant, fire extinguishers, fire alarm box and standpipe; when required, extend hydrants by suitable tubes or piping to an accessible point as approved and to the satisfaction of the jurisdictional fire department. Do not pile obstructions at any time or place within 15 feet of any fire hydrant or fire alarm box and, where materials are placed in the vicinity of a fire hydrant or fire alarm box and to such height as to prevent same from being readily seen, indicate the position of such hydrants or fire alarm boxes by suitable signs and lights, both day and night.

B. Safeguard, maintain, and protect the wires, cables, ducts, manholes, posts and poles, signals, and alarm boxes of others and DART. Do not cause interruption to the fire department fire alarm service, and in case of accident, promptly notify the fire department. Do not disturb fire department wire, cable, duct, manhole, post or pole, signal or fire alarm box except in the presence of a representative of the local fire department. In case such wire, cable, duct, manhole, post or pole, signal, or fire alarm box is disturbed, restore immediately to its original condition, and notify the Contracting Officer.

1.18 PROTECTIVE DEVICES

A. General:

1. Wherever necessary, shown or specified, erect and maintain signs, fences, barricades, and pedestrian bridges and provide watchmen and flagmen for the protection of or for performance of other contractors, maintaining public travel, the Worksite, adjoining property and adjoining public places.

2. Take positive measures to prevent entry into the site of the Work and storage areas by children, animals, and unauthorized adults and vehicles.

3. Provide protective devices in accordance with codes and regulations of jurisdictional agencies.

B. Fences:

1. In addition to the fencing indicated on the Drawings, furnish and construct approved wooden or metal fencing within the construction area to fence off pedestrian sidewalks, streets, and parking areas from operating areas as required for public safety and security of the site and as required by the Contracting Officer. Locate fencing for pedestrian sidewalks as shown on the Contractor’s Working drawings or as directed by the Contracting Officer.

2. Construct temporary fences of sound materials, neat in appearance and painted with two coats of approved exterior paint of approved color. Unless otherwise shown, provide fences 6 feet high consisting of a stud framework with a covering of tightly fitted plywood sheets. Provide the type of fence, whether fixed or movable, as shown on the Contractor’s Working drawings. Construct and maintain fences accessible to the public, so they are smooth, safe and do not splinter or catch clothing.

3. Immediately prior to completion of the Contract, restore site to original condition and repaint fencing shown to remain in place.

C. Barricades:

1. During the prosecution of the work, barricade or close excavations and openings in floors, walls, and other parts of the structures and excavations while such openings are not in regular use. Provide traffic area barricades to comply with the TMUTCD.
2. Barricade or close such openings before final acceptance of the Work.

3. Provide barricades substantial in character, neat in appearance, constructed of approved materials, and of approved size and arrangement.

4. Anchor barricades to the ground on all sides of excavations.

5. Provide flashing yellow lights and maintain on barricades at maximum intervals of 25 feet.

D. Pedestrian bridges: Construct bridges for pedestrians of suitable materials in accordance with local requirements, provide with handrails or with sides tightly boarded in accordance with such requirements and construct a minimum width of 6 feet or such greater minimum width as will accommodate the normal traffic flow at the particular location. Submit as part of Traffic Control Plans under Section 01570, "Maintenance and Control of Traffic", working drawings for required bridges.

1.19 PROTECTION OF PROPERTY

A. Requirements hereinafter specified are in addition to General Provisions Paragraph, "PROTECTION OF EXISTING SITE CONDITIONS".

B. Existing surfaces and facilities including building structures immediately outside the Contractor's Worksite:

1. Take positive action to protect existing surfaces and facilities from damage resulting from construction operations unless modifications to the surfaces or facilities are required as a part of the Contract.

2. Protect existing vegetation, including existing turf, not designated to be removed. Refer to Section 01532, "Tree and Shrub Protection and Care", for protection of trees and shrubs.

3. Where modifications to existing facilities or surfaces are required, provide such modifications in accordance with the applicable requirements of Section 01731, "Cutting and Patching".

4. Protect paving, landscaping, and utility facilities from damage. In regard to utility facilities, refer to Section 02760, "Maintenance, Support and Restoration of Existing Utility Facilities," for detailed requirements.

5. Protect finished surfaces, including jambs and soffits of openings used as passageways through which materials are handled, against possible damage.

6. Provide and maintain adequate protection for adjacent structures. When required by law, or for the safety of the Work, shore, brace, underpin, or otherwise protect those portions of adjacent structures which may be affected by the Work. Refer to Section 02150, "Underpinning, Support, and Restoration of Structures".

C. New Work:

1. Ensure finished surfaces of items are clean and not marred upon acceptance of the Work. Refinish all surfaces that have been damaged.

2. Do not permit traffic or material storage on roof surfaces. Where some activity must take place on the roof in order to perform the Work, provide and maintain adequate protection of the roof surfaces.

3. Provide and maintain protection against weather so as to preserve work, materials, equipment, apparatus, and fixtures free from injury or damage.

4. Do not load or permit any part of a structure to be so loaded as to either create an unsafe condition or affect its structural integrity.

5. Do not use items of equipment that are intended to form a part of the completed work as construction equipment without specific approval from the Contracting Officer in each instance.

D. Restoration and Repair of Damages:

1. Restore facilities which are removed during construction, which are to remain in place, to their pre-construction conditions.

2. Repair damage to surfaces or facilities which are to remain in place, as required by the Contracting Officer. Make repairs resulting in conditions equal in quality and strength to the previous conditions. Make repaired surfaces identical in color and texture to the adjacent existing materials, except that where materials cannot be matched, refinish the affected area and surrounding area to give a uniform appearance acceptable to the Contracting Officer and the owner of the damaged facility.
E. Salvaged Materials and Equipment:
   1. Maintain property control records for materials and equipment designated to be salvaged.
   2. Store and protect salvaged materials and equipment from damage. Replace salvaged materials and equipment which are broken or damaged as the result of Contractor's negligence during salvage operations, during storage, or when the Contractor is transporting salvaged items.
   3. Refer to Section 02072, “Removal and Restoration of Miscellaneous Existing Structures”, for detailed requirements regarding salvage of miscellaneous facilities.

1.20 MAINTENANCE OF WORK DURING CONSTRUCTION
   A. Contractor shall maintain the Work during construction and suspensions of work, if any, until the issuance of certificate of final completion for the entire contract. This maintenance shall include continuous and effective work performance as required, with adequate equipment and labor as well as security forces to the end that all parts of the Work be kept in safe and satisfactory condition at all times.
   B. Particular attention shall be paid to weather action and drainage both permanent and temporary at all times. Contractor shall use reasonable precautionary measures to avoid damage or loss that might result from accumulations and concentrations of drainage water and material carried by such water and such drainage shall be diverted or removed when necessary to protect the Work and the work area. Coordinate with the requirements of Sections 01560, “Environmental Protection”, and 01562, “Soil Erosion and Sediment Control.”
   C. Electrical and mechanical equipment shall be protected against weather, duly attended to, and maintained in satisfactory condition, including after testing, until the final acceptance of the entire Work. Maintenance shall include grease, oil, cleaning, and periodic operation, as appropriate. Contractor shall repair or replace at no cost to the Authority any work that is damaged or deteriorated due to Contractor's failure to comply with this Article.

PART 2 - PRODUCTS
   Not Used

PART 3 - EXECUTION
   Not Used.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the following:

1. Organization and mobilization of the Contractor's forces;

2. Transporting construction plant and equipment to the jobsite and setting up of same;

3. Transporting various tools, materials, and equipment to the jobsite; and

4. Erection of temporary buildings and facilities as required for field offices, staging, storage, and construction operations. Refer to Section 01500, "Temporary Facilities and Services", and Section 01580, "Project Signs" for specific requirements, as applicable.

B. Mobilization shall include mobilization of all construction equipment, materials, supplies, appurtenances, facilities, and the like, staffed and ready for commencing and prosecuting the Work; and the subsequent demobilization and removal from the jobsite of said equipment, appurtenances, facilities, and the like upon completion of the Work.

C. Mobilization shall also include assembly and delivery to the jobsite of plant, equipment, tools, materials, and supplies necessary for the prosecution of work which are not intended to be incorporated in the Work; the clearing of and preparation of the Contractor's work area; the complete assembly, in working order, of equipment necessary to perform the required work; personnel services preparatory to commencing actual work; obtaining permits as required under General Provisions Paragraph, "PERMITS AND RESPONSIBILITIES," and all other preparatory work required to permit commencement of the actual work on construction items for which payment is provided under the Contract.

1.2 SUBMITTALS

A. Refer to Section 01330, "Submittals", for submittal requirements and procedures.

B. Submit a plan of the proposed layout of the construction site, including fences, roads, parking, buildings, staging, and storage areas, within 20 days after the effective date of the Notice to Proceed.

1.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery to the jobsite of construction tools, equipment, plant, temporary buildings, materials, and supplies shall be accomplished in conformance with local governing ordinances and regulations.

1.4 TOOLS AND SUPPLIES

A. Provide construction tools, equipment, materials, and supplies of the types and quantities necessary to facilitate the timely execution of the Work.

B. Provide personnel, products, construction materials, equipment, tools, and supplies at the jobsite at the time they are scheduled to be installed or utilized.

1.5 PLANT LOCATION

A. Locate plant, or plants, appropriately close to the portion of the Work for which it will be used.

1.6 DEMOBILIZATION

A. Upon completion of the Work, remove construction tools, apparatus, equipment mobile units and buildings, unused materials and supplies, plant, and personnel from the jobsite.

B. Restore areas utilized for mobilization to their original, natural state or, when called for in the Contract Documents, complete such areas indicated.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Payment for mobilization will be made on a lump sum basis wherein no measurement will be made.

B. Payment for mobilization will be made in the following manner:

1. Payment for mobilization will be made in four equal portions:

   a. The first 75 percent will be paid in the first 3 progress payments, provided the Contracting Officer is satisfied the Contractor is making a
reasonable effort to mobilize for construction in a timely manner.

b. The last 25 percent will be paid when the Contractor has demobilized to the satisfaction of the Contracting Officer.

2. The value allocated to mobilization shall not exceed 3 percent of the Total Bid Amount.

END OF SECTION 01505
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for protection and care of existing trees and shrubs indicated to remain on the Contract Drawings. Protection includes protection of plant system above and below grade. Care includes watering and maintenance of protected vegetation and irrigation to ensure plant growth and health until final acceptance.

B. Existing vegetation to remain is designated on the Contract Drawings. Trees, shrubs, and vegetation to be removed are shown on the Contract Drawings and will be marked in the field prior to construction.

C. Refer to Section 02131, “Tree Pruning”, for provisions for pruning existing vegetation designated to remain.

1.2 DEFINITIONS

A. Barrier: A fence installed as a temporary divide for the purpose of preventing unauthorized access during the full period of construction.

B. Disturbance/Damage: Physical or visual change to the site or trees and shrubs, which, in the opinion of the Contracting Officer, is detrimental to the viability of the vegetation being protected. Equipment, material, or personnel may cause such disturbance. Damage includes protected plant which partially dies within the duration of the Contract, thereby damaging shape, size or symmetry.

C. Violation: Damage to trees and shrubs caused by any construction or delivery vehicle, construction material storage or disposal of solid or liquid debris shall be considered a violation to the Contract.

1.3 GUARANTEE

A. Guarantee existing trees and shrubs against damage until final acceptance of the Project. Repair damage, which, in the opinion of the Contracting Officer, can be satisfactorily corrected. Replace plant material that dies within the duration of the Contract, and replace damaged plant material which partially dies within the duration of the Contract, thereby damaging shape, size or symmetry. Guarantee replacement plants for duration of the Warranty of Construction described in the General Provisions.

B. Where chain link fencing is indicated on the Contract Drawings for tree and shrub protection or is otherwise required, provide 6 foot high, temporary chain link fencing, in accordance with Section 02830, Chain Link Fencing.

2.2 MISCELLANEOUS MATERIALS

A. Mulch: Coarsely shredded hardwood mulch.

2.3 REPLACEMENT PLANT MATERIALS

A. Trees 9 inch caliper or less that are damaged shall be replaced with a new tree of same size and species. Size will be determined by measuring caliper at 12 inches above grade for trees from 4 to 12 inch caliper and at 6 inches above grade for trees from 0 to 4 inch caliper.

B. Trees larger than 9 inch caliper that are damaged shall be measured at 4 feet above natural ground elevation, or from top of stump, if removed. Contracting Officer will assess the following damages for damaged or removed trees:

<table>
<thead>
<tr>
<th>Tree Size-Diameter</th>
<th>Value Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 9 to 12</td>
<td>$5,000</td>
</tr>
<tr>
<td>Greater than 12 to 15</td>
<td>$10,000</td>
</tr>
<tr>
<td>Greater than 15</td>
<td>$20,000</td>
</tr>
</tbody>
</table>

C. Replacement shrubs shall be replaced at the existing sizes.

D. Replacement of vines, grasses, or other vegetation shall be replaced in kind with the approval of the Contracting Officer.

PART 2 - PRODUCTS

2.1 BARRIER MATERIALS

A. Minimum 4 foot high orange plastic netting (“Snow Fence”) with steel posts.

PART 3 - EXECUTION

3.1 IDENTIFICATION AND VERIFICATION

A. Verify trees to be removed and trees to be protected and saved with the Contracting Officer prior to commencing site work. Clearly mark trees for removal and trees for protection.

B. Field verify and photo document the existing tree, shrub, and plant health with the Contracting Officer prior to commencing work.

3.2 PRESERVATION

A. Protect and preserve trees, shrubs, and vegetation to remain by the use of temporary enclosures, wrapping or other means. Protection shall be in place prior to any site work, demolition, or grading.
B. Obtain Contracting Officer’s approval of plant protection prior to starting any site work. Protect plants with approved barrier as indicated on the Contract Drawings. Spread and maintain mulch to a depth of two to three inches to cover 100 percent of the root zone.

1. Protect tree and shrub trunks, limbs, foliage, and root zones from damage. If fencing is not possible due to proximity of construction, then the Contractor shall wrap tree trunk with material sufficient to protect the trunk from damage. The Contractor may use 2x4 wood pieces wired together to protect the trunk to a minimum height of 8 feet above grade.

2. Protect the root zone from compaction and damage. In areas of vehicular traffic, place and maintain plywood boards in addition to the mulch to protect the root zone from damage.

3. When excavation is required in tree root zones, hand excavate whenever possible and avoid cutting of roots greater than 1 inch during construction. When it is not possible to avoid cutting roots, roots over 1-1/2 inch shall be coated on the faces with acceptable dressing for horticultural use for cut or damaged plant tissues.

C. Barrier: Protect vegetation to be saved by erecting a barrier around all existing vegetation in the construction area. Maintain barriers in place until all construction in the vicinity is completed and approved by the Contracting Officer. Barriers shall consist of either orange plastic netting or temporary chain link fencing. If barrier material is not designated on the Contract Drawings, then material shall be Contractor’s option, subject to approval by Contracting Officer.

1. Orange plastic netting: Set posts at 6 foot on center. Secure netting at each post with wire to provide a continuous barrier. Locate ends of netting at posts, lap ends, and fasten with wire to posts.

2. Install temporary chain link fencing as specified in Section 02830, “Chain Link Fencing”.

D. Repair injuries, abrasions and other damage to plants by cleanly removing broken members, lose and torn bark, and shape edges in order to permit drainage of rain water from wounds. Paint wounds with an approved tree wound paint.

E. Where depth of soil over root system of existing plantings is to be modified by final grading, provide the following:

1. Where increase of 1 foot or more in elevation is shown, spread continuous layer of rock aggregate, graded 1/4 inch to 2 inches, 6 inches deep from trunk to drip line of branches prior to installation of fill.

2. Provide proper aeration by installing within perimeter of spread, a system of 4 inch clay drain tile. Install vertically flush with soil surface and penetrating into layer of aggregate fill.

3. Construct stone wells around trunks as shown, as detailed or as approved. Extend stone wells vertically from rock fill layer to final grade, allowing sufficient space for trunk growth.

4. Install tree guard fencing at the tree drip line or as noted on the Contract Drawings.

F. Do not install gates in tree guard fencing. Do not stack or store any equipment inside the tree fence.

G. Do not clean construction equipment, dump liquids, nor perform field maintenance on vehicles in the vicinity of the trees to be preserved.

H. If tree designated to remain is damaged so as to cause death or severely injure the tree, then remove and replace the tree at no extra cost to the Contracting Authority. The replacement tree shall be the same caliper size and species as the tree removed, with the exception of trees larger than 9 inch caliper. For trees larger than 9 inch caliper, refer to Article entitled “Replacement Plant Materials” herein for details concerning assessment for trees. The Contractor shall provide a one-year warranty for the replacement tree.

3.3 REMOVAL OF TREE BRANCHES

A. Where tree limbs or branches impede construction, the Contractor may remove limbs only with the written approval of the Contracting Officer. Branches shall be removed according to recommended horticultural practices using a three cut process for limbs over 2 inches in diameter. Comply with “Pruning and Weed Removal” below.

B. Obtain Contracting Officer’s approval of branch removal in the field.

3.4 EXISTING TREE AND PLANT MAINTENANCE AND CARE

A. The Contractor shall be responsible for maintaining the health of the existing trees and vegetation during the Contract period.

B. Maintain existing trees, shrubs, and vegetation to remain during the construction by keeping fencing upright and secure. Provide protective fencing as indicated on the Contract Drawings and approved by the Contracting Officer.

C. Notify Contracting Officer at first sign of distress or if grass stops growing within protective fencing. Notify the Contracting Officer if protected trees start to show signs of stress, insects or disease, or decline.
D. Treat any Fire Ant mounds around or on top of a tree root zone immediately and physically remove mound. Do not allow mound to build on the tree trunk as this will cover the tree root flare and possibly cause injury or death. Ensure that any chemical application to the Fire Ant mound is safe for application atop tree root zones.

E. Pruning and Weed Removal:

1. Pruning shall be carried out by experienced pruning personnel. Pruning qualifications are specified in Section 02131, “Tree Pruning”.

2. Obtain approval in the field for extent of pruning from Contracting Officer. Remove all damaged and diseased branches.

3. Sterilize pruning tools between individual plants; take particular care in sterilizing tools for the genus Quercus. Paint all wounds on plants of the genus Quercus with wound paint as soon as possible. Paint deliberate wounds (pruning) within one hour and accidental wounds (storm or equipment damage or vandalism) as soon as they are observed.

4. Raise limbs to an acceptable height as approved by the Contracting Officer. Raise limbs to seven foot height for trees within 10 feet of parking or sidewalk.

5. Use no weed-eaters or edgers within 15 inches of any tree. Should the need for trimming be necessary within 15 inches of any tree, perform trimming by hand only.

6. Remove dead wood, broken branches, mistletoe, and suckers from trees as needed. Sterilize pruning tools between individual plants to keep down spread of disease. Paint all wounds of plants of the genus Quercus with wound paint as soon as possible. Paint deliberate wounds within one hour and accidental wounds due to storms, etc. as soon as they are observed.

7. Clean up after tree pruning and clearing activities. Remove and legally dispose of all debris off site.

3.5 WATERING

A. Water existing trees, shrubs and plants to remain as needed to maintain health, growth, and vigor throughout Contract period.

1. Deep root water trees once every two weeks during the months of June, July, August, and September. Adjust this watering to take into account the amount of rain or signs of stress.

2. Should drought of more than three weeks occur from October through May, provide deep root watering of existing trees. Unless it has rained at least 1/2 inch since the last watering, continue to deep root water.

3.6 SITE RESTORATION

A. Continue protection and care of trees, shrubs, and vegetation until final Acceptance.

B. Upon the approval of the Contracting Officer, remove barriers including posts and footings, wrapping, and other protective devices. Backfill holes resulting from removal of posts and footings. Fencing and other materials, with the exception of mulch, shall remain the property of the Contractor and shall be removed from the site.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section will not be measured for payment but will be paid for on a lump sum basis for “tree and shrub protection and care”.

B. Tree pruning performed as part of tree and shrub protection and care will be measured and paid for as specified under Section 02131, “Tree Pruning”.

C. Pruning performed for the Contractor’s convenience and pruning to help mitigate damage caused by the Contractor will not be measured and no payment will be made therefore.

D. Orange plastic netting and temporary chain link fencing for tree and shrub protection, including posts and footings, maintenance, removal, and disposal, will not be measured separately but will be paid for at the lump sum price for “tree and shrub protection and care”.

E. Assessments for trees larger than 9 inch caliper, which are damaged and not replaced, will either be deduced from the Contract Price or billed to the Contractor, at the Authority’s discretion.

END OF SECTION 01532
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the installation, maintenance, and removal of temporary street decking and its support system over excavated areas for the purpose of maintaining the flow of pedestrian and vehicular traffic during the construction period.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO HB-17 - Standard Specification for Highway Bridges

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code Steel

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

D. Occupational Safety and Health Administration (OSHA)
   1. 29 CFR 1926 Subpart P - Excavations
      a. 29 CFR Part 1926.650 – Scope, Application and Definitions Applicable to this Subpart
      b. 29 CFR Part 1926.651 – Specific Excavation Requirements
      c. 29 CFR Part 1926.652 – Requirements for Protective Systems
   2. 29 CFR 1926 Subpart S – Underground Construction, Caissons, Cofferdams, and Compressed Air
      a. 29 CFR 1926.800 – Underground Construction

1.3 DESIGN CRITERIA

A. Design of temporary decking shall be performed by and working drawings and computations shall be signed and sealed by the Contractor’s engineer who shall be a Professional Engineer registered in the State of Texas.

1.4 SUBMITTALS

A. Working Drawings:
   1. Prior to installation of elements for temporary decking, submit working drawings and design calculations.
   2. Show proposed procedures and methods of constructing temporary decking including support system, anchorage system, and necessary construction details.
   3. After existing utility facilities have been located by field investigations make necessary revisions to working drawings to reflect actual site conditions and resubmit drawings.

B. Certification:
   1. If used materials are utilized, submit certified information concerning each previous use. The information shall include the purpose, duration, and type of loading.
   2. Submit certifications verifying that welding, welding inspector, and testing personnel have been qualified in accordance with AWS D1.1/D1.1M or other AWS standard, as applicable, within the last 12 months prior to start of fabrication and erection.

1.5 REGULATORY REQUIREMENTS AND PERMITS

A. Design and perform work of this section in accordance with OSHA 29 CFR 1926 Subpart P, 29
TEMPORARY DECKING


1.6 PROJECT CONDITIONS

A. Refer to Section 01500, "Temporary Facilities and Services" and Section 01570, "Maintenance and Control of Traffic", for traffic control, barricades, and protective device requirements. Coordinate with Traffic Control Plan.

B. Perform work in accordance with construction sequence and maintenance of traffic schedules as shown and requirements of the jurisdictional agencies.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel, Concrete, and Other Materials: Used materials are permitted in lieu of new materials provided they are sound and free from defects, which might impair their strength.

B. Timber: Structural lumber, visually graded in accordance ASTM D2555, minimum working stress 1,100 psi.

C. Skid-Resistant Surface: Provide skid-resistant surface having a Skid Number at 30 mph (SN30) of no less than 35 when measured in accordance with ASTM E274.

PART 3 - EXECUTION

3.1 DECKING INSTALLATION

A. Install and maintain decking at design elevations.

B. Provide and maintain skid-resistant surface.

C. Maintain decking free of snow, ice, water, mud, and debris.

D. Secure decking to maintain its location or position over or next to the work by an approved anchorage system. If decking is dislodged or becomes unsecured, take all necessary measures to secure decking and protect public, workers, and the Work.

E. Place premixed asphaltic patching material to provide smooth transitions between existing pavement surfaces and decking and elsewhere as required to provide proper drainage and prevent ponding of water.

F. As removal of pavement and sidewalk progress, furnish and install barricades in accordance with Section 01500, "Temporary Facilities and Services", and requirements of the jurisdictional agencies.

G. Along sides of decked areas for pedestrian walkways where such walkways are adjacent to vehicular traffic, install concrete barriers as shown.

H. Install wooden fence along sides of decked areas for pedestrian walkways where such walkways are adjacent to open areas, storage areas and other areas used by the Contractor. Paint barricades and fences, and maintain in good repair.

I. Provide walkways or galleries for full length of excavation when excavation reaches depth of approximately 15 feet.

J. Erect and maintain load limit and other signs, if needed, to restrict loading on decking, so that it does not exceed maximum design loading.

K. Remove temporary decking and support system when no longer required. Comply with requirements of Section 02160, "Support of Excavation", when removing support system.

3.2 WELDING

A. Welding shall only be performed by certified welders and in accordance with the requirements of the AWS D1.1/D1.1M.

3.3 FIELD QUALITY CONTROL

A. Allowable Tolerances:

1. Maintain surface elevations at abutting elements within plus or minus 1/4 inch.

2. Do not allow horizontal gaps in decking to exceed 3/8 inch.

3. Where necessary or expedient to raise elevation of temporary decking above elevation of existing street or sidewalk, do not grade in excess of ten percent on ramp approaches.

3.4 VENTILATION AND ILLUMINATION

A. When excavations are decked, provide ventilation and lighting as required by regulatory requirements, jurisdictional agencies, and utility company access requirements.

B. In areas covered by decking, supply and maintain illumination of sufficient intensity to permit safe and expeditious conduct of all phases of construction, and inspection of support system, lagging, bracing, and utilities maintained in place.

C. Provide ventilation and illumination which meets specified safety requirements.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Work specified in this section will not be measured but will be paid for at the lump sum prices for “Temporary Decking - Steel Plates” and “Temporary Decking - Bridge”. “Temporary Decking - Steel Plates” shall include temporary decking consisting of steel plates spanning excavation without support structure. “Temporary Decking - Bridge” will include all other temporary decking.

B. Maintenance and control of traffic, illumination, ventilation, anchorage, fences, and barricades will not be measured separately but will be considered as included in the lump sum prices paid for “Temporary Decking”.

END OF SECTION 01533
PART 1 - GENERAL

1.1 DESCRIPTION
A. Environmental protection considerations consist of, but are not limited to, the following factors:
   1. Natural resources including air, water, and land.
   2. Solid waste disposal.
   3. Noise and vibration.
   5. The presence of chemical, physical, and biological elements and agents that adversely effect and alter ecological balances.
   6. Degradation of the aesthetic use of the environment.
   7. Historical, archaeological, and cultural resources.
   8. Storm water discharges Texas Pollutant Discharge Elimination System (TPDES)

B. Storm Water Pollution Prevention: See Section 01562, “Soil Erosion and Sediment Control” for provisions regarding the TPDES General Permit TXR 150000, Relating to Discharges from Construction Activities, including requirement for Contractor’s Environmental Compliance Manager (ECM).

1.2 GENERAL
A. Provide and maintain environmental protection defined herein.
B. Comply with all applicable Federal, state, and local laws, ordinances, and regulations pertaining to environmental protection.
C. Compliance by subcontractors with the provisions of this and various other sections of these specifications is the responsibility of the Contractor.
D. Use of equipment from which factory-installed anti-pollution and noise control devices are removed or rendered ineffective, either intentionally or through lack of proper maintenance, is prohibited.
E. Furnish a certificate that all materials and operating equipment installed as a part of this project, the installation thereof, and all equipment used in the construction, are in compliance with all applicable local laws, ordinances, regulations, and permits concerning environmental pollution control and abatement.
F. Provide and maintain a rain gauge, approved by the Contracting Officer, for Authority use during environmental inspection.

1.3 PROTECTION OF NATURAL RESOURCES
A. General: It is intended that the natural resources within the project boundaries and outside the limits of permanent work be preserved in the pre-construction condition or be restored to an equivalent of the pre-construction condition, as approved by the Contracting Officer, upon completion of the Work. Confine onsite construction activities to areas defined by the drawings and specifications, and as approved by the Contracting Officer. Ensure off-site storage areas are included in the Storm Water Pollution Prevention Plan (SWP3) and locations shown on site map. If no temporary usage areas are defined, shown or otherwise approved, restrict operations to permanent construction areas and those areas noted as Construction Staging or Storage.

B. Spills and Releases:
   1. At all times, take measures to prevent oil or other regulated/hazardous substances from entering the ground, drainage areas, and local bodies of water. In the event of any accidental violation of the requirements of the regulatory agencies, notify immediately the Contracting Officer and the Authority’s Manager of Environmental Compliance and take remedial measures as directed. Contractor through its ECM shall determine whether a spill is reportable and shall initiate and complete remediation. Contractor (through its ECM) shall report spill as soon as possible no later than immediately following implementation of initial remediation or control but no later than within the time period stipulated by regulation. Costs for all cleanup and remediation activities shall be the responsibility of the Contractor.
   2. Do not spray, pour or otherwise release oil, antifreeze or other regulated/hazardous substances onto the ground, roadways, parking lots, storm drains, creeks, bodies of water or elsewhere. In the event of a release or spill, the Contractor shall comply with all regulatory reporting requirements, including those promulgated in the Texas Administrative Code (TAC), Chapter 327, Spill Prevention and Control.
C. Protection of Existing Waterways and Highways:

1. Do not dump debris or rubbish of any kind into or otherwise allow it to fall into any body of water, onto adjacent banks, or onto highways. This includes paint splatters and spillage during painting operations as well as sediments, debris, and other materials that may be carried in storm water runoff. Capture waste paint from cleaning paint equipment, remove from site, and dispose of properly. Take care to prevent damage and injury to personnel, vessels, and vehicles using waterways, highways, or pedestrian ways. Provide and maintain devices to prevent such occurrences. Promptly remove any material or items falling into any body of water, onto adjacent banks, or onto highways and immediately report to the Contracting Officer and the jurisdictional agency. Use spill control materials where appropriate, to control spillage from paint and related materials. Contractor shall at all times be in compliance with the TPDES General Permit TXR 150000, Relating to Discharges from Construction Activities, as well as the SWP3 developed for this Project. Refer to Section 01562, “Soil Erosion and Sediment Control” for detailed requirements regarding the TPDES storm water permit program.

2. Do not close streets, walks, or other passageways to public access due to construction, demolition, or other related activities until an alternative routing plan is filed and written approval given by the appropriate local authority. For detailed Maintenance and Control of Traffic Plan, refer to Section 01570, "Maintenance and Control of Traffic".

D. Land Resources:

1. Except in areas indicated to be cleared, do not remove, cut, deface, injure, or destroy trees, shrubs, and vegetation without special permission from the Contracting Officer. Do not fasten or attach ropes, cables, or guys to any existing nearby trees for anchorage. Do not grade or store soil or debris against trees, shrubs, or vegetation that is outside the area to be cleared.

2. The use of herbicides is not permitted unless otherwise specified.

3. Submit a plan for protecting existing trees and vegetation to remain and that could be injured, bruised, defaced, and otherwise damaged by construction operations. Plan shall be in accordance with Section 01532, "Tree and Shrub Protection and Care", and shall be referenced in the SWP3 under maintaining existing vegetation. Remove rocks that are displaced into uncleared areas.

4. Protect monuments, monitor wells, markers, and works of art prior to the start of operations.

5. Trees and other landscape features scarred or damaged by the Contractor's equipment and operations shall be repaired and restored in accordance with the approved SWP3 and Section 01532, “Tree and Shrub Protection and Care”. Submit for the Contracting Officer's approval the repair and restoration plan prior to its execution.

6. Construction Facilities:

a. Requirements of this subparagraph are in addition to General Provision paragraph, "OPERATIONS AND STORAGE AREAS", and Section 01500, "Temporary Facilities and Services Required During Construction".

b. The location of the Contractor's staging area, storage area, and other construction buildings on public or privately owned property required temporarily in the performance of the Work, if not shown on the drawings, require approval of the Contracting Officer. Store equipment and materials at the job site in conformance with applicable Federal, state, and local statutes, ordinances, regulations, and rulings of the proper jurisdictional authority. Do not store unnecessary materials, equipment or containers on the jobsite. Take care to prevent any structure from being loaded with a weight that will endanger its structural integrity or the safety of persons. Do not store materials on or encroach upon private property without the written consent of the owners of such private property.

E. Water Resources:

1. At all times, the Contractor shall comply with the terms and conditions of the Clean Water Act of 1977, including the TPDES Storm Water Discharge Permit and SWP3 for this Project. Refer to Section 01562, “Soil Erosion and Sediment Control”, for detailed requirements regarding the TPDES storm water-permitting program.

2. Permit no stream crossings except as indicated in the Contract Documents. If the Contracting Officer agrees in writing that stream crossing is unavoidable, properly design and obtain required permits and construct such crossings according to such design and permit restrictions. The SWP3 shall include the design of any stream
crossings including properly sized culverts that remain in place in low flows/minor storms and allow high flows from major storms to pass over. Remove temporary culverts or bridge structures, if used, upon completion of the project and repair the area in conformance with its original condition and as specified herein.

3. Protection of Existing Wetlands and Watercourses:
   a. Plan, schedule, and undertake work in a manner that will ensure the protection and preservation of existing wetlands and watercourses.
   b. Undertake work in and around wetlands and watercourses in a manner to prevent any detrimental impact upon existing wetlands and watercourses.


G. Fish and Wildlife Resources: Do not alter water flows or otherwise disturb native habitat near or adjacent to the project construction area.

H. Staging Areas:
   1. Do not use in connection with this Contract, for storage, as a staging area, or as a preparation site, any cultural resource facility, building, site, or cleared area that is, as of the date of this Contract, on or eligible for listing on the National Register of Historic Places (16 U.S.C., paragraph 470a), without the prior approval of the Contracting Officer.
   2. For the purpose of the preceding paragraph the term “cultural resource” includes districts, sites, building, structures, and objects significant in American history, architecture, archaeology, or culture.

I. Illicit Dumping by Others: Contractor shall inform the Contracting Officer in the event that trash, debris or any other type of waste material is dumped or otherwise deposited on the site. The following applies whether or not the Contractor is responsible for the waste material’s presence on the site. Contractor has 7 days to clean up illicit dumping on the site unless the ECM determines the schedule must be extended to safely and effectively clean up or remove the material. Contractor shall make arrangements to dispose of the waste material in an appropriate manner. If the material is suspected of being either hazardous or regulated, prior to its removal the Contractor shall conduct testing and handle the material appropriately. If applicable, copies of any and all waste manifests shall be transmitted to the Contracting Officer and the DART Environmental Compliance Section in a timely manner.

J. Historical and Scientific Specimens:
   1. Protect and preserve intact all historic architectural features indicated on the drawings, the SWP3, or designated by the Contracting Officer. Protect these features from damage, including, but not limited to that resulting from the elements, vandalism, and effects of excavation, demolition, removal, and construction operations. Remove reserved features in an appropriate manner to prevent damage, and pack or crate in a manner to protect from damage. Mark all containers with proper identification and deliver to designated on-site areas for storage or transfer to a warehouse. Replace or repair lost or damaged designated architectural features as directed by the Contracting Officer. Submit proposed protection and removal procedures for review by the Contracting Officer prior to commencing the Work. Provide procedures for: the identification and protection of historic architectural features to be removed; safe conduct of the Work; careful removal and disposition of preserved features; and the protection and storage of preserved features. Notify the Contracting Officer in writing of the Contractor’s proposed schedule of removal of designated items. Protect the Authority’s right of ownership with regard to all preserved items.
   2. If during the course of work, artifacts or other evidence of archaeological, historical, or scientific value are discovered or accidentally exposed, report such artifacts or evidence immediately to the Contracting Officer. Halt work in the immediate area and protect the artifacts or other evidence from damage, including that resulting from the elements, vandalism, and the effects of excavation, demolition, removal, and construction operations until such time as qualified officials are able to conduct appropriate investigations. Do not proceed with work in the immediate area until authorization to proceed is obtained from the Contracting Officer. Deliver any such evidence or artifacts found during construction operations or subsequent investigations required by this section into the custody of the Authority; these items shall not become the property of the Contractor. Any delay in the progress of work on the project as a result of encountering archaeological or historical artifacts is to be mitigated by the Authority in
1.4 PETROLEUM STORAGE REQUIREMENTS

A. Contractor is responsible for all oil and oil products brought onto the site, including those introduced by sub-contractors. For the purposes of this section, oil and oil products shall include, but not be limited to, motor oils, hydraulic oils, transmission fluids, fuel (diesel, gasoline, kerosene, etc.), grease, grease, guns, grease cartridges, form release oil (if petroleum based), used oils, and used oil filters.

B. Prior to commencement of any on-site activities, the Contractor shall review and address the following:

1. Follow all applicable petroleum storage requirements and regulations, including those for underground, aboveground and mobile tanks. The location of all storage containers shall be clearly marked on the SWP3 as outlined in Section 01562, “Soil Erosion and Sediment Control”.

2. Spill Prevention Control and Countermeasures Plan:
   a. Contractor through its ECM shall prepare and submit a Spill Prevention Control and Countermeasures Plan (SPCC) if the total (cumulative of all contractors on project) on-site oil or oil product storage capacity is expected to meet or exceed 1,320 gallons at any time during the project. Contractor shall and all other contractors on site will be required to communicate in a weekly meeting to assess the on-site storage to determine if the SPCC has been triggered. All containers with a capacity of 55 gallons or greater will be included in determining on-site capacity including those of the Contractor and subcontractors.
   b. At a minimum, the Contractor’s SPCC shall conform to the requirements of 40 CFR, Part 112, Oil Pollution Prevention, as well as any laws or regulations imposed by state or local authorities.
   c. The on-site oil and oil product storage capacity shall be cumulative and include all containers introduced by the Contractor as well as all subcontractors. Containers will include tanks, drums, cartons, etc.
   d. The SPCC shall include the Contractor’s plan for containing a catastrophic spill from his largest on-site tank and/or the largest mobile tanker delivering oil products to the site.
   e. Underground storage should be avoided but if used, comply with applicable regulations and cover under SPCC.

3. Containers, drums, and storage tanks shall be clearly marked as required by the authority having jurisdiction. At a minimum, markings shall include the contents of the container, drum, tank and/or other storage device. Markings shall be legible and permanently attached to the outside of the container. There shall be no unmarked drums or containers (including trash containers) on the site.

4. Maintain an inventory of oil and oil containing products stored on-site.

5. Submit a list of oil and oil products to be used and stored on-site. All oil and oil products will be stored in appropriate containers. Used oil filters, grease cartridges, plastic oil containers, etc. will be disposed of promptly and in an appropriate manner. Appropriate disposal may include recycling.

6. Oil and oil product storage containers shall be placed within secondary containment structures. Each secondary containment structure shall be sufficiently sized to confine the contents of the largest container, drum, or tank stored within and shall be impervious so that any spilled product will be retained. Spilled and/or leaked products shall be promptly removed from containment structures. Secondary containment structures shall be configured or situated to prevent storm water from entering. Storm water entering any secondary containment structures shall be considered contaminated and shall be disposed of appropriately by the Contractor.

7. All containers, storage tanks, hoses, and piping shall conform to EPA, TCEQ, and/or local regulations, guidelines and codes.

8. SPCC shall be prepared under the direction of, and signed and sealed by a Professional Engineer licensed in the State of Texas.

1.5 HAZARDOUS WASTE, REGULATED MATERIALS, AND TOXIC SUBSTANCES

A. DART construction projects are subject to regulations promulgated by Federal, state, and local, regulatory agencies. Agencies include but are not limited to the Texas Commission on Environmental Quality (TCEQ), Texas Department of Health (TDH), U.S. Environmental Protection Agency (EPA), Occupational Safety and Health
ENVIRONMENTAL PROTECTION

Administration (OSHA), U.S. Department of Transportation (DOT), municipal fire departments and storm water management departments. Following is a summary of environmental regulations that may impact DART construction projects. This summary is not intended to be exhaustive; discovery of additional regulations that may apply are the responsibility of the Contractor.

1. Construction and Fire Prevention Resolution and Amendments to the Codes by the judicial authority.
2. Title 31, TAC Chapters 334, and 335.
4. TCEQ - Soil Remediation/Reuse/Treatment Levels. Adopted regulations 3/3/93, TAC Section 334.481-510
5. TSCA - Toxic Substances Control Act.
7. API Publication 2219, Safe Operating Guidelines for Vacuum Trucks in Petroleum Service, 1999
8. API Publication 1604, Closure of Underground Petroleum Storage Tanks, 1996
12. OSHA 40CFR1926, Training Requirements for the Construction Industry, applicable sections.

B. Contractor and all sub-contractors, working on Authority construction projects, shall comply with all existing applicable environmental laws and/or regulations promulgated and enforced by Federal, state and local agencies. This includes, but is not limited to, the storage, handling, transport, and disposal of all hazardous waste, regulated materials and/or toxic substances.

1. Hazardous Waste and Regulated Materials:
   a. Hazardous waste is a broad term used to denote industrial by-products and waste materials discarded from homes, commercial establishments, and industrial facilities that pose a risk to human health, safety, property, and/or the environment. Encountering heavy metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) defined under the Resource Conservation and Recovery Act of 1976 (RCRA) is the most common occurrence for DART construction projects.
   b. Regulated materials are usually thought of as those materials that may pose a risk but are not classified as hazardous. For DART construction projects, the discovery of total petroleum hydrocarbon (TPH) contaminated materials, associated with gasoline stations, is the most common occurrence.

2. Toxic Substances: The Toxic Substances Control ACT (TSCA) of 1976 provided EPA with authority to require testing of chemical substances, both new and old, entering the environment and to regulate them where necessary. The chemical substances addressed by TSCA, which are most commonly encountered during a DART construction project are asbestos or polychlorinated biphenyls (PCB’s).

C. HAZCOM: Contractor shall maintain all applicable Material Safety Data Sheets (MSDS), as required under Federal, state and local laws. MSDS(s) shall be kept current and made available for on-site review.

1.6 RESPONDING TO HAZARDOUS WASTE, REGULATED MATERIALS, AND TOXIC SUBSTANCES

A. Authority personnel (Manager, Environmental Compliance and Construction Engineering Manager) shall be notified immediately in the event the Contractor, during the course of work, encounters or suspects the presence of hazardous waste, regulated materials, toxic substances, and/or underground storage tank. Contractor shall not perform any work in the area of suspected contamination prior to receipt of special instruction from the Authority through the Contracting Officer. Any delay in the progress of the Work as a result of encountering hazardous or regulated materials, toxic substances, and/or underground storage tanks
1.7 CONTROL AND DISPOSAL OF EXCESS MATERIAL, TRASH, DEBRIS, AND EFFLUENT

A. Dispose of excess excavated material that is approved by the Contracting Officer as clean fill onsite if the Contracting Officer approves an onsite soil disposal area. If no such site is approved, dispose of the material in accordance with the provision of Paragraph 1.7.C. herein. Small amounts of material generated by excavation for fencing will be exempted from this provision. In all cases the provisions of Article 1.3 hereinbefore apply to the onsite disposal of excavated material.

B. Pick-up trash and place in containers. Develop a schedule for emptying containers regularly. Conduct handling and disposal to prevent contamination of the site and other areas. Do not dispose of any material or otherwise contaminate wetlands. On completion, leave the disposed areas clean.

C. Dispose of rubbish and debris as follows: Transport all waste off the site and dispose of in a manner that complies with State, and local requirements. Secure a permit or license, if required by the jurisdictional authority, prior to transporting any material off the site. Submit copies of approval documents from appropriate Authorities to the Contracting Officer prior to use of the disposal sites. Do not burn waste materials on the site.

D. Effluent: Contractor shall take all necessary measures to assure compliance with the requirements and intent of the TPDES Permit obtained for this Project and with the SWP3 developed for this Project.

E. Wash Down of Concrete Trucks: Wash down shall be performed only at locations designated by the ECM and in accordance with applicable laws and regulations. Indicate location on SWP3, as applicable.

1.8 CONTROL AND DISPOSAL OF CHEMICAL AND SANITARY WASTES

A. Dispose of sewage through authorized connections to municipal sanitary sewage systems. Where such systems are not available, use chemical toilets or comparably effective units with wastes regularly emptied. Include provisions for pest control and for masking or eliminating odors.

B. Store chemical waste in separate corrosion-resistant, properly labeled containers. Remove from the Project Site and dispose of as necessary, but not less frequently than monthly. Provide for disposal of chemical waste, including paint-related material, in accordance with TCEQ regulations, in addition to standard established practices as approved by the Contracting Officer. Conduct fueling and lubricating of equipment and motor vehicles on-site in a manner that affords the maximum protection against spills and evaporation. Dispose of lubricants, including used oil, in accordance with approved procedures meeting Federal, state and local regulations. Provide spill control materials in fueling and lubrication areas; and use them when needed. Immediately notify the Contracting Officer and the Authority’s personnel (as required in Paragraph 1.6. herein) of oil and hazardous material spills that may be large enough to violate state, and local regulations.

1.9 DUST CONTROL

A. Do not use oil or any other petroleum product to control dust.

B. Keep dust down at all times including non-working hours, weekends, and holidays. Treat soil at the site, haul roads, and other areas disturbed by the Contractor's operations as well as materials stockpiled for the project with dust suppressors or cover to control dust. Power brooming for dust control will not be permitted; use street vacuuming machines. Air blowing shall only be permitted for cleaning off non-particle debris, such as that from reinforcing bars. Sandblasting shall not be permitted except as specified elsewhere. Only wet cutting of concrete block, concrete, and asphalt will be permitted.

C. Secure and cover trailers and other transport equipment to prevent loose soil, debris and other materials from becoming airborne during transit.

D. Stabilized construction entrances shall be used to prevent offsite tracking of sediments and debris as shown in the SWP3 for the site. Design of the stabilized construction entrance shall prevent all washing effluent from leaving the site. The ECM shall monitor the washing of vehicles at the stabilized entrances to prevent tracking and to evaluate the quality of effluent leaving the construction site from washing of vehicles.

1.10 VEHICLE AND EQUIPMENT EMISSION LIMITATIONS

A. Contractor shall adhere to applicable requirements for vehicle and equipment emission limitations.

1.11 CONSTRUCTION NOISE AND VIBRATION CONTROL

A. Perform construction operations in a manner minimizing noise and vibration. Provide working machinery and equipment with efficient noise control equipment and implement noise and vibration control measures as provided in Paragraphs 1.10 and 1.11 herein.
suppression devices, and other noise and vibration abatement measures necessary for protection of both employees and the public. Schedule operations in a manner that will minimize the disturbance to the public in areas adjacent to the Work to the greatest extent feasible. Restrict working hours as required by municipal ordinances. Protect employees and the public against noise exposure in accordance with the requirements of the Occupational Safety and Health Act of 1970 and the current statutory noise limits set by OSHA. Comply with all other applicable Federal, state and local laws, regulations and ordinances.

B. Require the use of machines with effective mufflers or enclosures and the selection of quieter alternative procedures. Compliance may also require the use of complete enclosures (tongue-and-groove plywood or sheathing as specified in Section 01500) around the Worksites or a combination of closed boarding and effective mufflers and/or enclosures. Arrange haul routes to minimize noise and vibration at residential sites, and if necessary, place operating limitations on machines and trucks if suitable routes cannot be found. Submit shop drawings of the Worksites and haul routes showing provisions for the control of construction noise to the Contracting Officer for approval.

C. Monitor work operation noise and vibration levels to assure they comply with the noise and vibration limitations specified. Retain records of these noise and vibration measurements for inspection by the Contracting Officer. Inform the Contracting Officer of any complaints received from the public regarding noise and vibration. Propose the remedy and recommend if remedial action is required. If action is warranted, submit a proposed remedy and schedule to the Contracting Officer for approval prior to commencement of such actions.

D. Definitions:

1. Daytime/Nighttime: Daytime refers to the period from 7:00 a.m. to 9:00 p.m. local time, daily except Sundays and legal holidays, or as defined by the local jurisdictional agency, whichever is more restrictive. Nighttime refers to all other times, including all day on Sunday and all day on legal holidays.

2. Noise Level Restrictions at Affected Structures. Conduct construction activities so that the noise levels 200 feet from the construction limits or at the nearest affected building, whichever is closer, do not exceed the levels listed hereafter in Tables 01560 - 1 and 01560 - 2.

3. Continuous Noise. Prevent noises from stationary sources, parked mobile sources, or any combination of sources producing repetitive or long-term noise lasting more than one hour from exceeding the limits of Table 01560 - 1.

4. Intermittent Noise. Prevent noises from non-stationary mobile equipment operated by a driver or from any source of non-scheduled, intermittent, non-repetitive, short-term noises not lasting more than one hour from exceeding the limits of Table 01560 - 2.

5. More Than One Limit Applicable. Where more than one noise limit is applicable, the more restrictive requirement shall be used for determining compliance.

E. Noise Emission Restrictions: Use only equipment meeting the noise emission limits listed in Table 01560 - 3 as measured at a distance of 50 feet from the equipment. Take the measurements in accordance with the latest revisions of SAE J366b, SAE J88, and SAE J952b or in accordance with the measurement procedures specified.

F. Vibration Level Restrictions:

1. Vibration Limits in All Areas. Conduct construction activities so that vibration levels at a distance of 200 feet from the construction limits or at the nearest affected building (whichever is closer) do not exceed the root-mean-square (rms) vibration velocity levels of 0.1 inch per second in any direction over the frequency range of 1 to 100 Hz.

2. Special Zones. In zones designated by the local agency having jurisdiction as a special zone or special premise or special facilities, the vibration level and working time restrictions imposed by the agency shall apply.

G. Noise and Vibration Control: The control measures listed below may be utilized to minimize the noise and vibration levels in all areas outside the construction limits in order to meet the specified limitations:

1. Shields, impervious fences, or other physical sound barriers that inhibit transmission of noise.

2. Sound retardant housings and/or enclosures placed around noise producing equipment.

3. Intake and exhaust mufflers installed on internal combustion engines and compressors.

4. Lining or covering hoppers, storage bins and chutes with sound-deadening material.

5. Minimizing the use of air or gasoline driven saws.

6. Conducting truck loading, unloading, and hauling operations so that noise and vibration is kept to a minimum.
7. Planning the route used by construction equipment and vehicles carrying concrete, or other materials over streets that will cause the least disturbance to residents. Advise the Contracting Officer in writing of the proposed haul routes prior to securing a permit from the local government, in accordance with Section 01570, "Maintenance and Control of Traffic".

8. Subject to the approval by the Contracting Officer, placing stationary equipment to minimize noise and vibration impact to the community.

9. Using vibratory pile drivers or augering for setting piles rather than impact pile drivers wherever feasible. If impact pile drivers must be used, the hours shall be limited to 8:00 a.m. to 5:00 p.m. weekdays in residential and semi-residential/commercial areas.

1.12 BLASTING

A. Blasting is expressly prohibited.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, "General Requirements".
CONTINUOUS AND INTERMITTENT CONSTRUCTION NOISE LIMITS

<table>
<thead>
<tr>
<th>Affected Structure or Area</th>
<th>TABLE 01560 - 1</th>
<th>Maximum Allowable Continuous Noise Level, dBA</th>
<th>TABLE 01560 - 2</th>
<th>Maximum Allowable Intermittent Noise Level, dBA</th>
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<tr>
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<td>Nighttime^2</td>
<td>Daytime^1</td>
<td>Nighttime^2</td>
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<td>Residential</td>
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<td></td>
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<td>Single family residence, multi-family residential areas, including hospitals and hotels</td>
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<td>50</td>
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<td>70</td>
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<tr>
<td>Commercial</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed residential/commercial areas, including schools</td>
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<td>90</td>
<td>80</td>
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<tr>
<td>Commercial areas with no nighttime residents</td>
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<tr>
<td>Industrial</td>
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<td></td>
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<tr>
<td>All locations</td>
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<td>85</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

Notes:
1. Daytime refers to the period from 7:00 a.m. to 9:00 p.m. local time, daily except Sundays and legal holidays, or as defined by the local jurisdictional agency, whichever is more restrictive.
2. Nighttime refers to all other times, including all day on Sunday and all day on legal holidays.

TABLE 01560 - 3
CONSTRUCTION NOISE EMISSION LIMITS

| TYPE OF EQUIPMENT                              | MAXIMUM NOISE LIMIT | Date Equipment Acquired | |
|------------------------------------------------|----------------------|-------------------------|
| All equipment other than highway trucks; including hand tools and heavy equipment | 95 dBA 90 dBA       | Before 1-1-1986         |
| Highway trucks in any operating mode or location | 90 dBA 87 dBA       | Before 1-1-1988         |

Note: Peak levels due to impact pile drivers may exceed the above noise emission limits by 10dBA.
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies soil erosion and sediment control measures and stabilization practices required during construction in order to minimize the levels of pollutants in storm water run-off from DART construction sites.

B. Soil erosion and sediment control measures are required under Texas law, specifically Section 26.040 of the Texas Water Code and Section 402 of the Clean Water Act. Under the provisions of these laws, the Texas Commission on Environmental Quality (TCEQ) has developed the Texas Pollutant Discharge Elimination System (TPDES) General Permit TXR150000, relating to discharges from construction sites located in the State of Texas. Throughout this section, the TPDES General Permit TXR150000 with effective date March 5, 2013, will be referred to as the Construction General Permit (CGP). In the event TCEQ issues an update or otherwise a new permit, the Contractor shall adhere to any and all provisions, including those that may conflict with this section.

C. This section also specifies Contractor's responsibilities under the TPDES CGP. These responsibilities include assuming operational control of the site (as defined in the CGP), updating and maintaining a Storm Water Pollution Prevention Plan (SWP3), performing inspections, submitting various notices, and providing qualified personnel to assure compliance with Federal, state and local environmental regulatory requirements.

D. Contractor shall also be responsible for furnishing, installing, maintaining throughout construction, and removing temporary measures and practices defined in the CGP as Best Management Practices (BMPs). BMPs include silt fences, stabilized construction entrances, ditch checks, storm sewer inlet protection and other structural controls, as required; as well as temporary and permanent seeding, mulching, sodding, and other stabilization methods.

E. Contractor shall also develop appropriate procedural controls that will facilitate compliance with the CGP and the SWP3. These may include BMP maintenance, trash removal, and employee training.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO),


B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A116 - Standard Specification for Metallic Coated, Steel Woven Wire Fence Fabric
2. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
3. ASTM A491 - Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
6. ASTM D3776 - Standard Test Methods for Mass Per Unit Area (Weight) of Fabric
7. ASTM D3786 - Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics- Diaphragm Bursting Strength Tester Method
8. ASTM D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
9. AASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity
14. ASTM D4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples


D. Texas Department of Transportation (TxDOT): "Storm Water Management Guidelines for Construction Activities"


1.3 DEFINITIONS

A. The Definitions found in Part I of the CGP are included by reference and shall apply to this Section.

B. Jurisdictional Entities, as used herein, is defined as the US Environmental Protection Agency (USEPA), TCEQ, U.S Army Corps of Engineers (USACE), as well as the operators of the Municipal Separate Storm Sewer Systems (MS4) receiving discharge from the construction site. (The MS4 operator is usually the city in which the construction activities are occurring, however, it may also be another government entity, such as the Texas Department of Transportation or North Texas Tollway Authority.) This definition shall also include any other entity having legal jurisdiction or ownership over the project or any portion of thereof.

C. Construction Site Notice (CSN) shall be defined as the on-site contact information sheet required by the CGP. The CSN shall include all information required to be posted in public view. Contractor shall strictly adhere to placement requirements as specified in the CGP.

1.4 PERFORMANCE REQUIREMENTS (PERMIT APPLICABILITY AND COVERAGE)

A. Contractor shall be considered the “Primary Operator”. As Primary Operator, Contractor shall fulfill all requirements of the CGP as well as any other applicable laws, regulations, or ordinances.

B. Compliance with Storm Water Permitting Regulations:

1. Contractor shall comply with all requirements of the CGP in addition to other requirements stated elsewhere in this Specification as well as Specification 01560, "Environmental Protection".

2. Under this permit, TCEQ requires the development and implementation of an SWP3, including erosion and sediment controls, storm water management measures, other site controls and housekeeping BMPs, and prevention of prohibited discharges to storm water.

3. Contractor shall meet with all appropriate Jurisdictional Entities prior to commencing any onsite work activities. Jurisdictional Entities, in this case, shall include the operator(s) of the Municipal Separate Storm Sewer System (MS4) where the construction activity will occur. Contractor shall document this (these) meeting(s) and submit this documentation to the Contracting Officer’s Representative.

4. Jurisdictional Entities may impose additional storm water pollution prevention requirements under the provisions of their local ordinances or MS4 permit.

C. Notices of Intent (NOI), Notices of Termination (NOT), Notices of Change (NOC) Letters and CSNs shall be signed in accordance with 30 TAC (Texas Administrative Code), §305.44 (relating to Application for Permit).

D. Environmental Compliance Manager: Prior to commencing construction activities, the Contractor shall propose a qualified Environmental Compliance Manager (ECM) and receive concurrence from the Authority. The ECM shall be formally delegated the responsibility for assuring compliance with the CGP, the SWP3, as well as all other environmental requirements imposed by applicable Jurisdictional Entities.

1. The delegated ECM shall have acquired, through a combination of education, training, and experience, the knowledge necessary to ensure that the Contractor’s activities on the project site meet environmental regulatory requirements, as described in this Section, Section 01560, "Environmental Protection", as well as any other requirements imposed by applicable Jurisdictional Entities. Minimum qualifications for the ECM shall include familiarity, knowledge, and an understanding of:

a. Environmental construction issues, including the NPDES and/or TPDES storm water discharge permitting regulations (preferably the most current CGP),
b. Spill response and reporting requirements necessary to protect human health and the environment, which shall include regulatory deadlines for making notification to the applicable Jurisdictional Entities. (Contractor shall be fully responsible for completing all required notification requirements within the timeframes dictated by each applicable Jurisdictional Entity).

c. Applicable regulations and requirements governing product containers, storage, and disposal, as well as chemical and product management, including documentation requirements and applicability of product use.

d. The ECM shall have obtained competency recognition via college degree, certification, registration, and/or licensing from a recognized professional or technical association, state agency, or other Jurisdictional Entity. The ECM shall also have acquired the regulatory knowledge and field experience necessary to understand and ensure compliance with the requirements of applicable Jurisdictional Entities, particularly during environmental emergencies.

e. The ECM can be a direct employee of the Contractor or a third party environmental professional or qualified technician employed by a third party environmental consultant. In either case, the ECM shall only perform duties directly related to environmental compliance, be at the job site full time, and be delegated the comprehensive authority necessary to enforce the Contractor's compliance with the applicable Federal, state and local environmental laws, regulations and ordinances. Delegation shall be from, and the ECM shall report directly to, the Contractor's executive officer who signed the Authority's Contract, the CSN, and when applicable, the NOI. In no case shall the ECM be subordinate to the Contractor's superintendent or project manager. The ECM shall have full authority to stop work on the project in order to prevent or correct non-compliance with the CGP or other environmental regulations. The ECM shall only perform duties associated with ensuring environmental compliance for this project.

2. The duties of the ECM, relative to the CGP, shall be as follows:

a. Oversee the installation of storm water pollution prevention devices and BMPs to assure that they are installed as depicted in the SWP3, accompanying detail drawings, the recommendations of the manufacturer, or Jurisdictional Entity.

b. Supervise the repair and maintenance of temporary and permanent BMPs.

c. Prepare SWP3 modifications when BMPs either prove ineffective or are no longer necessary due to changed site conditions, or changes to the progress or sequence of construction.

d. Assure that field modifications to the baseline SWP3 are depicted on, and incorporated into, the updated SWP3 maintained on the project site.

e. Make annotations to the SWP3 denoting devices or controls that are temporarily removed to facilitate construction. These annotations shall explicitly state why the specific BMPs was removed and when it will be reinstalled.

f. Develop site inspection reports summarizing each inspection. A copy of the inspection results, including a list of all deficiencies, shall be provided to the Contracting Officer’s Representative at the close of the inspection. A formal written report shall be transmitted as soon as it is prepared, but no later than 7 days following the inspection. The formal report shall detail the actions taken to correct each deficiency as well as include photographic documentation noting BMP repair and maintenance. Minimum report content shall include the name(s) and qualifications of personnel making the inspection, the date of the inspection, and major observations relating to the implementation of the SWP3. Major observations shall include:

1) The locations of discharges of sediment or other pollutants from the site;

2) Locations of all BMPs;

3) Locations of BMPs that require maintenance, failed to operate as designed, or proved inadequate for a particular location;
4) Locations where additional BMPs are needed.

a. Prepare a formal written report including actions taken as a result of inspections, which shall be described within, and retained as a part of, the SWP3. Reports shall identify any incidents of non-compliance. Where a report does not identify any incidents of non-compliance, the report shall contain a certification that the site is in compliance with the SWP3 and the CGP. The report shall be signed in the manner required by 30 TAC §305.128.

3. The ECM shall also perform the duties specified in Section 01560, “Environmental Protection”.

E. Contractor shall conform to the requirements stipulated within the CGP and mandated by the Jurisdictional Entities and shall be solely responsible for responding to any citations, paying any fines, or otherwise addressing any written notices of non-compliance with the CGP as may be issued by TCEQ, EPA, or other Jurisdictional Entities.

F. Projects equal or greater than 5 acres or part of a larger common plan of development that is equal or greater than 5 acres shall be considered “Large Construction Activity”, as defined in the CGP, and shall comply with all CGP requirements, including:

1. NOI: As site operator, the Contractor (or subcontractor if subcontractor has operational control of site or portion of site) shall complete and submit an NOI and associated fees to TCEQ and all applicable Jurisdictional Entities. NOIs shall be submitted within the timeframes identified within the CGP. A copy of the NOI shall be included in the SWP3 documents maintained for the project. Contractor shall post the NOI for public information per CGP.

2. CSN: As site operator, the Contractor (or subcontractor if subcontractor has operational control of site or portion of site) shall complete and submit a CSN to the Jurisdictional Entities no later than 10 business days prior to the commencement of any on-site soil distributing activities, or as otherwise required by the CGP. A copy of the CSN shall be included in the SWP3 documents maintained for the project. Contractor shall post the CSN for public information per CGP.

3. Contractor shall be responsible for all subcontractors and ensure their compliance with the CGP and SWP3. Contractor shall determine if a subcontractor will meet the definition of “Operator” within the CGP. Subcontractors determined by the Contractor to be Operators shall comply with all Operator requirements stipulated in the CGP as well as those imposed by applicable Jurisdictional Entities.

4. Contractor shall be responsible for paying all permitting fees associated with its TPDES permit. Payment shall be made in a manner considered timely by the TCEQ. In the event a subcontractor files an NOI, the Contractor shall be responsible for assuring payment of fees by the subcontractor.

5. Contractor shall be responsible for posting and maintaining all notices and documents required by the CGP as well as applicable Jurisdictional Entities. Contractor shall also obtain a copy of DART’s Secondary Operator CSN from the Contracting Officer’s Representative and shall be responsible for posting and maintaining it as required by the CGP.

6. Prior to being granted "Substantial Completion of the project", the Contractor shall request through the Contracting Officer’s Representative a field inspection from DART’s Environmental Compliance Section (ECS). This inspection will determine if minimum stabilization requirements established by TCEQ and applicable Jurisdictional Entities have been met. Contractor shall furnish a copy of the final updated SWP3 at the beginning of the inspection. This final SWP3 shall note any BMPs that the Contractor proposes to leave in place. A punch list shall be developed during the inspection. "Substantial Completion" shall not be granted until after all items on the list have been addressed and written approval from ECS is received.

7. NOT: Upon receipt of written approval from ECS, the Contractor shall submit an NOT for its portion of the project to TCEQ and all applicable Jurisdictional Entities. A copy of the NOT shall be included in the SWP3 documents maintained for the project.

8. Contractor shall be responsible for ensuring submission of NOTs by subcontractors, as applicable. In no case shall the Contractor submit its NOT prior to that of all subcontractors.

G. Projects equal to 1 acre but less than 5 acres shall be considered "Small Construction Activity", as
defined in the CGP, and shall comply with all CGP requirements, including:

1. CSN: As site operator, the Contractor (or subcontractor if subcontractor has operational control of site or portion of site) shall complete and submit a CSN to the Jurisdictional Entities no later than 10 business days prior to the commencement of any on-site soil distributing activities, or as otherwise required by the CGP. A copy of the CSN shall be included in the SWP3 documents maintained for the project. Contractor shall post the CSN for public information per CGP.

2. Contractor shall be responsible for all subcontractors and ensure their compliance with the CGP and SWP3. Contractor shall determine if a subcontractor will meet the definition of "Operator" within the CGP. Subcontractors determined by the Contractor to be Operators shall comply with the CGP.

3. Contractor shall be responsible for posting and maintaining all notices and documents required by the CGP as well as applicable Jurisdictional Entities. Contractor shall also obtain a copy of DART’s Secondary Operator CSN from the Contracting Officer’s Representative and shall be responsible for posting and maintaining it as required by the CGP.

4. Prior to being granted “Substantial Completion of the project”, the Contractor shall request through the Contracting Officer’s Representative a field inspection from ECS. This inspection will determine if minimum stabilization requirements established by TCEQ and applicable Jurisdictional Entities have been met. Contractor shall furnish a copy of the final updated SWP3 at the beginning of the inspection. This final SWP3 shall note any BMPs that the Contractor proposes to leave in place. A punch list shall be developed during the inspection. “Substantial Completion” shall not be granted until after all items on the list have been addressed and written approval from ECS is received.

5. Site Termination: Upon receipt of written approval from ECS, the Contractor shall comply with CGP and complete the applicable portion of the CSN and submit a copy to Jurisdictional Entities within 30 days after the completion of the project. A copy of the completed CSN shall be included in the SWP3 documents maintained for the project.

6. Contractor shall be responsible for ensuring submission of the complete CSN by subcontractors, as applicable. In no case shall the Contractor submit its completed CSN prior to that of all subcontractors.

H. TCEQ Website: Additional information relating to the CGP, forms, and general information on storm water permitting requirements may be obtained from the TCEQ, either directly or from their website.

1.5 STORM WATER POLLUTION PREVENTION PLAN

A. The Authority has prepared a “Baseline” SWP3 for this project that meets the requirements of the CGP; the Municipal Storm Water Discharge Permit issued to the Jurisdictional Entity; and other local codes, standards and regulations.

B. Contractor shall prepare an “Erosion Control Plan” based on its intended sequence of construction activities as well as the storm water BMPs it proposes to use.

C. Contractor shall update and certify the SWP3 before performing any soil disturbing activities at the project site or delivering materials to its material storage areas. The updated SWP3 shall incorporate the Baseline SWP3, the Contractor’s Erosion Control Plan, related provisions of the Contract Documents, the CGP, NOI, CSN, and any additional items required by the CGP and/or applicable Jurisdictional Entities. Refer to Paragraph 1.5.I “SWP3 Modifications” herein for additional provisions.

D. Contractor shall install all BMPs per manufacturer’s specifications or the recommendations of an appropriate technical or Jurisdictional Entity. In no case shall soil disturbing activities take place prior to installation of BMPs.

E. In the event that a BMP proves ineffective in meeting the requirements or intent of the CGP, the Contractor shall propose and install alternate BMPs that will protect the quality of storm water being discharged from the site.

F. The location and installation dates of each BMP shall be recorded in the SWP3 by the Contractor’s ECM. BMPs shall be maintained throughout the construction process until project completion, or as otherwise directed by the Contractor’s ECM, an authorized Jurisdictional Entity, the CGP, the SWP3, or the Contracting Officer’s Representative.

G. Contractor’s ECM shall record and date annotations to the SWP3 denoting devices or controls that are temporarily removed to facilitate construction. These annotations shall explicitly state why the specific device or control was removed, when it was removed, and when it will be reinstalled.

H. Contractor shall be responsible for keeping the SWP3 current at all times, as required by the CGP. The information listed below shall be incorporated by the Contractor into the Baseline SWP3. Updates to the
SWP3 shall be documented within 7 days and shall be dated.

1. In addition to the detailed Erosion Control Plan site map or maps required by the CGP, site map(s) shall be annotated and shall include the following additional information:

a. Areas subject to clearing and grubbing, grading, excavation, and utility and infrastructure installation;

b. Locations for stockpiles of topsoil, fill soils, sands, aggregates and other similar construction materials;

c. Construction staging areas, office trailer locations, haul roads, and vehicle and construction equipment parking areas;

d. Locations for equipment repair and maintenance;

e. Storage areas for hazardous and regulated materials;

f. Storage areas for miscellaneous construction or waste materials;

g. The location of concrete batch plants as well as all specific BMPs installed to address runoff from these areas;

h. Locations of solid waste dumpsters and portable toilets for sanitary waste;

i. Areas where major construction activities have ceased (either temporarily or permanently, as identified in the CGP) and site stabilization practices are underway;

j. Off-site locations of material, waste, borrow, fill, or equipment storage areas shall also include including estimates of the total area of such sites;

k. Any additional items required by the CGP, Jurisdictional Entities, or as directed by the Contracting Officer’s Representative.

2. A construction sequencing plan or schedule exhibiting relevant dates for major grading, excavation and construction activities, the temporary or permanent cessation of these activities, and for the initiation of interim or permanent site stabilization practices. This plan or schedule shall be updated as necessary to reflect overall progress at the site and may reference the Construction Schedule specified in Section 01320, “Construction Schedule and Progress Reports” or 01321, “Construction Schedule and Progress Reports for Small Projects” as applicable.

3. A description of any construction or waste materials stored on-site or within 1 mile of the project site. If any hazardous and regulated materials, toxic substances, or other chemicals are stored on-site, the Contractor shall update the SWP3 to include proper storage, handling, and disposal procedures and show locations on site map. If the quantity or means of storage of oil and oil-products on site triggers the requirements for a Spill Prevention Control and Countermeasures Plan (SPCC), the Contractor shall provide a written SPCC that meets the requirements of the USEPA. Said SPCC shall be signed and stamped by a Professional Engineer licensed in the State of Texas. Refer to Section 01560, “Environmental Protection”, for detailed SPCC requirements including when an SPCC is required.

4. A description of any other potential pollutant sources not identified in the Baseline SWP3.

I. SWP3 Modifications: Contractor is responsible for determining means and methods of construction. Modification of BMPs shown within the Baseline SWP3, whether to facilitate construction or to conduct operations differently than were assumed during design and/or project planning, shall be consistent with the intent of the CGP as well as good engineering principles and practices. Contractor movement, relocation, or substitution of any BMP shown within the plans shall meet the requirements of this section, the Authority’s Standard Erosion and Sediment Control Detail Drawings, and applicable codes and regulations. Any change or substitution shall be noted on the SWP3 by the Contractor within 7 days after it has been implemented. Substitute BMPs that follow the following standards and guidelines may be acceptable:


2. TxDOT - Storm Water Management Guidelines for Construction Activities.


J. Each modification to the baseline SWP3 shall be signed and certified by the Contractor as required by 30 TAC § 305.44. The signed certification shall be retained as part of the SWP3 documentation.
K. Contractor shall maintain all BMPs identified in the SWP3 in effective operating condition. A schedule for maintaining BMPs conforming to the CGP shall be developed by the Contractor and incorporated into the SWP3. BMPs that are not functioning properly shall receive maintenance before the next anticipated storm event or as otherwise required under the CGP. Contractor shall document all maintenance, repairs, and their respective dates in the SWP3.

L. Contractor shall immediately address any deficiencies in implementation and adherence to the provisions of the SWP3 as determined during regular site inspections. In addition, any storm related damage to any BMPs (either temporary soil erosion and sediment control measures or permanent storm water management devices) shall be repaired as soon as is practicable, but not longer than 7 days following the date of the storm which caused said damage. Contractor shall implement alternative temporary soil erosion and sediment control measures when a particular control measure has failed repeatedly or completely as determined by the ECM. Any damage caused by construction operations or equipment shall be repaired immediately. Contractor shall also document damage repairs in maintenance logs that accompany inspection reports.

M. The Authority's development of the Baseline SWP3 and periodic audit of the Contractor's overall compliance shall not in any way relieve the Contractor of the responsibility to comply with the terms and conditions of the CGP and other applicable codes and regulations, including all notification and record keeping requirements.

N. When construction requires other contractors to work within the site or to take over portions of the site prior to completion of the contract, the Contractor shall cooperate with each contractor through the Contracting Officer's Representative(s) to coordinate overall storm water pollution prevention. The SWP3 shall be modified to recognize the areas of responsibility for each contractor, based on their work location and type. In addition, the contractors shall draw up and sign a Memorandum of Agreement formalizing their acceptance of responsibility for their respective portions of the site. Contractor shall continue to have operational control of its portion of the site and conform to CGP requirements.

1.6 SUBMITTALS

A. Regulatory Compliance Documentation: Submit the following documentation:

1. A copy of the completed and executed NOI filed with the TCEQ and the Jurisdictional Entities.
2. A copy of the proposed CSN.
3. Copies of any other documentation the Contractor is required to submit to the applicable Jurisdictional Entity(ies) for Municipal Storm Water Discharge Permit compliance, or to meet the requirements of local erosion and sediment control, storm water management or land development codes, ordinances and regulations.
4. Copy of Contractor's SWP3 Certifications.
5. Copies of the pre-construction inspection report and pre-construction photographs.
6. Copies of all inspection reports and deficiencies noted in SWP3. Each submitted inspection report shall also not those steps taken to correct the deficiencies.
7. A copy of the final SWP3 for the project, which has been updated and revised to reflect the site stabilization verification inspection.
8. A copy of the completed and executed CSN filed with the Jurisdictional Entity (ies) upon completion of the project.
9. A copy of the completed and executed NOT filed with TCEQ the Jurisdictional Entity (ies).
10. Copies of the information listed herein shall also be included as part of the SWP3 documents maintained for the project.
11. Documentation of all meetings between the Contractor and Jurisdictional Entities. Meeting documentation shall include signed attendance sheets.

B. SWP3 and Personnel Qualifications: These submittals shall be made to the ECS through the Contracting Officer's Representative.

1. Contractor shall submit prior to the Pre-Construction Conference, a copy of this section of the specifications and of the Standard Drawings showing which temporary soil erosion and sediment control products and structural control measures (BMPs) will be applied to the work. Non-applicable products and measures shall be crossed out.
2. Contractor's initial update of SWP3 and any subsequent on-going modifications.
3. The credentials of the ECM proposed by the Contractor as being responsible for CGP and SWP3 compliance. Submittal shall include a letter delegating appropriate authority to the ECM. Upon
approval of the ECM, this letter shall be filed with the applicable Jurisdictional Entities.

4. The credentials of the environmental inspector(s) and/or third party environmental or engineering subcontractor designated by the Contractor to perform site inspections. Submittal shall include a letter delegating appropriate authority to the inspectors and/or subcontractor. Upon approval of the inspectors and/or subcontractor, this letter shall be filed with the applicable Jurisdictional Entities.

5. The proposed NOI or CSN at least 14 working days prior to commencement of site work. Contractor shall not submit NOI to TCEQ, or CSN to the Jurisdictional Entities, prior to receipt of review comments from the Contracting Officer’s Representative.

C. Product Data and Test Reports:

1. Product Data: Submit copies of manufacturer’s specifications and installation instructions or catalog information (“catalog cuts”) for products furnished under this section. Submit product samples if requested.

2. Test Reports: Materials testing laboratory test reports exhibiting gradation and other appropriate physical and chemical properties as specified herein for stone, rock, and gravel filter material for used in stabilized construction entrances, rock berms, stone ditch checks, or as part of storm sewer inlet protection measures.

1.7 QUALITY ASSURANCE

A. Comply with the appropriate codes and regulations promulgated by regulatory agencies, including the EPA, the TCEQ, Texas Department of State Health Services (DSHS), MS4, and all other applicable Jurisdictional Entities.

PART 2 - PRODUCTS

2.1 SILT FENCE

A. Geotextile Filter Fabric:

1. In accordance with AASHTO M288, the following requirements shall apply:

   a. Geotextile filter fabric weighing approximately 0.02 to 0.05 pounds per square foot.

   b. Fabric: Shall consist of long-chain synthetic polymers composed of at least 95 percent by weight of polyolefins or polyesters.

   c. Filter fabric shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

   d. Fabric edges shall be selvaged.

   e. Physical properties: All property values listed below shall be minimum average roll values in the weakest principle direction (or cross direction, as indicated) except for grab tensile elongation and apparent opening size. Grab tensile elongation and apparent opening size shall be maximum average roll values as per Table 01562 - 1.

2. Labeling, shipment and storage: In accordance with ASTM D4873, including the following:

   a. Each roll of filter fabric shall include a product label clearly showing the name of the manufacturer or supplier, the product and style name, the roll number, and shall state that the geotextile is in accordance with the manufacturer’s certification.

   b. Each roll of filter fabric shall be wrapped with a material to protect the geotextile from damage due to shipment, water, sunlight, and contaminants. The integrity of the protective wrapping shall be maintained during periods of shipment and storage.

   c. During storage, rolls of filter fabric shall be elevated off the surface of the ground and adequately covered to further protect them from site construction damage; precipitation; extended exposure to ultraviolet radiation; chemicals, including strong acids or bases; flames, including welding sparks; temperatures in excess of 160 degrees F.; and any other potentially damaging physical or environmental conditions.

B. Wire Backing Support:

1. Woven Wire Mesh:

   a. Mesh Size: 4x4 - W1.4 x W1.4 minimum.

   b. Wire Size: 14 gauge minimum.

   c. Coated in accordance with ASTM A116, Class 3.

2. Chain Link Fence Fabric:

   a. Wire Size: 9 gauge minimum.
b. Coated in accordance with ASTM A392, Class 2 or ASTM A 491.

3. Hog Wire:
   a. Opening Size: 6 inches x 6 inches.
   b. Galvanized in accordance with ASTM A641.

C. Posts:
   1. Steel, T-section or L-section.
      a. Length: 4 feet minimum.
      b. Weight: 1.3 pounds per linear foot minimum.
      c. Fabricated with ground anchor plate and lugs or projections for fastening wire backing support.
      d. Factory painted with rust resistant primer and finish coat, or galvanized in accordance with ASTM A641.
   2. Wood:
      a. Length: 4 feet minimum.
      b. Diameter: 3 inches minimum or nominal cross-section of 2 inches by 4 inches for pine, 2 inches by 2 inches for hardwoods.

D. Fasteners:
   1. For attachment of wire backing support to posts:
      a. Steel Posts: T-clips or ring wire fasteners, galvanized in accordance with ASTM A641.
      b. Wood Posts: Staples with a minimum 3/4 inch wide crown and 1/2 inch long legs, galvanized as above.
      c. Tie-wire may be used with either steel or wooden posts.
   2. For attachment of geotextile filter fabric to wire backing support:
      a. Fabric ties recommended by geotextile fabric manufacturer.
      b. Hog rings, galvanized in accordance with ASTM A641.
      c. Nylon cord may be used to attach filter fabric to top of wire backing.

2.2 STABILIZED CONSTRUCTION ENTRANCE


B. Crushed Stone or Rock:
   1. Hard, clean, stone. Concrete rubble may be used provided it is free of reinforcing materials.
   2. Diameter: 3 to 5 inches, gradation per ASTM C136.

C. Wash Rack (optional): If required, see Reference No. 4 (TxDOT) in Paragraph 1.2B. for specified materials.

2.3 ROCK BERM

A. Rock: Shall meet requirements stated in Paragraph 2.2B. above with the following additions and exceptions:
   1. Angularity: Maximum length to width ratio of 3:1.
   2. Diameter: 4 to 8 inches if rock berm is to be placed in a flowing streambed. 3 to 5 inches for all other locations.

B. Woven Wire Sheathing:
   1. Wire Size: 20 gauge minimum.
   2. Opening Size: 1 inch maximum.
   3. Galvanized in accordance with ASTM A641. PVC coating also allowable upon

2.4 STONE DITCH CHECK

A. Well-graded crushed Stone, Rock or Recycled Material:
   1. Clean, hard, crushed stone or rock.
   2. Recycled, crushed concrete rubble may be used only if free of reinforcing steel, debris, cement fines, and other substances that may contribute to storm water pollution.
   3. Stone, Rock or Recycled Concrete: Diameter shall range from 1-1/2 inches through a maximum in inches equal to three times the width of the drainage channel bottom in feet.
   4. Diameter: 2 inches by 2 inches minimum for hardwood. Larger cross-sectional dimensions required if pine is used.
2.5 PIPE INLET PROTECTION

A. Crushed Stone, Rock or Recycled Material:
   1. Clean, hard, crushed stone or rock.
   2. Recycled, crushed concrete rubble may be used only if free of reinforcing steel, debris, cement fines and other substances that could contribute to storm water pollution.
   3. Stone Riprap: Diameter shall be nominal 6 inches.
   4. Filter Stone: Diameter shall be 1-1/2 or 2 inches.

2.6 INLET PROTECTION

A. Provide inlet protection in accordance with NCTCOG - "Storm Water Quality Best Management Practices for Construction Activities". Four variations of applications for inlet protection are listed including Filter Barrier Protection, Block and Gravel Protection, Wire Mesh and Gravel Protection, and Excavated Impoundment Protection shown on S-4 in Specification Section M, with Detail ID 2120-2150. Inlet protection improperly used on a slope will cause inlet to be bypassed, forcing flows to continue the slope, and overloading inlets below. Provide protection inlets on slopes by means shown in SWP3; typically provide BMPs upstream of inlets.

2.7 EROSION CONTROL MATTING

A. Jute Mats:
   1. Jute mats shall be composed of a woven jute yarn, free of any dyes.
   2. Unit weight: Minimum 2.7 pounds per square yard per ASTM D3776.

B. Fiber Mats:
   1. Fiber mats shall be composed of wood or coconut husk (coir) fibers and may be encased in netting made of nylon, cotton, or other suitable materials.
   2. Unit weight: Minimum 1.2 pounds per square yard per ASTM D3776.
   3. Tensile strength: Minimum 40 pounds per ASTM D4632.
   4. Elongation: Maximum 35 percent per ASTM D4632.

C. Synthetic Mats:
   1. Synthetic mats shall be made of non-woven polyvinyl chloride or polypropylene monofilaments that are bonded together into a three-dimensional web-like material designed to serve as an erosion control and revegetation mat.
   2. Porosity: Minimum 85 percent.
   3. Unit weight: Minimum 11 ounces per square yard per ASTM D3776.
   4. Tensile strength: Minimum 25 pounds in all directions, as measured by ASTM D5735.

D. Staples: For use in anchoring down matting material.
   1. Size: Minimum 10 gauge wire.
   2. Length: 6 to 10 inches.
   3. Shall be galvanized or zinc coated to inhibit corrosion.

2.8 TEMPORARY SEEDING

Temporary Seed Mix: Avena spp (oats) at 20 lbs./acre (no mulch required) or as otherwise specified within the Project Technical Specifications.

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION INSPECTION

A. Prior to the commencement of any on-site activities, the Contractor shall schedule and conduct a pre-construction inspection.

B. In conjunction with the Contracting Officer’s Representative and the Authority’s Environmental Compliance Section, conduct a pre-construction inspection of existing facilities, structures, and environmentally sensitive areas in the vicinity of the Worksite. This inspection shall document the pre-construction condition of vegetation, streets, creeks, storm drainage, etc, that may be affected by the project. Document the inspection with photographs, sketches, and narratives and assemble into a pre-construction inspection report. Photographic documentation shall include vegetation densities. Photographs shall comply with Section 01345, “Construction Photographs”.

C. The pre-construction inspection shall include the MS4 located within and adjacent to the Worksite. Note: The purpose of this inspection is to
document pre-existing drainage issues/problems that could later result in a fine or penalty being awarded by the Jurisdictional Entity. Contractor shall note the following:

1. Storm drains, culverts, swales and other components of the MS4 shall be inspected to verify that they are free of floatable trash, silt, debris, and functioning as originally intended.

2. Storm drains or culverts that do not function or appear not to function as originally intended.


4. The presence of construction on adjacent, up-gradient, or down-gradient properties. If construction on other properties is noted, the Contractor shall photographically document the general condition of these properties and their compliance with storm water regulations.

5. Pre-existing off-site tracking from the Worksite or surrounding properties.

6. Potential pre-existing contamination (i.e. any areas of soil discoloration or distressed vegetation).

7. Any other pre-existing condition that, by its nature, could be construed as a violation of the CGP.

3.2 BMPs (STRUCTURAL CONTROL MEASURES)

A. Examine the site conditions in areas where soil erosion and sediment structural control measures are to be installed. BMPs, as defined in the SWP3, shall be implemented prior to the commencement of any soil disturbing activity. Correct unsatisfactory site conditions as necessary to install BMPs.

B. The CGP requires sediment basins at common drainage locations, where feasible, serving areas with 10 or more acres disturbed at one time within a common drainage basin. Contractor shall install sediment basins as required by the CGP or note site conditions that make basin construction infeasible.

C. The installation of stabilized construction entrances may require minor grading and site preparation. If a wash rack is also required, it shall be installed in accordance with the provisions stated in TxDOT Storm Water Management Guidelines for Construction Activities.

D. Manufactured erosion and sediment control products such as straw wattles, check dams, and a variety of storm sewer inlet protection devices, are now commercially available. In the event Contractor chooses an “off-the-shelf” product, it shall be responsible for ensuring that it adequately protects the quality of storm water discharged from the site.

E. Inlet protection devices shall incorporate an overflow weir in their design and installation. Note: Erosion bales (straw or hay bales) shall not be used as a structural control measure for inlet protection.

3.3 STABILIZATION PRACTICES

A. Undertake temporary or permanent stabilization practices in order to maintain cover over site soils or to establish cover as soon as practicable in disturbed areas. In meeting this requirement, the Contractor shall minimize the amount of existing vegetated area that is disturbed or denuded, especially those areas outside the immediate zone of construction activity. Prior to its disturbance, the Contractor shall document existing vegetation cover through photography or video.

B. Complete stabilization practices, including temporary or permanent seeding, mulching, hydro-mulching, sodding, and other practices shown in the SWP3 or otherwise on the plans, as stated in Section 02931, “Seeding and Sodding - Non-Irrigated Areas”. Seed/grass shall be watered as necessary for germination.

C. As required under the CGP, erosion control and stabilization measures shall be initiated immediately in portions of the site where construction activities have temporarily ceased and will not resume for a period exceeding 14 calendar days. Stabilization measures that provide a protective cover shall be initiated immediately in portions of the site where construction activities have permanently ceased. TCEQ defines “immediately” to be “… as soon as practicable, but no later than the end of the next work day, following the day when the earth-disturbing activities temporarily or permanently ceased.” Stabilization measures shall be completed within the timeframe required by the CGP.

D. Close-out and final acceptance: Close-out of the project shall not be accepted by the Authority until the requirements of the CGP and applicable Jurisdictional Entities have been fulfilled.

3.4 PROTECTION AND MAINTENANCE

A. In addition to the specific protection and procedures stated or referenced in the Baseline SWP3, the following provisions shall apply:

1. Contractor shall only allow those off-site discharges specifically identified in the CGP.
2. Once installed, BMPs shall be repaired or replaced at the expense of the Contractor and shall function as necessary to protect the quality of storm water discharged from the site.

3. Locations on the site adjacent to surface waterways, wetlands, or other environmentally sensitive areas, or off-site areas subject to vehicle tracking of sediments, shall receive the highest maintenance priority, followed by the protection of drainageways and storm sewer inlets and outfalls.

4. Stockpiles used for the temporary storage of topsoil, fill soil, rock, or related construction materials shall be protected by perimeter BMPs and/or covered to prevent exposure to storm water. Temporary seeding of stockpiles may also be acceptable. Stockpiles include materials located off-site which may be maintained for the project. Excess spoil and other materials shall be promptly removed from the site.

5. Fugitive dust, including dust generated from soil stabilization operations or vehicle tracking, shall be controlled at all times by using water or special purpose products commercially manufactured for this use. If water is used to control dust generation, any excess or runoff must first be routed to a sediment trapping device before being allowed to leave the site. See Section 01560, "Environmental Protection" for more information on dust control requirements.

6. Contractor shall implement appropriate BMPs as necessary to minimize off-site tracking of soil, sediment, and debris. BMPs may include construction entrance stabilization measures, frequent adjacent street cleaning, and vehicle and equipment wash rack areas. Additional or alternate BMPs may be necessary to control the generation of fugitive dust related to off-site tracking. Contractor is responsible for clean up of any eroded or tracked sediment from streets, storm sewers and adjacent properties at no expense to the Authority.

7. Construction staging areas, haul roads, jobsite office trailer locations, and vehicle and equipment parking areas that have more than 25 vehicle trips per day shall be graveled, as well as monitored for vehicle tracking and fugitive dust generation.

8. During project construction, Contractor shall clean out, remove, and properly disposal of any sediment deposits or debris which may accumulate in the storm sewer inlets, manholes or in other areas of the site storm sewer system up to the point of system outfall or connection with the MS4.

3.5 INSPECTION REQUIREMENTS

A. Contractor shall conduct inspections at least once every 7 days. The inspection shall occur on a specifically defined day. Contractor shall comply with any revision in inspection frequency required by applicable Jurisdictional Entities at no additional cost to the Authority.

B. Inspections shall include disturbed areas of the site, stockpiles and material storage locations, areas where temporary and permanent soil stabilization practices have been implemented, BMPs, and storm water discharge locations.

C. The ECM shall be responsible for overseeing and documenting the results of each inspection. Refer to Paragraph 1.4.D entitled "Environmental Compliance Manager" for inspection report requirements.

D. Contractor shall provide, install, maintain, and monitor a rain gauge approved by the Contracting Officer's Representative. Said rain gauge shall be located where it will collect a representative amount of rainfall received by the site.

E. Contractor shall immediately address any deficiencies in implementation and adherence to the provisions of the CGP and SWP3 as determined during site inspections. BMPs shall be repaired as required by the CGP. Alternative BMPs shall be implemented when, as determined by the ECM, a particular control measure has failed repeatedly or become ineffective in protecting the quality of storm water discharged from the site.

F. Periodic site audits, performed by the Authority, do not relieve the Contractor of the responsibility to perform regular inspection and maintenance activities for the BMPs employed on the site. The Authority's audits also do not relieve the Contractor of the duty to comply with the terms and conditions of the SWP3, the CGP, the Municipal Storm Water Discharge Permit of the Jurisdictional Entity, or any other local erosion and sediment control or storm water management regulations or ordinances.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. BMPs, soil erosion and sediment structural control measures and stabilization practices required under this section shall be measured, and paid at the lump sum for "Soil Erosion and Sediment Control" as installed in accordance with the relevant detail drawing and
accompanying notes shown in the plan, and shall include maintenance through the period of the work, and removal and properly disposal of surplus material at the completion of construction and final stabilization of the site, or as required by the Contracting Officer.

B. Rock Filter Dams. Rock filter dams shall be measured by the linear foot along the centerline of the top of the dam.

C. Pipe Inlet Protection shall be measured by the cubic yard.

D. Inlet Protection shall be measured by the each.

E. Construction Exits shall be measured by the square yard of surface area.

F. Temporary Sediment-Control Fence shall be measured by the linear foot.

G. Erosion Control Matting. Erosion control matting will be measured by the square yard of surface area

H. No separate measurement or payment shall be made for the relocation or maintenance of structural control measures for the Contractor's convenience or due to intermediate stages in the construction sequence.

I. No separate measurement or payment will be made for alternate BMPs installed when BMPs prove ineffective.

J. Temporary seeding and associated maintenance, if required, shall not be separately measured and shall be considered as incidental to the Contract, except as otherwise specified. Permanent seeding shall be paid as outlined under Section 02930, "Seeding and Sodding - Irrigated Areas", or Section 02931, "Seeding and Sodding - Non-Irrigated Areas", as applicable.

K. There shall be no separate measurement for payment under this Section for the installation, protection, or maintenance of BMPs, or for performing final stabilization, at off-site locations where materials or equipment are stored for this project.

4.2 CHANGES IN PROJECT SCOPE

A. Refer to General Provisions Paragraph, "Changes". In the event the Authority makes changes to the work such that additional BMPs are required or specific BMPs are rendered unnecessary, the Contractor shall make appropriate modifications to the SWP3 and site BMPs, as necessary. Changes to either the SWP3 or site BMPS resulting from changes to the work shall be considered incidental to the Contract.
### TABLE 01562-1

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Temporary Silt Fence</th>
<th>APPLICATION Stabilization/Reinforcement</th>
<th>Erosion Protection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Grab Tensile Strength, ASTM D4632, tbs.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(a) Principal Direction</td>
<td>125</td>
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<td>350</td>
</tr>
<tr>
<td>(b) Cross Direction</td>
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<td>n/a</td>
</tr>
<tr>
<td>2) Grab Tensile Elongation, ASTM D4632, percent</td>
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<td>20</td>
<td>20 max</td>
</tr>
<tr>
<td>3) Sewn Seam Strength, ASTM D4632, lbs.</td>
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<td>285</td>
</tr>
<tr>
<td>4) Trapezoidal Tear Strength, ASTM D4533, lbs.</td>
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<td></td>
</tr>
<tr>
<td>5) Puncture Strength, ASTM D4833, lbs.</td>
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<td>185</td>
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<tr>
<td>6) Mullen Burst Strength, ASTM D3786, lbs.</td>
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<td>620</td>
<td>620</td>
</tr>
<tr>
<td>7) Permittivity, ASTM D4491, 1/sec.</td>
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<td>0.2</td>
</tr>
<tr>
<td>8) Apparent Opening Size, ASTM D4751,</td>
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<td></td>
</tr>
<tr>
<td>9) U.S. Standard Sieve Size No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultraviolet Stability, ASTM D4355, percent</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10) Weight, oz/sq yd</td>
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<td>12</td>
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<tr>
<td>11) Thickness, mils</td>
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<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

*Note: Erosion protection here refers to use in permanent erosion control applications; for example, as an underlayment for riprap.

END OF SECTION 01562
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for maintaining an orderly flow of vehicular and pedestrian traffic through and around the areas affected by the Contractor's construction activity and protecting the public from incurring injury or property damage as a result of the Contract's construction operations.

B. For any occasion or event requiring special traffic control measures, the Contracting Officer will notify the Contractor in advance and the Contractor shall promptly comply and adopt necessary measures to ensure safe movement of vehicular and pedestrian traffic through work areas.

C. Details not shown on the Contract Documents and the approved Traffic Control Plans shall conform to the Texas Manual on Uniform Traffic Control Devices and the regulations of the jurisdictional authority.

D. Coordinate the Work in this Contract requiring traffic maintenance with traffic control procedures, requirements, and conditions for other contracts listed in the Contract Documents and as directed by the Contracting Officer.

E. Temporary decking over excavated areas is specified in Section 01533, "Temporary Decking".

1.2 REFERENCE STANDARDS

A. Texas Manual on Uniform Traffic Control Devices (TMUTCD).

B. US Department of Transportation, Federal Highway Administration (FHWA), Standard Alphabets for Highway Signs and Pavement Markings.

1.3 TRAFFIC CONTROL PLAN

A. The Vehicular and Pedestrian Traffic Control Plan or Plans (referred to herein as Traffic Control Plan) shall include the following information. Submit multiple plans as required to depict traffic control throughout each stage of construction. Refer to Article entitled "Submittals" herein for submittal requirements.

1. Vehicular including bicycles and pedestrian traffic routing, including detours.

2. Proposed location of barricades, lighting, signage, pavement markings, markers, signals, and other traffic control devices.

3. Details of nonstandard signs, including size of sign, letter size, type, and message.

4. Arrangements for access to buildings within and immediately adjacent to the construction site.

5. Arrangements for emergency exiting from buildings within and immediately adjacent to the construction site.

6. Anticipated traffic, bus zone, and driveway blockage resulting from construction operations. Include the anticipated loss of bus, passenger, and truck loading zones.

7. Locations where on-street parking will be permitted within the immediate vicinity of the site.

8. Arrangements for temporary passenger and commercial loading and unloading zones, and temporary bus stop zones, where existing zones will be blocked by construction activity.


10. Areas for material delivery and Contractor's staging areas access and egress points.

11. Locations of historic properties.

B. Draw the Traffic Control Plan to a scale of one inch equals 40 feet, and details in a larger scale, as necessary for clear understanding.

C. Submit with the Traffic Control Plan a list of telephone numbers and contact persons for those departments of the jurisdictional authority and others who shall be notified three days prior to scheduled street closure and as soon as possible prior to emergency access closure. Refer to Article entitled "Notifications" herein for more information.

D. If the Contract Drawings include suggested Construction Sequencing/Temporary Traffic Control Plans, the following provisions apply:

1. Upon review and acceptance by the Contractor, Contractor may use any suggested Construction Sequencing/Temporary Traffic Control Plans included in the Contract Drawings in obtaining the necessary approvals and permits from the jurisdictional authority.
2. If the Contractor desires to carry out construction activities differently than as designated in the Contract Drawings, he shall either submit copies of the appropriate Construction Sequencing/Temporary Traffic Control Plan drawings from the Contract Drawings, showing on the drawings any modifications he wishes to incorporate; or submit new drawings, showing alternate plans for sequencing construction activities and handling traffic, in accordance with the Traffic Control Plan submittal requirements described herein.

1.4 SUBMITTALS

A. Submit the proposed Traffic Control Plans described herein to the jurisdictional authority and Contracting Officer.

B. Schedule submittals of Traffic Control Plans which include the following closures or changes to traffic patterns sufficiently in advance of and obtain approval from the appropriate jurisdictional agency at least 30 calendar days prior to the time such closures and changes are scheduled to be made.

1. Any full closure of a street proposed to be closed to all but construction activity and emergency traffic.

2. Partial street closures for an extended period of time. "Extended period of time" is defined as overnight, weekends, holidays, or periods of inclement weather.

3. Temporary closing to traffic of part of any street, sidewalk or other access, or other changes to traffic patterns

C. Do not cause traffic, sidewalk, or bus zone disruptions before receiving approval of the Traffic Control Plan from the Contracting Officer, and applicable jurisdictional authorities.

D. Submit notice of intent to permanently close existing street to the jurisdictional authority, with copy to Contracting Officer, a minimum of 30 days in advance of each closing. Refer to Article entitled “Notifications” herein for detailed requirements.

1.5 GENERAL MAINTENANCE OF TRAFFIC REQUIREMENTS

A. Keep the areas adjacent to the construction site in such condition that traffic will be accommodated safely. Provide and maintain traffic control devices and services both inside and outside the project limits as needed to facilitate traffic guidance. Traffic control devices and services shall conform to the requirements set forth in the Contract Documents and in the TMUTCD.

B. Traffic Control Devices: Provide, erect, place, maintain, and adjust traffic control devices necessary to alert and forewarn the public of construction activities and potential hazards associated with them at all times. Do not work on or adjacent to the roadway until all necessary traffic control devices are in place.

1. Traffic control signs: Provide temporary traffic control signs as shown in the approved Traffic Control Plans and in compliance with TMUTCD standards which are standard signs of the jurisdictional authority. Adequately post each change in location of traffic with a minimum of two signs mounted on temporary or standard posts. Provide all signage in accordance with the requirements of TMUTCD.

2. Pavement Markings and Markers: Provide necessary temporary pavement markings and markers required in connection with temporary street work. Remove or obliterate existing or temporary pavement markings whenever vehicular traffic is moved to newly available pavement areas or to different traffic patterns.

3. Redirecting traffic: Directing, channeling, and shifting of traffic lanes as well as barricading of traffic in connection with this work will be subject to approval of the jurisdictional authority.

C. Replace any devices provided under this section that are lost, stolen, destroyed, or deemed unacceptable while their use is required on the Project without additional compensation. This includes services, foundations, utilities, and similar items that are disturbed, destroyed or otherwise rendered unusable during construction.

D. During nonworking hours and following completion of a particular construction operation, signs, except those necessary for the safety of the public, shall be removed or entirely covered with plywood sheeting or other material approved by the Contracting Officer so that the sign panel will not be visible.

E. Keep retroreflective sheeting clean on signs, drums, barricades, and other devices. Promptly correct scratches, rips, and tears in the sheeting.
F. If a vehicular or pedestrian signal within the Work area goes dark or fails to function properly, the Contractor shall:

1. Immediately call Police for any required Police control of the intersection and provide temporary flaggers until Police arrives.

2. Immediately notify the concerned office of the jurisdictional authority. (i.e., for the City of Dallas, "concerned office" is the Maintenance Division of Department of Transportation).

3. Immediately notify the Contracting Officer.

4. If signal failure is a result of the Contractor's Work, the Contractor shall be responsible for all costs incurred.

1.6 TRAFFIC CONTROL SYSTEM REQUIREMENTS

A. Schedule operations to minimize potential traffic backups. The Contracting Officer may suspend the performance of the work, either in whole or in part, should an inordinate traffic delay occur during a construction operation.

B. Maintain vehicular traffic at all locations to the greatest extent possible and reduce and reroute traffic only for the shortest time possible consistent with effective construction operations.

C. The required travel lanes shall not be blocked by the Contractor's activities, including trucks delivering materials.

D. Maintain the existing directional operation of the street system at all times, unless specially designated otherwise in the Contract Documents.

E. Make provisions to minimize disruption to adjacent properties including construct of temporary facilities to allow business functions to be maintained.

F. Temporary Street Closure Restrictions: No more than one complete street closure will be allowed at any particular time. Show proposed temporary closing to traffic of part of any street, sidewalk or other access, and other traffic pattern changes on the Traffic Control Plan.

G. Material Delivery Areas and Staging Area Access and Egress: Material deliveries and other related trucking activities shall occur in the Contractor's protected work area. Refer to Section 01500, "Temporary Facilities and Services", for provisions regarding staging areas. Material delivery areas and access and egress points of staging area are subject to the approval of the Contracting Officer. Coordinate access and egress with the Contracting Officer.

H. Traffic signal systems shall remain in operation at all times except as approved by the Contracting Officer. Obtain Contracting Officer's and jurisdictional authority's approval of temporary traffic signals prior to use of temporary traffic signals. Temporary signals shall be in compliance with Section 02590, "Traffic Signals".

I. Maintain existing street lighting wherever possible. Obtain approval from the local jurisdictional authority prior to disconnecting or relocating existing street lighting. If relocating existing street lighting is required or proposed to accommodate proposed construction, coordinate work with the Contracting Officer and jurisdictional authority to the satisfaction of both. Illuminate areas where street lighting is cut off by equipment, barriers, and similar obstructions.

J. Work in or near Airports: Equipment type and heights, sign heights, hours of construction and sequencing, illumination and signal work in or near airports shall meet clearance and lighting restrictions of the Federal Aviation Administration and airport owner.

K. Illuminate nighttime construction operations by use of a lighting system approved by the Contracting Officer and approved by the jurisdictional authority, if applicable. Position and operate the nighttime system to preclude glare to the approaching traveling public. Refer to Section 01010, "Summary of the Work", for work hour provisions.

L. Flaggers: Provide flaggers where required by approved Traffic Control Plan. When necessary, provide flaggers for controlling movement of equipment and materials to the worksite.

1. Flaggers shall be physically and mentally qualified, trained in their duties, efficient, and courteous, as outlined in the TMUTCD. Identify each flagger on duty with appropriate and distinctive apparel, including orange retroreflective vest and hat. Equip each flagger on duty with a highly visible, retroreflective "Stop/Slow" hand sign conforming to TMUTCD. Flags will not be permitted unless approved by the Contracting Officer. Flaggers shall be fluent in English so that verbal instructions to motorists may be provided.

2. Provide approved equipment for two-way radio communications between flaggers when they are not in plain view of each other, and make such equipment available...
to the Contracting Officer for use as may be necessary.

M. Traffic Pattern Changes: Prior to changing traffic patterns, provide the following:

1. Adequate personnel and equipment to remove and set up traffic control devices as approved by the Contracting Officer.
2. Acceptable two-way radio communications network other than citizen band units.
3. Remove paving equipment and related equipment from the travel lane.

N. Use Type A flashing warning lights only on "ROAD CONSTRUCTION AHEAD" signs, on barricades and drums (used singly), and on the first two barrier units or drums used in a series for delineation. Mount Type C steady burn warning lights on channelizing devices and use them in a series for delineation (except that the first two devices shall have Type A warning lights).

O. Deviations from Approved Traffic Control Plans: Deviations from approved Traffic Control Plans will be allowed for bona fide emergencies only and as approved by the jurisdictional authority and Contracting Officer.

1.7 MAINTENANCE OF ACCESS AND EGRESS

A. Maintain vehicular and pedestrian access to residences, businesses (including public buildings), and properties at all times. Where construction activities will require the temporary closures of building entrances, arrange access with the affected residents and establishments.

B. Maintain emergency access to and from buildings within and immediately adjacent to the construction site.

C. Maintain local access for emergency traffic such as police, fire, medical, and disaster units at all times. Maintain an emergency response route at all times which includes the following:

1. A 25 foot inside and 45 foot outside turn radius for Fire Department vehicles.
2. Provisions for emergency vehicles traveling two ways in any lane. Such provisions include:
   a. Maintenance of a non-skid surface on steel plates on the roadway and on steel plates on both sides of cross-street approaches.
   b. No stacking of steel plates.
   c. Maintenance of smooth transitions between steel plates and the roadway surface.
   d. Secure steel plates in position and re-secure immediately if steel plates become dislodged.
3. Provide smooth transitions between permanent paving, temporary decking, and temporary pavement to reduce jolts and bumps within the construction zone.

D. Maintain pedestrian movements through the construction areas as follows:

1. Unless noted otherwise, a minimum of three pedestrian crosswalks at each intersection at all times.
2. No residence or business shall be denied pedestrian access at any time (without owner's consent). Structures with multiple points of access (especially those with access from adjacent streets) may be subjected to restricted access with the prior written consent of the property owner (or building management if so empowered).
3. In areas where the removal of existing sidewalks is necessary, maintain access to adjacent businesses, entrances, and properties by temporary level or sloped walkways having a width of not less than 6 feet.
4. Include provisions for the safe movement of mobility and sight-impaired individuals, including temporary ramps.
5. Construct temporary walking surfaces of non-skid materials.
6. Provide fencing or similar confining barrier to prevent errant pedestrian entry into work areas, restricted areas, and vehicular traveled way.

1.8 SEQUENCING

A. Upon completion of a segment of work in the streets, restore traffic to a normal flow as soon as possible. The impact of work activities at intersections shall be kept to a minimum and restoration of cross-street traffic flow at intersections shall be a priority item.

B. Contractor's surface operations: Schedule surface operations so as not to be working intermittently
throughout the area. Carefully schedule excavation or construction activities and vigorously pursue to completion as required to permit opening of street areas to traffic as soon as possible without unnecessary delays.

C. Pavement Reconstruction: Excavate and construct intersections in stages as shown on approved Traffic Control Plan. Phase construction so that the required number of traffic lanes on each street are provided at all times during these operations.

1.9 NOTIFICATIONS

A. Coordination Notifications:

1. Notify the Authority and adjacent property owners and business establishments a minimum of 3 working days prior to work which will disrupt normal traffic and pedestrian flow patterns in their immediate areas.

2. Refer to Section 01010, “Summary of Work” for work sequence and constraints as supplementary requirements.

B. Street Closures Notifications:

1. Permanent Closures: Authorization for permanent closure of streets indicated on the Contract Drawings will be obtained by the Agency in the process of final plan approval by the jurisdictional authority and related Governmental action. However, the Contractor shall submit separate notifications of intent to physically close each of these streets as specified under the Article entitled “Submittals,” herein.

2. Temporary Closures: Three (3) working days prior to any street closure, partial street closure, or, as soon as known, for temporary emergency access closure, notify the jurisdictional authority’s applicable departments such as transportation, traffic, fire, police, sanitation, and ambulance service (if notification separate from fire department is required) and DART bus operations. Contract Specifications will list applicable departments and telephone numbers. Verify telephone numbers and determine the appropriate contact person for each department and include this information with its Traffic Control Plan submittal. Contact DART bus operations at (214) 828-6838.

PART 2 - PRODUCTS

2.1 TRAFFIC CONTROL DEVICES

A. Traffic control devices shall conform to the requirements set forth herein and as indicated elsewhere in the Contract Documents. Details not covered by the Contract Documents shall conform to the applicable provisions of the TMUTCD.

B. Retroreflective Material: Sign panels, barricades, cones, drums, vertical panels, and flagger paddles shall have retroreflective sheeting meeting the minimum requirements for Type C retroreflective material, as described in TMUTCD.

C. Sign Panels: Construction warning sign panels shall be orange with black legend unless otherwise indicated in the TMUTCD. Regulatory signs used during construction operations shall be fabricated in the colors specified in the TMUTCD.

1. Sign panels: Fabricate sign panels from 0.75-inch thick plywood or other material acceptable to the Contracting Officer with retroreflective sheeting on the face side. Panels shall be true, square, and free from warping, bending, blemishes, and punching. Drill holes prior to final surface preparation and application of retroreflective sheeting.

2. Sign Legends: Text on temporary traffic control signs shall be 4 inches series D or larger, as specified in FHWA Standard Alphabets for Highway Signs and Pavement Markings.

D. Sign Posts: Fabricate sign posts from untreated soft wood, or other materials acceptable to the Contracting Officer.

E. Barricades: Construct Type II and III barricades of wood or plastic. The Type II barricades shall collapse when tipped over. Barricade markings shall conform to TMUTCD.

F. Cones: Cones shall be a minimum of 18 inches in height with a broadened base and shall be capable of withstanding impact without damage to the cones or vehicles. Cones shall be orange colored and highly visible both in daylight and darkness. Cones shall be capable of remaining upright during normal traffic flow and wind conditions in the area where they are used. Retroreflection requirements shall be in accordance with TMUTCD.

G. Vertical Panels: Construct vertical panels of wood or other material acceptable to the Contracting Officer.
H. Drums: Drums shall be plastic and shall be approximately 36 inches in height and have a minimum diameter of 18 inches. Drum markings shall conform to TMUTCD.

I. Temporary Guardrail: Temporary guardrail shall conform to TMUTCD. Used guardrail material will be permitted, subject to the approval of the Contracting Officer.

J. Temporary Concrete Barriers: Temporary concrete barriers shall conform to the requirements of TMUTCD. The barrier shall have white or yellow reflector units as applicable, approximately 1 inch by 3 inches in size, firmly mounted to the top of each barrier, at ten-foot centers.

K. Warning Lights (flashing or steady burn): Warning lights shall be Type A (low intensity flashing) or Type C (steady burn), as specified in the plans and meeting the requirements of the TMUTCD.

L. Provide temporary pavement markings and markers in conformance with Section 02580, "Pavement Markings and Delineators".

M. Provide the temporary pavement composition and patching and related aggregate base conforming to the requirements of the jurisdictional authority.

PART 3 - EXECUTION

3.1 GENERAL

A. Execute Traffic Control Plans and comply with other traffic maintenance requirements as specified herein.

B. Prior to the start of construction operations, install pavement markings and markers and erect signs, barricades, and other traffic control devices as required by the Contract Documents and approved Traffic Control Plans. Operate traffic control devices only when they are needed, and only those devices that apply to conditions actually in existence shall be used. Cover existing signs to the satisfaction of the Contracting Officer, whether signs are permanent or temporary, that conflict with the traffic operations proposed for the current stage of construction. Uncover signs as soon as traffic conditions warrant their use.

C. Remove existing pavement markings which conflict with proposed pavement markings for a particular phase of construction. Perform removal by sandblasting or other approved method that does not materially damage the surface or texture of the pavement. Make the removal pattern in an uneven shape that does not perpetuate the outline of the removed markings. Repair damage to the surface at the Contractor's expense using methods acceptable to the Contracting Officer. Remove accumulations of sand or other material that might constitute a traffic hazard. Upon completion, lightly coated with a coal tar emulsion (or approved equal) sandblasted areas on bituminous surfaces.

D. Equipment Storage: During non-work hours, park equipment either in the staging areas, or at least 30 feet from the edge of lanes open to the public. Where due to land features or right-of-way, it is not feasible to meet these restrictions, and work is expected to resume within 24 hours, park equipment (except rubber-tire equipment) a minimum of 10 feet from the edge of open lanes, as approved by the Contracting Officer. Place three or four Type II barricades, with Type A warning lights, on the pavement side of the equipment. Park rubber-tire equipment a minimum of 30 feet from traffic lanes open to the public or store at approved staging areas.

E. Temporary pavement and patching: Construct, maintain and remove temporary pavement, patching, and aggregate bases required to safely and expeditiously handle vehicular and pedestrian traffic within or adjacent to the Worksite.

F. Upon completion of the Work, unless directed otherwise, remove temporary construction and installations specified in this Section, clean up, and restore area. Include restoration of facilities to their original condition or better.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section will be paid for on a lump sum basis for "Maintenance and Control of Traffic" wherein no measurement will be made.

B. Warning devices, flaggers, signs and lights, barricades, and other precautionary measures in regard to installation of temporary decking, water distribution systems, storm sewer systems, sanitary sewer systems, and traffic signal systems will be considered included in lump sum and unit prices paid for temporary decking and the respective utility system.

C. Temporary pavement markings and temporary reflectorized traffic buttons will not be paid for separately, but will be considered subsidiary to the work of this Section.

D. Asphaltic concrete pavement and aggregate bases for temporary pavement will not be measured for payment, but will be considered subsidiary to work of this Section.
E. Temporary decking specified under Section 01533, "Temporary Decking", required for maintenance of traffic will be paid for under Section 01533, "Temporary Decking".

F. Temporary traffic signals will be paid for in accordance with Section 02590, "Traffic Signals".

END OF SECTION 01570
SECTION 01580
PROJECT SIGNS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work specified in this section includes providing, displaying, and subsequently removing project signs and supplements the Addendum to General Provisions Paragraph, "PROJECT SIGNS".

1. Project signs displayed at the Worksite shall be as specified herein and shown on the Contract Drawings and as directed by the Contracting Officer.

B. Maintain the project signs and supports, keep clean, repair deterioration and damage throughout the duration of the Contract.

C. The following shall not be displayed at the Worksite:

1. Separate Contractor's, subcontractor's, or supplier's signs or advertisements.

2. Signs which flash, blink, rotate, or otherwise draw unusual attention, except where required by safety regulations.

1.2 SUBMITTALS

A. Submit shop drawings showing size of sign, complete layout, lettering and size, and colors.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Project signs shall be fabricated from the following materials:

1. Plywood face: High-density overlay type, with overlay each side, 3/4 inch nominal plywood thickness.

2. Paint: Exterior, gloss, alkyd enamel. Provide two coats on sign faces, backs, and edges, and one coat on posts.

3. Wood posts: Douglas fir, S4S, nominal four inches by four inches, length as required. Paint the entire post. Provide posts in sizes and depths of embedment as specified.

4. Sign may be mounted otherwise if approved by the Contracting Officer.

B. Lettering shall conform to the following requirements:

1. Type: Lettering shall be of the "Futura" typeface (refer to the Contract Drawings for requirements).

2. Letter size: Proportioned as shown in the Contract Drawings.

3. Colors: As indicated in the Contract Drawings and approved.

4. Symbols: Use only those symbols shown in the Contract Drawings.

2.2 FABRICATION AND INSTALLATION

A. Sign panel: Cuts and edges shall be square, clean, with defects patched before painting.

B. Image: Symbol or type may be screened or hand painted. No screen patterning, paint build-up, bleed-thru, or drips and runs will be allowed. Hand-made patterns must be carefully cut and true to the symbols provided therein. Only clear, crisp sign painting is acceptable. Hand-painted typography shall be true to the font design.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Posts: Sign posts shall be embedded in compacted earth three feet minimum.

B. Locate project sign at the direction of the Contracting Officer.

C. Provide and install project signs as shown on the Contract Drawings and as directed, within 30 days after Notice to Proceed (NTP).

3.2 REMOVAL

A. Remove sign, framing supports, and foundation at completion of Project and restore the area.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, "General Requirements".

END OF SECTION 01580
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes administrative and procedural requirements for the selection of products for use in the Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; product substitutions; and comparable products.

B. Administrative procedures for handling requests for substitutions made after award of Contract are included in Section 01630, "Product Substitution Procedures".

C. Procedures for receiving and installing products furnished by the Authority are included in Section 01640, "Authority-Furnished Materials and Equipment".

1.2 Definitions

A. Products: Items purchased for incorporating into the work, whether purchased for the Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.

1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation, shown or listed in manufacturer's published product literature that is current as of the date of the Contract Documents.

2. New Products: Items that have not previously been incorporated into another project or facility, except that products consisting of recycled-content materials are allowed, unless explicitly stated otherwise. Products salvaged or recycled from other projects are not considered new products.

3. Comparable Product: Product that is demonstrated and approved through the submittal process, or where indicated as a product substitution to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of the specified product.

B. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor. Refer to Section 01630, "Product Substitution Procedures".

C. Basis-of-Design Product Specification: A specific manufacturer's product named and accompanied by the words "basis of design," including make or model number or other designation, to establish the significant qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics for purposes of evaluating comparable products of other named manufacturers.

D. Manufacturer's Warranty: Preprinted written warranty published by the individual manufacturer for a particular product and specifically endorsed by the manufacturer to the Authority.

E. Special Warranty: Written warranty required by or incorporated into the Contract Documents, either to extend the time limit provided by the manufacturer's warranty or to provide more rights for the Authority.

1.3 QUALITY ASSURANCE

A. Compatibility of Options: If the Contractor is given the option of selecting between two or more products for use on the Project, the product selected shall be compatible with products previously selected, even if previously selected products were also options.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft. Comply with the manufacturer's written instructions.

1. Schedule delivery to minimize long-term storage at the Project site and to prevent overcrowding of construction spaces.

2. Coordinate delivery with installation time to ensure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.

3. Deliver products to the Project site in an undamaged condition in the manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.

4. Inspect products on delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected.
PRODUCT REQUIREMENTS

5. Store products to allow for inspection and measurement of quantity or counting of units.

6. Store materials in a manner that will not endanger Project structure.

7. Store products that are subject to damage by the elements under cover in a weather tight enclosure above ground, with ventilation adequate to prevent condensation.

8. Comply with the product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.

9. Protect stored products from damage.

1.5 ASBESTOS

A. The asbestos restrictions and documentation requirements found in TX Regulation 25 TAC 295.34(i) and (j) shall apply to work of the Contract including those areas of the work classified as public buildings and areas not classified as public buildings. The additional restriction shall apply: Asbestos containing materials or parts shall not be incorporated in the work except when there is no alternative material or part.

B. When use of asbestos containing material is incorporated in the work, the following documentation provision shall apply in addition to the requirements of TX Regulation 25 TAC 295.34(i) and (j): Contractor shall submit documentation, satisfactory to the Contracting Officer, showing that there is no alternative material or part.

1.6 PRODUCT WARRANTIES

A. Warranties specified in other Sections shall be in addition to, and run concurrently with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of obligations under requirements of the Contract Documents.

B. General Warranty: Special warranties specified in each section shall not deprive the Authority of other rights the Authority may have under other provisions of the Contract Documents and shall be in addition to, and run concurrently with, other warranties made by the Contractor under requirements of the Contract Documents.

C. Special Warranties: Prepare a written document that contains appropriate terms and identification, ready for execution. Submit a draft for approval before final execution.

1. Manufacturer's Standard Form: Modified to include Project-specific information and properly executed.

2. Refer to Divisions 2 through 16 Sections for specific content requirements and particular requirements for submitting special warranties.

D. Submittal Time: Comply with requirements in Section 01770, "Contract Closeout".

PART 2 - PRODUCTS

2.1 PRODUCT SELECTIONS

A. General Product Requirements: Provide products that comply with the Contract Documents, that are undamaged and, unless otherwise indicated, that are new at time of installation.

1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.

2. If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other projects.

3. The Authority reserves the right to limit selection to products with warranties not in conflict with requirements of the Contract Documents.

4. Where products are accompanied by the term "as selected," the Contracting Officer will make the selection.

5. Where products are accompanied by the term "match sample," the sample to be matched will be made available by the Contracting Officer. The product match shall be subject to the approval of the Contracting Officer.

B. Descriptive Specification Requirements: Where Specifications describe a product or assembly, listing exact characteristics required, without use of a brand or trade name, provide a product or assembly that provides the characteristics and otherwise complies with Contract requirements.
C. **Performance Specification Requirements:** Where Specifications require compliance with performance requirements, provide products that comply with these requirements, and that are recommended by the manufacturer for the application indicated. Where the product is specified for a specific application, general overall performance is also required.

1. Manufacturer's recommendations may be contained in published product literature or by the manufacturer's certification of performance.

D. **Compliance with Standards, Codes and Regulations:** Where Specifications only require compliance with imposed code, standard or regulation, select product that complies with standards, codes or regulations specified.

E. **Visual Matching Specification:** Where Specifications require matching an established sample, select a product (and manufacturer) that complies with requirements and matches the Contracting Officer's sample. The Contracting Officer's decision will be final on whether a proposed product matches satisfactorily.

1. If no product available within specified category matches satisfactorily and complies with other specified requirements, comply with provisions of the Contract Documents on "substitutions" for selection of a matching product.

F. **Visual Selection Specification:** Where Specifications include the phrase "as selected from manufacturer's colors, patterns, textures" or a similar phrase, select a product (and manufacturer) that complies with the specified requirements.

1. **Standard Range:** Where Specifications include the phrase "standard range of colors, patterns, textures" or similar phrase, Contracting Officer will select the color, pattern, or texture from the manufacturer's product line that does not include premium items.

2. **Full Range:** Where Specifications include the phrase "full range of colors, patterns, textures" or similar phrase, the Contracting Officer will select the color, pattern, or texture from the manufacturer's product line that includes both standard and premium items.

### 2.2 **PRODUCT OPTIONS**

A. For Products specified by naming a minimum of three manufacturers with brand names or model numbers, select one of products and manufacturers named, which complies with Contract Documents.

1. Requests for manufacturer's products not listed must be submitted as Substitutions.

B. For Products specified by naming only one Product or manufacturer, Contractor must submit a request for substitution for a Product or manufacturer not specifically named.

C. For Products specified by naming only one Product and manufacturer and indicated as "no substitute", there is no option.

D. For Products specified only by reference standard, select a product meeting that standard.

E. For Products specified as Basis-of-Design Products: Where Specification paragraphs or subparagraphs titled "Basis-of-Design Product" are included and also introduce or refer to a list of manufacturers' names, provide either the specified product or a comparable product offered by one of the other named manufacturers. Drawings and Specifications indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with the provisions in the "Comparable Products" Paragraph under the Article entitled "Definitions" to obtain approval for use of an unnamed product.

### PART 3 - EXECUTION

#### 3.1 **GENERAL INSTALLATION PROVISIONS**

A. Comply with manufacturer's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements contained in the Contract Documents.

B. Inspect materials or equipment immediately upon delivery and again prior to installation. Reject damaged and/or defective items.

C. Provide attachment and connection devices, and methods necessary for securing work. Secure work true to line and level. Allow for expansion and building movement.

D. Provide uniform joint widths in exposed work. Arrange joints in exposed work to obtain the best visual effect. Refer questionable choices to the Contracting Officer for final decision.
E. Recheck measurements and dimensions before starting each installation.

F. Install each component during weather conditions and Project status that will ensure the best possible results. Isolate each part of the completed construction from incompatible material as necessary to prevent deterioration.

G. Where mounting heights are not indicated, install individual components at standard mounting heights recognized within the industry, including ADA, for the particular application indicated. Refer questionable mounting height decisions to the Contracting Officer for final decision.

H. Handle, install, connect, clean, condition and adjust products in accordance with manufacturer's instructions and in conformity with specified requirements.

   1. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with the Contracting Officer for clarifications.

   2. Do not proceed with work without clear instructions.

I. Perform work in accordance with manufacturer's instructions. Do not omit any preparatory step or installation procedure unless specifically modified or exempted by the Contract Documents.

J. Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01600
PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section specifies administrative and procedural requirements for handling requests for substitutions made after award of the contract.

1.2 DEFINITIONS
A. Definitions in this Article do not change or modify the meaning of other terms used in the Contract Documents.

B. Substitutions: Requests for changes in products, materials, equipment, and methods of construction required by Contract Documents proposed by the Contractor after award of the contract are considered requests for substitutions. The following are not considered substitutions:

1. Revisions to Contract Documents requested by the Authority or the Contracting Officer.
2. Specified options for products and construction methods included in the Contract Documents.
3. Contractor's determination of and compliance with governing regulations and orders issued by governing authorities.
4. Value engineering change proposals. Refer to the General Provisions Paragraph, "VALUE ENGINEERING".

1.3 SUBMITTALS
A. Submit three copies of each request for product substitution complete with a properly executed form and all supporting data.

B. Substitution Requests: Identify product or fabrication or installation method to be replaced. Include the applicable Specification Section number and title, and drawing numbers and titles.

1. Substitution Request Form: Use form provided at end of this Section.
2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:
   a. Statement indicating why the specified material or product cannot be provided.
   b. Coordination information, including a list of the changes or modifications needed to other parts of the work and to the construction performed by Authority and separate contractors that will be necessary to accommodate the proposed substitution.
   c. Detailed comparison of significant variances created by the proposed substitution with those of the work specified. Significant variances may include attributes such as performance, weight, size, durability, visual effect, or other specific features and requirements indicated.
   d. Product Data, including drawings and descriptions of products, and fabrication and installation procedures.
   e. Samples, where applicable or requested.
   f. List of similar installations for completed projects with project names and addresses and names and addresses of architects/engineers and owners.
   g. Material test reports from a qualified testing laboratory indicating and interpreting test results for compliance with requirements indicated. Refer to Section 01450, "Quality Control", for requirements for Contractor's qualified testing laboratory.
   h. Research/evaluation reports evidencing compliance with building code in effect for Project, from a model code organization acceptable to authorities having jurisdiction.
   i. Detailed comparison of Contractor's Construction Schedule using the proposed substitution with products specified for the work, including its effect on the overall contract time. If specified product or method of construction cannot be provided within the contract time, include a letter from the manufacturer, on the manufacturer's letterhead, stating the lack of availability or delays in delivery.
   j. Cost information, including a proposal for the change, if any, in the contract sum.
   k. Contractor's certification that proposed substitution complies with requirements in the Contract Documents and is appropriate for the applications indicated.
   l. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of
the proposed substitution to produce indicated results.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

A. Bids shall be based upon providing materials and products, identified in these Specifications or indicated on the Drawings.

B. Contractor's submittal and the Contracting Officer's acceptance of shop drawings, product data or samples for construction activities not complying with the Contract Documents does not constitute an acceptable or valid request for substitution, nor does it constitute approval.

C. Timing: The Contracting Officer will consider requests for substitution if received within 60 days after the Notice to Proceed. Requests received after that time may be considered or rejected at the discretion of the Contracting Officer.

D. Conditions: The Contracting Officer will consider a Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, the Contracting Officer will return requests without action, except to record noncompliance with these requirements:

1. The requested substitution offers the Authority a substantial advantage in cost, time, energy conservation, or other considerations, after deducting any additional costs or responsibilities the Authority must assume. The Authority's additional responsibilities may include redesign and evaluation services, increased cost of other construction to the Authority, and similar considerations.

2. Requested substitution does not require extensive revisions to the Contract Documents.

3. Requested substitution is consistent with the Contract Documents and will produce the indicated results.

4. Substitution request is fully documented and properly submitted.

5. Requested substitution will not adversely affect the Contractor's Construction Schedule.

6. Requested substitution has received necessary approvals of authorities having jurisdiction.

7. Requested substitution is compatible with other portions of the work.

8. Requested substitution has been coordinated with other portions of the work.

9. Requested substitution provides the specified warranty.

10. If requested substitution involves more than one contractor, requested substitution has been coordinated with the other contractors, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

E. Burden of proof of equality rests with the Contractor.

F. By making request for substitution, the Contractor:

1. Represents and warrants that the Contractor has personally investigated the proposed substitution product and determined that it is equal to or superior in all respects to the one specified;

2. Represents and warrants that Contractor will provide the same warranties or bonds for the substitute that the Contractor would have provided for the one specified.

3. Certifies that cost data presented is complete and includes all related costs under this Contract, except for Contracting Officer's redesign cost, and waives all claims for additional costs related to the substitution which may subsequently become apparent; and

4. Will coordinate installation of the accepted substitute, making such other changes as may be required to make the work complete in all respects.

G. The Contracting Officer will review requests for substitutions with reasonable promptness, and notify the Contractor, in writing, of decision to accept or reject the requested substitution.

H. The Contracting Officer reserves the right to accept or reject proposed substitutions. Each request shall state the amount of savings, if applicable, to the Authority, if the substitution is accepted.

I. Cost of testing required for analysis of the proposed substitution shall be paid for by the Contractor at a testing agency selected and approved by the Contracting Officer.

J. Should the substitution be accepted, the Contractor shall be responsible for making the necessary adjustments to the Work which may be affected as result of the substitution at no additional cost to the Authority.

K. Contractor warrants that the substituted material or system will perform the same as the originally specified material or system would have performed. Should the accepted substitution fail to perform as required, the Contractor shall replace the substitute material or system with the one specified and bear the costs incurred thereby.
PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01630
SUBSTITUTION REQUEST

Project: ___________________________ Substitution Request Number: ___________________________

To: ___________________________________________________________

From: ___________________________ Date: ___________________________

Re: ___________________________ Contract For: ___________________________

Specification Title: ___________________________ Description: ___________________________

Section: _________ Page: _________ Article/Paragraph: ____________

Proposed Substitution: __________________________________________

Manufacturer: ___________________________ Address: ___________________________ Phone: ___________________________

Trade Name: ___________________________ Model No.: ___________________________

Installer: ___________________________ Address: ___________________________ Phone: ___________________________

History: ☐ New product ☐ 2-5 years old ☐ 5-10 yrs old ☐ More than 10 years old

Differences between the proposed substitute and the specified product:

☐ Point-by-point comparative data attached.

Reason for not providing the specified item: ___________________________

Similar Installation:

Project: ___________________________ Designer: ___________________________

Address: ___________________________ Owner: ___________________________

Date Installed: ___________________________

Proposed substitution affects other parts of the work: ☐ No ☐ Yes; explain ___________________________

Savings to Authority for accepting the substitution: ___________________________ ($ ____________).

Proposed substitution changes to contract time: ☐ No ☐ Yes [Add] [Deduct] ____________ days.

Supporting Data Attached: ☐ Drawings ☐ Product Data ☐ Samples ☐ Tests ☐ Reports ☐

Page 1 of 2

Form 1630
The Undersigned certifies:

- Proposed substitution has been fully investigated and is determined to be equal or superior in all respects to the specified product.
- Same warranty will be furnished for the proposed substitute as for the specified product.
- Same maintenance service and source of replacement parts, as applicable, is available.
- Proposed substitution will have no adverse effect on other trades and will not affect or delay scheduled progress.
- Cost data as stated above is complete. Claims for additional costs related to accepted substitution, which may subsequently become apparent are to be waived.
- Proposed substitution does not affect dimensions and functional clearances.
- Payment will be made for changes to design, including A/E design, detailing, and construction costs caused by the substitution.
- Coordination, installation, and changes in the work as necessary for the accepted substitution will be completed in all respects.

Submitted by: ____________________________
Signed by: ________________________________
Firm: ________________________________
Address: ________________________________
Telephone: ________________________________
Attachments: ________________________________

CONTRACTING OFFICER’S REVIEW AND ACTION

☐ Substitution approved - Make submittals in accordance with Specification Section 01330.
☐ Substitution approved as noted - Make submittals in accordance with Specification Section 01330.
☐ Substitution rejected - Use specified materials.
☐ Substitution Request received too late - Use specified materials.

Signed by: ________________________________ Date: ________________________________
Additional Comments: ________________________________

☐ Contractor ☐ Subcontractor ☐ Supplier ☐ Manufacturer ☐ Contracting Officer
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the acceptance, pick up, loading, transporting, unloading, handling, storage, protection, and utilization of materials and equipment furnished by the Authority for installation by the Contractor, including installation supervisors.

B. Refer to Section 01600, “Product Requirements”, for handling, storage, and other pertinent requirements.

1.2 ABBREVIATIONS

A. Authority-furnished materials may be referred to herein and in other Sections of the Specifications, where applicable, by the abbreviation AFM.

B. Authority-furnished equipment may be referred to herein and in other Sections of the Specifications, where applicable, by the abbreviation AFE.

1.3 AUTHORITY-FURNISHED MATERIALS AND EQUIPMENT

A. The materials and equipment to be furnished by the Authority for installation by the Contractor are specified in the Contract Specifications, Section 01640, “Authority-Furnished Materials and Equipment”.

1.4 CONTRACTOR’S RESPONSIBILITIES

A. Requirements: The Contractor shall assume custody of, and provide protection for, all Authority-furnished materials and equipment from pick up or delivery, as applicable, and acceptance by the Contractor until Substantial Completion of the Work and the return of any excess materials and equipment.

B. Protection: Protect all Authority-furnished materials and equipment while in custody from theft, vandalism, loss, and damage during unloading, storing, handling, distributing, and installing the materials and equipment. Lost or damaged materials and equipment, as documented by the Authority, shall be replaced by the Contractor at no additional cost to the Authority.

C. The Contractor shall provide all labor, equipment, and materials necessary to pick up, load, transport, unload, handle, stockpile, and store Authority-furnished materials and equipment. Handling shall be in accordance with the respective manufacturer’s recommendations as furnished by the Contracting Officer.

D. Storage Plan: Prepare a storage plan for each storage area where Authority-furnished materials and equipment are proposed to be stored or stockpiled. The plan shall be in sufficient detail to demonstrate that efficient handling and security provisions have been provided, that supporting soils will not be overloaded, and that materials will not be overstressed due to bending or shear. A running inventory of the materials on hand shall be provided and kept, and the Contractor shall notify the Contracting Officer at least 30 days in advance of any anticipated shortages.

E. AFM and AFE Acceptance: Inspect Authority-furnished materials and equipment at time of pick up (or delivery if delivery of the specific AFM or AFE to the Contractor by others is specified), and submit certification to the Contracting Officer showing the quantity of accepted materials and equipment. Set aside all damaged materials and equipment, and immediately notify the Contracting Officer in writing of the damage and circumstances of discovery. If delivery of AFM or AFE is, Contractor shall inspect Authority-furnished materials and equipment.

F. Inventory Records: Prepare and maintain perpetual inventory records of Authority-furnished materials and equipment, and assign stock number, date of receipt from the Authority, and approximate date of construction placement. All checkout and returns of Authority-furnished materials and equipment or other transfer of materials and equipment between the Contractor and the Authority shall be accompanied by an inventory record form.

G. Excess Materials: Upon Substantial Completion of the Work, the Contractor shall transport, unload, and stockpile, all excess Authority-furnished materials and equipment to a delivery location within a 50 mile radius of the jobsite, as determined by the Contracting Officer.

1.5 INSTALLATION FACILITIES, TOOLS, AND MATERIALS

A. The Contractor shall furnish all facilities, tools, equipment, materials, and services needed to complete the installation of Authority-furnished materials and equipment, and such other tools, equipment, materials, and services as required to complete the Work.

B. Authority-furnished materials and equipment shall be installed accurately and efficiently to avoid waste, such as that due to incorrect or inaccurate installations. Wasted materials and equipment, as documented by the Contracting Officer, shall be
replaced by the Contractor at no additional cost to the Authority.

1.6 INSTALLATION INSTRUCTIONS

A. The Contracting Officer will provide the Contractor with installation instructions and drawings from the manufacturers of Authority-furnished equipment.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section. Costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

END OF SECTION 01640
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for pre-construction inspection.

B. Contractor will be responsible for other surveys as required prior to commencement of the Work. Refer to Section 01722, “Field Engineering”.

C. Monitor existing structures for damage and movement as and where indicated in Section 02316, “Geotechnical Instrumentation”.

D. Where necessary to safeguard adjacent structures and property, provide underpinning and support in accordance with Section 02150, “Underpinning, Support, and Restoration of Structures”.

1.2 SUBMITTALS

A. Submit copies of the pre-construction inspection report to the Contracting Officer.

1.3 AUTHORITY’S INSPECTION

A. Conditional inspection of buildings or structures in the vicinity of the Project, which may possibly be affected by the Work, will be performed by the Authority. These surveys will be conducted to:

1. Define and document existing property conditions and

2. Assist the Authority in resolving possible disputes over property conditions.

1.4 PRE-CONSTRUCTION INSPECTION

A. In conjunction with the Contracting Officer and the Authority’s designers, conduct a pre-construction inspection of existing facilities, structures, and environmentally sensitive areas in the vicinity of the Worksite. Document the inspection with photographs, sketches, and narratives and assemble into an inspection report submitted to the Contracting Officer. Photographic documentation shall include vegetation densities. Photographs shall comply with Section 01345, “Construction Photographs”.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for survey services as required for layout and performance of the Work.

B. The work includes providing field engineering services as required to verify lines, levels, grades, and elevations, and that the work was constructed and installed accurately within specified tolerances.

C. The work includes maintaining Authority-provided monuments and bench marks and establishing and maintaining new temporary and permanent monuments and bench marks to facilitate the work of this Contract, work of adjacent and follow-on contracts, and for the Authority’s on-going use. Refer to Section 02110, “Survey Markers and Monuments” for related requirements.

D. The work includes verifying constructed work including verifying alignment and grades of structures, stations, and trackbed in preparation for turn-over to follow-on contracts.

E. The work also includes survey services for obtaining field measurement of work quantities to be determined by survey.

1.2 REFERENCED STANDARDS

A. The work of this Section shall be in accordance with the following referenced standards and manuals.


C. Federal Geodetic Control Committee (FGCC):

D. Texas Board of Professional Land Surveyors (TBPLS):
   1. TBPLS - Rules, Regulations and “Minimum Standards of Practice”

E. Texas Society of Professional Surveyors (TSPS):
   1. TSPS - Manual of Practice for Land Surveying in the State of Texas

1.3 SUBMITTALS

A. Survey notes, drawings, and calculations shall be completed as the work progresses and one signed copy of each survey document shall be submitted to the Authority for record purposes. Surveys submitted shall include a dated certification signed and sealed by a Professional Land Surveyor registered in the State of Texas attesting to the survey’s accuracy and purpose.

B. Construction survey notes shall be provided to the Contracting Officer within 48 hours after completion of the Contractor’s survey.

C. As-Built Survey: Submit drawings showing all final centerline, station, and other Contractor-installed monumentation, properly prepared and submitted to the Contracting Officer for approval. Depict actual as-built conditions of the constructed improvements and said improvements relationship or conformance with the Contract Documents. Illustrate the horizontal and vertical (if appropriate) location of all improvements and indicate and clearly dimension all nonconformance or variations from the Contract Documents.

D. Submit a survey plan for establishing, controlling, and checking the layout for all work.

E. Submit monthly when the request for payment is submitted, a survey showing actual as-built conditions for all work indicating its conformance to the Contract Documents. Include survey data of actual conditions required by quantitative records of actual work; damage and settlement surveys; surveys of adjacent construction; and similar data as required by the Contracting Officer. Submit three copies.

1.4 QUALIFIED SERVICES

A. Surveying services and field engineering services shall be performed under the direct supervision of a State of Texas Registered Professional Land Surveyor.

1.5 SURVEY CONTROL

A. DART Coordinate System: The Authority has established the Texas Coordinate System of 1983 (NAD 1983), North Central Zone as the basis for it’s horizontal system and National Geodetic Vertical Datum of 1988 (NGVD 1988) as the basis for it’s vertical system. The official scale factor on DART Buildout II Projects is 1.000136506, to convert from grid to surface values. All coordinates and distances shall be published as surface values.
B. Horizontal Datum: The horizontal control for all alignments shall be based on survey control points established under the direction of the Authority. Coordinates for control points established for the system shall be located on NAD 83, Texas Coordinate System, North Central Zone (Lambert Grid), as established by the National Geodetic Survey (NGS).

1. The accuracy of the horizontal ground control and of supporting ground surveys as a minimum shall be Second Order, Class I, in accordance with the FGCC Standards and Specifications for Geodetic Control Networks.

2. GPS relative positioning accuracy as a minimum shall be Order C Class 2-I as defined in FGCC Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques.

C. Vertical Datum: The vertical control shall be based on the NGVD 1988 Datum, as defined by the NGS descriptions with the most recent adjustments.

1. The accuracy of the vertical ground control and of supporting ground surveys shall be as a minimum Second Order, Class I, as defined above.

1.6 LINES AND GRADES

A. Only such primary control lines, monuments, and bench marks will be set by the Authority as the Authority determines to be necessary to control establishment of the lines and grades required for completion of the Work. In general, these will consist of the primary horizontal and vertical control points indicated on the Contract Drawings. Contractor shall establish work points for all major structures, all track alignments, and all roadway alignments. Contractor shall set survey monuments at each end of station platforms to establish platform finish horizontal and vertical alignment based on the Authority control datum.

B. Contractor shall carefully preserve primary control monuments set by the Authority. In case such monuments are destroyed or damaged, they will be replaced at the Authority's earliest convenience. Contractor will be charged for the cost of replacing or restoring monuments destroyed or damaged by the Contractor's operations. This charge will be deducted from any monies due or to become due the Contractor.

C. Contractor shall temporarily suspend work at such points and for such reasonable times as the Authority may require for resetting monuments, and the Contractor will not be entitled to any additional compensation or extension of time therefore.

D. All other stakes or markers required to establish the lines and grades required for the completion of the Work shall be the responsibility of the Contractor.

1.7 SURVEYS FOR LAYOUT AND PERFORMANCE

A. Surveying Requirements: Perform all surveys for layout and performance of the Work, reduce the field notes, and make all calculations and drawings necessary to carry out such work. Contractor shall check the relative positions of all Authority-provided primary monuments and bench marks to be used and shall report any damaged or out-of-position monuments to the Contracting Officer at once. Contractor shall check such relative positions each time the Contractor uses such monument or bench mark.

B. Datum: Contractor shall be responsible for correctly locating all lines and grades and for performing all measuring as required for the construction and completion of the Work from established reference points and information is shown on the Contract Drawings.

C. Equipment: Contractor's instruments and other survey equipment shall be accurate, suitable for the surveys required, and in proper condition and adjustment at all times, per manufacturer's instructions.

D. Field Notes and Records: Furnish certified copy of all survey records to the Contracting Officer at intervals required by the Contracting Officer. Furnish each field notebook to the Contracting Officer when filled or completed.

1. Record deviations which are accepted by the Contracting Officer on the record drawings.

2. Furnish the Contracting Officer with a plan sheet showing the horizontal distance, azimuth, and angle from the control points indicated to the references indicated.

3. Electric or unprocessed field will be accepted. Additional "hard copies" plots, sketches, spread sheets or processed data are required in specific situations or even on a routine basis if deemed necessary for checking or archiving.

E. Use by the Contracting Officer: The Contracting Officer may at any time use line and grade points and markers established by the Contractor. Contractor's surveys are a part of the work and may be checked by the Contracting Officer at any time. Contractor shall be responsible for any lines, grades, or measurements which do not comply with specified or proper tolerances, or which are otherwise defective, and for any resultant defects in the work. Contractor shall conduct resurveys or check surveys to correct errors indicated by review of the field notebooks or by check surveys performed by the Contracting Officer.

1.8 SURVEYING ACCURACY AND TOLERANCES IN SETTING SURVEY STAKES

A. Surveying Accuracy: Control traverse field surveys and computations, including surveys of control lines to determine horizontal and vertical alignment of major structure components, shall meet the accuracy requirements for Second Order, Class I Surveys as
specified by the FGCC. Staking for construction or equipment installations shall meet the accuracy requirements for Second Order, Class II Surveys as specified by FGCC.

B. Tolerances: The tolerances generally applicable in setting survey stakes shall be as set forth in Paragraph 1.8.A above. Such tolerances shall not supersede stricter tolerances required by the Contract Drawings or Specifications, and shall not otherwise relieve the Contractor of responsibility for measurements in compliance therewith.

1.9 MONUMENTATION

A. In accordance with Paragraph 1.6A. herein, monuments will be provided by the Authority to establish the centerlines of tracks.

B. The Contracting Officer will furnish the Contractor with horizontal coordinate values to 1/100 of a foot and vertical values to 1/100 of a foot for all existing baseline monuments.

C. Do not use controls for surveys other than the monumentation described above unless otherwise approved by the Contracting Officer.

1.10 TRACKWORK SURVEYING REQUIREMENTS

A. The following trackwork surveying requirements apply to preparation for trackwork construction.

1. Verify layout information shown in relation to the existing Authority provided monuments and existing structures before proceeding with layout of the actual work. As the work proceeds, check every major element of work for line. Bring discrepancies in location of structures to the attention of the Contracting Officer before starting trackwork. Maintain an accurate surveyor's field book of such checks, make available for the Contracting Officer's reference.

2. Verify the actual grade line and the profile of the top of the subballast. Variations from the design grade line and profile of less than plus or minus 1/2 inch to be compensated for by the quantity of ballast or the thickness of concrete slab at no additional cost to the Authority. Variations more than plus or minus 1/2 inch shall be reported to the Contracting Officer for direction.

1.11 FINAL ALIGNMENT AND TRACK INSPECTION

A. Survey of the track to verify that the horizontal alignment, vertical alignment, and superelevation are within the tolerances specified for each type of track construction.

B. Areas found to exceed the tolerances shall be resurveyed after deficiencies are corrected.
SECTION 01731  
CUTTING AND PATCHING

PART 1 - GENERAL

1.1 DEFINITION

A. This section specifies the cutting and patching of nominally completed and/or previously existing work in order to accommodate the coordination of work, to install other work, to uncover other work for access or inspection, to obtain samples for testing, or for similar purposes; and excludes integral cutting and patching during the manufacturing, fabricating, erecting, and installing of individual units of work.

1. Demolition is a related category of work, which may require cutting and patching as specified in this section.

2. Excavation and the associated operations of dewatering, bracing, backfilling, and surface restoration, are separate categories of work.

B. Refer to other sections of the Specifications for specific cutting and patching requirements and limitations applicable to individual units of work.

1. Refer to Division 15 and 16 of these Specifications for additional requirements and limitations pertaining to the cutting and patching of mechanical and electrical work, respectively.

3.1 INSTALLATION

A. Structural Work: Do not cut and patch structural work in a manner resulting in a reduction of load-carrying capacity or load/deflection ratio.

B. Operational and Safety Related Components: Do not cut and patch operational elements and safety-related components in a manner resulting in a reduction of capacities to perform in the manner intended or resulting in decreased operational life, increased maintenance, or decreased safety.

C. Visual Requirements: Restore or refinish work which has been cut or patched as near as possible to its original condition, using new materials. Restore or repair continuous surfaces to the nearest intersections and refinish entire assemblies.

D. Do not proceed with cutting and patching for which submittals are required until such submittals have been approved by the Contracting Officer.
3.3 CUTTING

A. Cut work by methods least likely to damage work to be retained and adjoining work.

1. In general, where mechanical cutting is required, cut work with saws or rotary tools, not with impact tools. Core drill openings larger than 1-1/2 inch diameter through concrete work.

2. Comply with the requirements of applicable sections of Division 2 of these Specifications where cutting and patching requires excavating and backfilling.

B. Fittings: Cut products as required for fitting and adjusting to provide for finished installation complying with specified tolerances and finishes.

3.4 PATCHING

A. Patch with seams which are durable. Comply with specified tolerances for the work. Where feasible, inspect and test patched areas to demonstrate integrity of work.

B. Restore exposed finishes of patched areas; and, where necessary, extend finish restoration onto retained work adjoining in a manner which will minimize evidence of patching.

3.5 INSPECTION

A. Request Contracting Officer's inspection of cutting and patching and obtain his approval prior to any further action with or about the cut and patched product.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Cutting and Patching is incidental to the work being performed and will not be measured separately.

4.2 PAYMENT

A. Cutting and Patching is incidental to the work being performed. No separate payment will be made.

END OF SECTION 01731
PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section includes specifications for performing operations necessary for, and properly incidental to, site cleanup during construction and final cleaning of the facilities and the site prior to acceptance of the Work by the Authority as specified herein and in other sections when specified.

1.2 CLEANING AND CLEANUP DURING CONSTRUCTION
A. The entire site of the Work, including the Contractor's work and storage areas, shall be kept in a neat, clean, and orderly condition at all times during the course of this Contract. The Contracting Officer may, at any time during construction, order a general cleanup of the site as a part of the Work, and there shall be no additional cost to the Authority. The Contractor shall provide general daily clean up and disposal service for removal of waste, rubbish, trash, and debris away from the jobsite.

B. Perform cleaning of facilities and ancillary buildings as required during construction to prevent accumulations of dust, dirt, soil, trash, and debris, so that a clean and safe working environment will be present at all times.

C. Walkways or designated pathways for authorized visitors shall be kept broom clean at all times. Walkways over exposed earth surfaces shall also be kept neat and free of pebbles and other obstacles to walking comfortably, equivalent to broom clean of paved surfaces.

1.3 DUST CONTROL
A. Clean interior spaces prior to the start of finish painting and the application of other finishes, and continue cleaning as required until such work is completed.

B. Schedule operations to prevent dust and other contaminants, resulting from cleaning operations, from adhering to set or newly finished surfaces.

1.4 DISPOSAL OF DEBRIS
A. Dispose of waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction. Bury no waste material and debris on the site. Burning of trash and debris on the site will not be permitted.

B. Location of disposal site for trash and debris and length of haul are the Contractor's responsibility.

1.5 FINAL CLEANING OF STATION FACILITIES AND ANCILLARY BUILDINGS
A. Prior to final inspection by the Authority, and after construction work is essentially complete, thoroughly clean station facilities and ancillary buildings and structures, utilizing professional building cleaners where appropriate.

B. Items to be cleaned include glass, doors, hardware, opening frames, grilles, trim, exposed metal surfaces, plastics, concrete, pavers, floor coverings, light fixtures and plates, plumbing fixtures and trim, and finish surfaces throughout the construction.

C. Vacuum-clean where appropriate and remove spots, smears, dust, debris, hand prints, and defacements of every sort, including those of vandals. Use commercial cleaning compounds where necessary.

D. Follow the recommendations of the manufacturers of the materials and items to be cleaned for cleaning, polishing, and treatment such as waxing or sealing. Polish stainless steel and other non-ferrous metal surfaces.

E. Clean permanent filters of the air-conditioning system and replace disposable filters of units operated during construction. Clean ducts, blowers, and coils if units were operated without filters during construction.

1.6 FINAL SITE CLEANUP
A. Prior to final inspection, thoroughly clean the entire site and put it into a clean and neat, acceptable condition. Remove from the site construction waste and unused materials, dunnage, loose rock and stones, excess earth, and debris of any description resulting from the Work.

B. Hose down and scrub clean where necessary pavement and paved walks. Remove oil and grease stains.

C. Thoroughly remove mortar droppings from concrete slabs and pavement where they occur. Hose down and scrub clean concrete flatwork and exposed vertical surfaces of concrete and masonry.

D. Free and clear new and existing drainage systems.

E. Clean and protect conduit openings.
PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”

END OF SECTION 01740
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for performing all operations necessary for and incidental to closing out the Contract work and assisting in the Contracting Officer’s final inspection.

B. Refer to General Provisions Paragraphs, “USE AND POSSESSION PRIOR TO COMPLETION” and “FINAL ACCEPTANCE”.

1.2 BENEFICIAL OCCUPANCY

A. Refer to General Provisions Paragraph, “USE AND POSSESSION PRIOR TO COMPLETION”. The Authority may take possession or use any completed or partially completed part of the work under construction. Such occupancy neither relieves the Contractor of the responsibility for completing the work in accordance with the contract, nor removes contractual warranties or guarantees of construction.

B. Beneficial Occupancy is preceded by inspections of the work areas to be possessed by the Authority and other agencies. Such inspections will usually result in a work list being developed. Reference procedures established in Article entitled “Substantial Completion Inspection”, utilizing the work list in lieu of the punch list.

C. The Contracting Officer will make arrangements for maintenance, heat, utilities, and insurance prior to Beneficial Occupancy.

D. The Contractor shall sign and return the Certificate of Beneficial Occupancy prepared by the Contracting Officer. This Certificate establishes a Beneficial Occupancy Date (BOD) as the Authority takes occupancy.

1.3 SUBSTANTIAL COMPLETION - GENERAL

A. Substantial Completion (when recognized by the contract) is defined as the point at which all work is sufficiently completed to allow full use of the contracted items for their intended purpose. Intended purpose is defined to mean useable from an operational and safety standpoint. This includes the ability for follow-on contractors to perform their tasks without the Authority incurring any liability for additional costs or delays as a result of incomplete work.

B. Substantial Completion Requirements: To be considered substantially complete, the following items shall be addressed (as applicable).

   1. Physical completion
   2. Successful testing of the work
   3. Submittal of permits, certificates of occupancy and other certificates, as required.
   4. Submittal and approval of required submittals
   5. Inspection Tags: Mount “green” inspection tags on 8-1/2 x 11 paper, identify as to item that was inspected, and submit.
   6. Operating instructions for equipment shall be properly mounted and posted as specified in Section 01786, “Operation and Maintenance Instructions”.
   7. Required operations and maintenance manuals shall be submitted as specified in Section 01786, “Operation and Maintenance Instructions”.
   8. Guaranties and warranties shall be submitted to the Contracting Officer, as specified in the General Provisions and various sections of the Specifications.
   9. Submittal of spare parts, maintenance materials, keys, special tools, testing equipment, and required surplus material.
   10. Submittal of a list of subcontractors and vendors with contact names, phone numbers, addresses and description of work performed.
   11. Temporary facilities, except as may be required for punch list work, shall be removed from the site.
   12. The site and applicable appurtenances and improvements shall be cleaned as specified in Section 01740, “Cleaning”.
   13. Non-Conformance Reports, Audit Finding Reports, and Corrective Action Reports have been addressed and closed.

C. When the Contractor believes that the work required by any designated part of the contract has been substantially completed in accordance with the contract, the Contractor shall make a written request to the Contracting Officer for an inspection.

1.4 PRE-SUBSTANTIAL COMPLETION INSPECTION (PRE-SCI)

A. Prior to the scheduled date of a Substantial Completion Inspection, the Contractor shall request that the Contracting Officer make arrangements for inspections with the Authority, end user, the Authority’s designer, and other agencies as required. The intent of these inspections is to review current work list items in manageable sized groups and to determine if the work is ready for a Substantial Completion Inspection. Items documented during Pre-SCI’s will be provided to the Contractor so that these items may be completed prior to the Substantial Completion Inspection.
1.5 SUBSTANTIAL COMPLETION INSPECTION (SCI)

A. Substantial Completion Inspection (SCI): Substantial Completion is determined by a series of inspections of the project features, including the Storm Water Pollution Prevention Plan. The Contracting Officer will establish the dates of these inspections based on the Contractor’s readiness for the inspection. The Contractor shall cooperate with the Contracting Officer in the coordination of attendees. The makeup of the inspection team will depend upon the nature of the work being inspected, but normally will include the Contractor, the Contracting Officer, representatives of other DART divisions, and outside agencies as deemed appropriate. The Contractor shall be represented by its principal superintendent and such Subcontractors and Suppliers as may be necessary to answer the questions of the Contracting Officer’s inspection team.

B. The Contracting Officer will organize, schedule, and guide the inspection teams. Following inspections, the Contracting Officer will prepare a "first draft" punch list and distribute within 72 hours to all members of the inspection group. The Contractor shall review the draft list for completeness and accuracy, adding additional information as necessary. Draft lists, with supporting references, shall be returned to the Contracting Officer within 72 hours of receipt.

C. If the inspection team concurs that the work is substantially complete, the Contracting Officer will complete the "Certificate of Substantial Completion". The Contracting Officer will retain the certificate and a copy will be given to the Contractor. If the inspection team does not find the work substantially complete, the SCI will be treated as a Pre-SCI and a new SCI will be scheduled.

D. Punch list: Punch list items will be entered and tracked by the Contracting Officer.

E. Following preparation, punch lists will be formally transmitted to the Contractor for immediate action. Once a list is forwarded to the Contractor, no new items will be added or deleted. New items will be addressed as latent defects or warrantees.

F. The Contractor shall return a copy of the punch list within one week after receipt indicating the forecast completion date. Obtain the Contracting Officer’s sign-off of individual items as they are completed.

G. Certificate of Substantial Completion: A Substantial Completion (SC) Certificate will be issued for each area that has been contractually designated as having a specified completion date, as well as for overall contract completion. The date of inspection resulting in issuance of the Certificate is the date of Substantial Completion. Each SC Certificate issued prior to the final certificate shall be marked “Partial”. The final SC Certificate shall be marked “Final”.

H. The Substantial Completion Certificate, if necessary, will contain the following documents:

1. Punch list.
2. A list of outstanding Change Orders, problem statement, and claims.
3. A list of outstanding operation and maintenance manuals, warranties, guarantees, and permits.
4. A list of outstanding test results.
5. A list of spare parts, maintenance materials, keys, special tools, testing equipment, and required surplus material.
6. A list of outstanding QC documentation.

I. Post-Substantial Completion Inspection and Turnover: Following a completed SCI, record documentation and deliverables shall be transferred to the Contracting Officer within the time deemed appropriate by the Contracting Officer.

1.6 SUBSTANTIAL COMPLETION INSPECTION FOR EQUIPMENT

A. The following procedures apply to a Substantial Completion Inspection for the purpose of accepting possession of equipment prior to final completion of the facility housing the equipment:

1. The DART representative will accept the equipment.
2. DART operations will maintain the equipment after acceptance.
3. The Contracting Officer will control the keys to the facilities containing the equipment on behalf of the Authority.
4. The Contracting Officer will retain authority to provide access by other contractors required to work in the facilities containing the equipment and by the DART Operations personnel who will maintain the equipment.

1.7 FINAL INSPECTION

A. Final Inspection: When all requirements of the previously prepared punch lists have been completed, the Contractor shall request final inspection for full completion. Prior to scheduling the final inspection, the Contracting Officer will verify full completion. When satisfied, the Contracting Officer will arrange for and conduct the final inspection accompanied by the Contractor and other participants of previous inspections.
B. Final Inspection/Acceptance by Third Parties:

1. The Contractor shall request in writing to the Contracting Officer final inspection by third parties of work of performed on their facilities.

2. Prior to making such request for final inspection, the Contractor shall have successfully completed testing of subject facilities, documented the testing, completed all punch list items in regarding to the facilities, completed related as-built drawings, and performed cleaning of facilities, as applicable.

1.8 RISCAL COMPLETION

A. Variations in Quantities: The final payment estimate cannot be prepared until the Contracting Officer and the Contractor have reached final agreement on all quantities of unit price items. All variations between individual contract quantities, as adjusted by contract modifications, and the final measured or calculated quantities may be subject to the General Provisions Paragraph “VARIATIONS IN ESTIMATED QUANTITIES”.

B. A contract modification is not necessary for any variation in an estimated quantity when the Contractor and the Contracting Officer agree that the actual quantity is equitably paid by application of the contract unit price and there is no change in contract time. However, a modification summing-up all overruns and under-runs is required before final payment.

C. Deliverables: The final payment cannot be issued until the Contracting Officer is satisfied that the following contract deliverables have been received in full compliance with the contract:

1. Record documents submitted as specified in Section 01785, “Project Record Documents”. Including required certification of Record (As-Built) Drawings and Specifications.

2. Tabulation of Tests, test reports, and other QC documents.

3. Final as-built progress schedule (if required by contract).

4. Operation and Maintenance Manuals and Training.

5. Warranties and guarantees.

6. Certificates of inspection and acceptance of relocation, modifications, and new work performed have been obtained from utility companies, public agencies, and others.

7. Spare parts, maintenance materials, keys, special tools, testing equipment, and required surplus material.


9. If performance bond is in place, letter from bonding company regarding warranty provision (if required by contract).

10. Final payroll documents and certifications.

11. Completed Storm Water Pollution Prevention Plan (including Notice of Termination).

D. Claims and Changes: Before the final contract amount can be determined and the final payment made, all changes shall be negotiated and finalized by contract modification. All outstanding claims shall be identified.

1.9 FINAL ACCEPTANCE

A. Recommendation for Final Acceptance: Refer to General Provisions Paragraph “FINAL ACCEPTANCE”. When the Contractor considers that all portions of the contract are in complete conformance with contract requirements, Contractor shall request that the Contracting Officer prepare a letter to the Authority recommending final acceptance and payment.

B. Closeout Package: The following items will be transmitted to the Contractor. The Contractor shall complete applicable items and return to the Contracting Officer.

1. Final Acceptance Letter

2. Contractor’s Affidavit of Payment of Debts and Claims

3. Contractor’s Affidavit of Release of Liens

4. Contractor’s Release Form

5. Consent of Surety Company to Final Payment

C. Contractor’s Releases: In accordance with the contract, the Contractor shall submit an affidavit that all applicable bills have been paid, thereby releasing the Authority from all claims arising by virtue of the contract, other than any claims specifically stated on the Contractor Release Form. Fiscal close-out of the contract will not necessarily be delayed pending decision on claims that are before the Authority.

D. Final Payment: After completion of the foregoing requirements, the Contractor shall prepare the final pay application.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”

END OF SECTION 01770
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for preparation, maintenance, completion, and submission of project "as-built" drawings, specifications, and related documents for record purposes as required.

1.2 REFERENCED STANDARDS

A. Institute for Electrical and Electronic Engineers (IEEE)

B. Dallas Area Rapid Transit (DART)
   1. DART Light Rail Project Design Criteria Manual – Volume III: Drafting (CADD) Standards (DART CADD Standards)

1.3 SUBMITTALS

A. Contractor shall submit the following sets for approval by the Contracting Officer prior to final payment for the contract.
   2. Working (As-Built) Specifications: original markup.
   4. Record (As-Built) Specifications: original markup.
   5. Record Shop Drawings Including Product Data.
   6. As-Built Survey.

B. Submit the following record documents prior to substantial completion:
   1. Record Sample Submittal.
   2. Miscellaneous Record Submittals.

1.4 MAINTENANCE OF RECORD DOCUMENTS

A. Maintain at the jobsite 1 copy of the following documents for record purposes:
   1. Conformed Contract Documents. One set of prints and specifications (Working (As-Built) Drawings and Specifications) shall be maintained for recording "as-built" revisions and special features.
   2. Changes.
   3. Approved Shop Drawings including product data.
   4. Clarifications or Explanatory Details and Specifications.
   5. Inspection Reports.
   7. Field Test Reports and Records.
   8. Inspection Tags: Mount “green” inspection tags on 8-1/2 inch by 11 inch paper, identify as to item that was inspected, and submit a copy as they are received in the field.

B. Store documents used for record purposes in the Contractor’s field office or other approved location, apart from documents used for construction. Do not use record documents for construction purposes. Protect from deterioration in a secure fire and heat-resistive location.

C. Provide files and racks for storage of documents.

D. Maintain documents in clean, dry, legible condition.

E. Label each document “as-built” or “Record Documents” as appropriate.

F. Provide access to Working (As-Built) Drawings and Specifications for the Contracting Officer’s inspection during normal working hours

1.5 WORKING (AS-BUILT) DRAWING SET

A. Maintain at the job site, a current working (blueline or blackline) set of as-built drawings, reflecting any and all changes, revisions, clarifications, and actual field conditions to date. The Authority will accept in-progress drawings based on redlines or CADD electronic files for review and certification of ongoing preparation and maintenance of as-built documents.
B. Contractor shall maintain an index to the drawing set which shall be manually updated upon receipt of revised drawings. This index shall show, at a minimum, the drawing number, revision number, sheet number, and any drawings deleted. Revised drawings shall be inserted into the working set immediately. The working set shall be maintained in current construction status as the project progresses.

C. For preparation and maintenance of the working set, the Contractor shall physically and legibly draw or mark on the most recent design-issued drawing revision with dark pencil to fully and accurately record the permanent construction as actually made and shall include to the following specific items.

1. Transfer all construction identification information, dimensions, and materials from RFI's, clarifications, field adjustments, and revisions.

2. Include only those RFI's that change locations or dimensions of the work on the working and record as-built sets. Clarification RFI's which do not change what is indicated on the plans shall not be noted on the drawings.

3. Field changes of facility dimension and detail not otherwise recorded by contract change or modification drawings.

4. Give particular attention to concealed work that would be difficult to measure and record at a later date. No work shall be permanently concealed until the required information has been recorded and verified by the Contracting Officer.

5. Show underground utilities by station and offset, not real world coordinates. Reference buried and concealed piping underground services and utilities to permanent construction or permanent surface control points. Record concurrent with actual installation complete plan and profile information (including layout geometry adequate to reestablish the locations and depths of the new and existing man-made improvements, list of fittings, material types and sizes) of utilities. Include changes of direction and elevations of utilities.

6. Dimension locations of all concealed appurtenances from visible accessible features of structures.

7. Show as-built information for each utility on the contract drawings for that particular utility only. As-built conditions for a utility shall not be shown on other utility drawings. In other words, as-built conditions for water lines will be shown on water line drawings, but shall not also be duplicated on electrical or communications drawings where the waterline might also be shown. Utility composite drawings shall not be marked with as-built conditions. These drawings shall be annotated to refer to specific utility drawings for as-built conditions for a particular utility.

8. Where the Contract Drawings are not of sufficient size, scale, or detail, the Contractor shall furnish its own drawings for incorporation of details and dimensions.

9. Nomenclature and labels shall correspond to actual labels on installed equipment.

10. Each connection to each piece of equipment, junction box, or terminal block shall be identified by function and color code.

11. Dimensions, physical details, connections, and other information pertinent to system diagnostics, maintenance, or troubleshooting shall be shown.

D. Incorporate Request for Information (RFI’s) responses when a design-issued drawing revision has not been received, is not required or is not appropriate at the time of receipt of the RFI response:

1. If an RFI affects a drawing, the information shall be transferred to the Working (As-Built) Drawing set.

2. If an RFI response is too extensive to be drawn on the face of the drawing:
   a. The area affected by the change shall be clouded and reference made to the specific RFI on the face of the drawing.
   b. This shall be supported by a legible copy of the RFI, with the RFI number clearly shown, copied onto a full-size (22 inches by 34 inches) sheet of paper. This copy will be inserted directly behind the affected drawing, followed by sequential character, (i.e., 250a, 250b) until all inserted pages affecting the specific drawing are included.

3. If an RFI affects more than one drawing, the change shall be drawn on the face of each drawing affected or a legible copy of the RFI shall be inserted behind each drawing so affected. The copies will bear the appropriate page number(s).

4. The information changed by the RFI response may appear in a later design-
issued drawing revision, if appropriate. Until that time, the Contractor will continue to carry the RFI response information forward on later revision(s) of the drawing.

E. Sketches: Incorporate a sketch provided with an approved and issued contract change in the following manner:

1. The information changed by the use of the sketch will be included in the next revision of the specific drawing issued by the Authority.

2. In all other respects, sketches shall be incorporated into the as-built drawing in the same manner as RFI response specified above. The only difference being that the contract change number shall be referenced on the face of the drawing, instead of the RFI number.

3. If a copy of the sketch is attached, it shall be legible and shall show the originating change number.

F. When a design-revised drawing is received, the Contractor shall verify that it is complete and accurate to date for design changes, including RFI and sketches used during construction.

G. Upon approval of the contents of the as-built set by the Contracting Officer, the Contractor shall transfer the as-built information to the record vellum copy as provided in Article entitled “Record (As-Built) Drawing Set” herein.

H. Contractor shall submit current original Working (As-Built) Drawings to the Authority as electronic files.

1. The files shall be digital electronic Computer Aided Design and Drafting (CADD) files created by Bentley Systems, Inc., use most current version of MicroStation software.

2. Digital electronic CADD files shall be created in compliance with the most current version of the Authority’s CADD Standards.

3. Digital electronic CADD files shall be provided to the Authority on CD ROM disk or DVD and each CD ROM or DVD shall:
   a. Be provided in a protective cover.
   b. Have an exterior label.
   c. Contain an index of the CD ROM OR DVD’s contents that lists each file name along with a file description.

d. PDF’s of the drawings shall be included and all PDF’s, electronic CADD files and hard copies shall match one another.

4. The electronic files shall be named using the accepted naming convention specified in the current DART CADD Standards.

1.6 RECORD (AS-BUILT) DRAWING SET

A. At Notice to Proceed (NTP), the Authority will provide a vellum set of drawings for the Contractor’s use for reproduction, as well as for final submittal of Record (As-Built) Drawing deliverable. As contract changes occur and drawings are revised, the Authority’s Configuration Management Section (through the Contracting Officer) will provide vellum copies of the associated drawings to the Contractor for placement in the vellum set. The superseded vellum shall be pulled from the set and retained for record purposes.

B. Contractor shall maintain a full size vellum set of Contract Drawings in clean, undamaged condition.

C. Contractor shall use prints of the full-size drawings for its Working (As-Built) Drawing set and shall transfer the information from the Working (As-Built) Drawing set to the full-size Record (As-Built) Drawing set (vellum) for final delivery to the Contracting Officer.

D. Contractor shall mark with black ink (preferred) or dark pencil to show actual installations which vary from the work as shown on the latest design-issued revision, clouding the area(s) affected and assigning the next sequential revision number for each drawing to identify it as the record (as-built) submittal. The revision number shall appear in three places on a drawing:

   1. In the revision description block, lower left-handed corner, by assigning the next sequential number for the specific drawing. In the description area, indicate “Record (As-Built) Submittal” and enter the appropriate date.

   2. In the revision number block, lower right-handed corner, by lining through the current revision number and entering the same number on each drawing as entered in Paragraph 1. above.

   3. On the face of the drawing, by each cloud or connected to each cloud by leader lines.

E. Contractor shall update the index to reflect the actual contents of the Record (As-Built) Drawing set to accurately reflect the contents therein, by drawing number, revision number, and sheet number. Any drawings that have been deleted shall be so indicated on the index.
F. Each cover sheet, index sheet and drawing sheet in the Record (As-Built) Drawing set shall be stamped with a Contractor-provided certification stamp worded exactly as in Figure 01785-1 and sealed and signed by a Professional Engineer registered in the State of Texas.

G. The cover and index sheets shall be signed by an officer of the Contractor’s organization, certifying compliance with the as-built conditions.

H. Organize record (as-built) drawing sheets into manageable sets; bind with durable paper cover sheets; print suitable titles, dates, and other identification on the cover of each set.

I. Contractor shall submit Record (As-Built Drawings to the Authority as electronic files.

1. The files shall be digital electronic Computer Aided Design and Drafting (CADD) files created by Bentley Systems, Inc., use most current version of MicroStation software

2. Digital electronic CADD files shall be created in compliance with the Authority’s CADD Standards.

3. Digital electronic CADD files shall be provided to the Authority on CD ROM OR DVD and each CD ROM OR DVD shall:
   a. Be provided in a protective cover.
   b. Have an exterior label.
   c. Contain an index of the CD ROM OR DVD’s contents that lists each file name along with a file description.
   d. PDF’s of the drawings shall be included and all PFR’s, electronic CADD files and hard copies shall match one another.

4. The electronic files shall be named using the accepted naming convention specified in the current DART CADD Standards.

5. Contractor shall provide 1 set of electronic files for sheet files (drawings) and 1 set of electronic files for reference files. The electronic, MicroStation files must match the hard copy submitted to the Authority. The electronic, MicroStation files will not be accepted. PDF’s of the drawings and specifications will also be submitted with the electronic CADD files.

6. During the progress of the Work, maintain 1 electronic copy and 1 hard copy of the latest annotated source code of software and application.

1.7 WORKING (AS-BUILT) SPECIFICATIONS

A. During the progress of the work, maintain at the job site a current working copy of the Specifications reflecting current construction status for Contracting Officer’s review, including Amendments Addendums, contract changes, and RFI’s that affect the project and are not for clarification only and similar modifications issued in printed form during construction. Maintain Working (As-Built) Specifications in 1 or more large-ring, 3-ring binder or binders.

B. Contractor shall markup in dark pencil variations in the actual work in comparison with the text of Specifications and modifications, selection of option, and similar information on work where it is concealed or cannot otherwise be readily discerned at a later date by direct observation. Note, related working (as-built) drawing information where applicable.

C. Record information, changes, and notes in the specifications in blank areas, such as page margins or the backs of opposite pages, or on separate sheets inserted in the binder.

D. In applicable specification sections, record the manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually furnished and installed.

E. The record specifications shall be complete and shall include all applicable Contract Documents other than drawings.

F. Contract Changes:

1. Contract Changes shall be incorporated into the front of the record specifications in reverse chronological order. Use appropriate page dividers to identify Contract Changes and to separate Contract Changes from the Specifications.

2. In addition, changes to the Specifications effected by Contract Change shall be annotated on the affected page or pages of the Specifications or adjacent thereto.

G. Upon completion, transfer the current information to the Record (As-Built) Specifications copy as directed in Article entitled “Record (As-Built) Specifications”.

1.8 RECORD (AS-BUILT) SPECIFICATIONS

A. Contractor shall use the Working (As-Built) Specifications and transfer the information to the Record (As-Built) Specifications, using black ink for final delivery to the Contracting Officer.

B. Contractor shall update the table of contents to reflect the actual contents of the Record (As-Built) Specifications to accurate reflect the contents
therein by section number. Any sections that have been added or deleted shall be so indicated on the table of contents.

C. The cover and table of contents pages shall be signed by an officer of the Contractor organization, certifying compliance with the as-built conditions.

D. Organize Record (As-Built) Specifications into manageable binders; print suitable titles, dates, and other identification on the cover of each binder.

1.9 OTHER RECORD SUBMITTALS

A. Record Shop Drawings Including Product Data: During the progress of the Work maintain 1 copy of each shop drawing and product data submittal, and mark-up variations in the actual Work in comparison with the submitted information. Submittals shall be clearly revised, completed, and brought up to date, showing permanent construction as actually made. Include both variations from the manufacturer's instructions and recommendations for installation. Give particular attention to concealed products and portions of the Work that cannot otherwise be readily discerned at a later date by direct observation. Note related Changes and mark-up of Record (As-Built) Drawings and Specifications. Upon completion of mark-up, submit complete set to Contracting Officer for record.

1. One complete full-size set of approved Shop Drawings, including manufacturers' printed catalog cuts and data, shall be collected and maintained for record purposes. Maintain in clean, undamaged condition.

2. All pages of catalog cuts shall be clear, legible, and permanent.

3. Shop Drawings shall be filed and maintained separate from Contract Drawings. Shop Drawings shall be filed in 9 inch by 12 inch file folders to the greatest extent possible and shall be indexed in accordance with the Contract Specifications as herein before specified.

4. Shop Drawings shall be delivered in new boxes as specified in Article entitled “Submission of Documents” herein.

B. Record Sample Submittal: Immediately prior to the time(s) of substantial completion, the Contracting Officer and the Contractor will meet at the Site, and determine which of the submitted samples maintained by the Contractor during the progress of the Work shall be transmitted for record purposes.

C. Miscellaneous Record Submittals: Immediately prior to the time(s) of substantial completion, complete miscellaneous records and place in good order, properly identified and bound or filed, ready for continued use and reference. Submit to the Contracting Officer for record.

D. As-Built Survey: Refer to Section 01722, “Field Engineering – Surveying”, for requirements.

1.10 SUBMISSION OF DOCUMENTS

A. At completion of the Work, and before requesting final inspection, deliver as-builts and record documents to the Contracting Officer.

B. Record documents shall be delivered neatly and efficiently filed and packaged in appropriate file storage cabinets or boxes, 12 inches by 15 inches in size. Boxes shall be type manufactured for file folder storage, shall have covers and cutout handles, and shall be accurately identified as to the contents. Include a packing list of all boxes and their contents. As-built drawings shall be folded correctly, with title block clearly visible on top, to fit neatly in the 12-inch by 15-inch boxes. Record (As-built) Drawings shall not be folded.

C. Submission of record documents shall be accompanied with a transmittal letter, in triplicate, containing the following information:

1. Date of submission.

2. Project title and number.

3. Contractor’s name and address.

4. Title and number of each record document. (Shop Drawings may be grouped in basic categories or divisions of work and by box identification.)

5. Certification that each document as submitted is complete and accurate.

6. Signature of Contractor, or its authorized representative.

1.11 WORKING (AS-BUILT) SOFTWARE AND APPLICATION LOGIC

A. During the progress of the Work, maintain 1 electronic copy and 1 hard copy of the latest annotated source code of software and application logic source code and listings for the Authority’s review. The code and listings shall be kept on site at the Contractor’s Field Office, in 3-ring binders. Code and logic for each process shall be kept in a separate notebook. Electronic copies corresponding to the listing shall be kept in pockets in each of the binders. The contractor shall discuss with DART the software to be used and shall be agreed upon by the Authority and the contractor.
1.12 RECORD (AS-BUILT) SOFTWARE AND APPLICATION LOGIC

A. Contractor shall use the approved Working (As-Built) Software and Application Logic and transfer the information to the Record (As-Built) Software and Application set for final delivery to the Contracting Officer.

B. Contractor shall update the index to reflect the actual conditions of the Record (As-Built) Software and Application set by location name/number and revision number.

C. An officer of the Contractor’s organization, certifying compliance with as-built conditions, shall sign the cover and index pages.

1.13 RECORD SET

A. The following As-Built Software Documentation shall be provided for any software item supplied under this Contract:

1. A Software Design Description (SDD) document:
   a. Contractor shall provide a traditional SDD document in accordance with IEEE 1016.
      1) The Authority may consider a Contractor alternative SDD submittal if the Contractor’s SDD Submittal provides the IEEE 1016 Standard SDD technical content.
      2) The Authority retains the unilateral right to approve or disapprove any Contractor alternate SDD submittal.
   b. The Software Design description shall be submitted in 8.5 inch by 11 inch laser-quality printed format in 1 or more 3-ring binders. A key to the specification method(s) shall be provided with each binder. A table of contents shall be included. Four laser-quality printed copies of the Software Design Description and 2 electronic copies on CD ROM OR DVD shall be provided.

2. Software Version Description Document:
   a. The Software Version Description Document shall be submitted in 8.5 inch by 11 inch laser-quality printed format.
   b. Four laser-quality printed copies of the software Version Description Document and 1 electronic copy on CD ROM OR DVD shall be provided.

   c. Printed copy shall be bound in 1 or more 3-ring binders.
   d. A key to the specification method(s) and a table of contents shall be provided with each binder.

3. Software Listings Document:
   a. Software listings shall be organized consistent with the Software Version description Document and shall describe current inventories and history of all software revisions loaded onto a particular platform.
   b. The Software Listings Document shall be submitted in 8.5 inch by 11 inch laser-quality printed format.
   c. Four laser-quality printed copies of the Software Listings Document and 1 electronic copy on CD ROM OR DVD shall be provided.
   d. Printed copy shall be bound in 1 or more 3-ring binders.
   e. A key to the specification method(s) and a table of contents shall be provided with each binder.

4. Software source code shall be provided in machine readable format, shall correspond to the software listings, and shall be organized consistent with the Software Version Description Document. Four laser-quality printed copies of the machine-readable software source code and 1 electronic copy on CD ROM OR DVD and all tools to view and/or modify the code shall be provided.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 01001, “General Requirements”

B. Refer to Section 01220, “Measurement and Payment”, for submittal of as-built certification with each pay request.
FIGURE NO. 01785-1

Record (As-Built) Certification Stamp

To be used by the Construction Contractor

Record (As-built) Certification

"Having checked this submission, we certify that it conforms to the requirements of the contract in all respects, except as otherwise indicated."

Company Name: __________________________________________
Officer of Firm Signature: __________________________
Date: _________________________________________________
Officer of Firm Name (typed): __________________________
Title of Officer (typed): _________________________________
Seal of Professional Engineer of Construction Contractor, including signature and date, thereby sealing record (as-built) drawings for accuracy of as-built condition reflected herein, must be placed below:

Stamp size shall to be 2” x 4” for full-size drawings and 1-1/2” x 3” for half-size (11” x 17”) drawings. The title of the stamp, company name, and statement regarding sealing shall to be font size 12; all else shall be font size 10.

END OF SECTION 01785
PART 1 - GENERAL

1.1 DESCRIPTION

A. Operation and Maintenance Manuals and training provided under this Section shall provide the Authority’s personnel with the knowledge to operate, maintain, troubleshoot, and repair the installed equipment and systems provided by these Specifications.

B. Provide the following for each make and model of equipment and system installed or modified under this contract:

1. Posted operating and maintenance instructions for installed equipment and systems.

2. Preparation and submission of an Operation and Maintenance Manual(s) for installed equipment and systems hereinafter referred to as the O&M Manual.

3. Operation and maintenance training.

C. Manuals

1. General and specific content requirements for equipment and system manuals required under this Contract can be found in these Specifications.

2. Information to be provided shall include all required information required for the operation, maintenance, troubleshooting, repair, and restore of the equipment and systems.

3. Provide where directed, printed sheets under framed clear acrylic plastic, giving brief, concise operating and maintenance instructions for all items of mechanical and electrical equipment and similar equipment and specialty items, as applicable, at their respective locations.

D. Training Program

1. The Authority will assign supervisory, maintenance, and other personnel to the Contractor's training classes as required, at an Authority location with adequate seating and required lighting.

2. Each training course shall be held on consecutive days, excluding weekends and holidays. Each day’s training shall be for 8 hours, unless otherwise specified. Training schedule shall accommodate all personnel on all shifts. Specific training days and availability shall be coordinated with the Authority at least 2 weeks prior to commencement. Instructors present at the class location shall conduct training.

3. Courses shall include hands-on training. The Authority will provide transportation to the field locations to allow for hands-on training if required.

4. Course instructors shall be certified professional instructors and shall have performed training in similar systems before, and shall be adept in the use of the training and test equipment employed in the training program.

5. The Authority reserves the right unto itself to videotape all training sessions for its own use. Video taped training material will become the property of the Authority and shall not be subject to Contractor copyright protection.

6. In addition to the personnel specified to receive training herein, up to 2 additional personnel may observe and participate on any or all training classes, including hands-on training.

1.2 SUBMITTALS

A. Manuals

1. Refer to Section 01330, "Submittals", for submittal requirements and procedures, “minimum 21 days” to “minimum 30 days” for review.

2. A minimum of 60 days prior to the Contractor's request for final inspection in accordance with Section 01770, “Contract Closeout”, submit to the Contracting Officer 6 complete bound sets of instructions for each equipment and its component parts, including manufacturers’ certificates, warranty slips, parts lists, descriptive brochures, and maintenance and operating instructions, printed on 20-pound bond white paper, for all equipment and systems installed, tabbed and identified for easy reference. Preprinted material, photo copies not acceptable, provided by the manufacturer may be used as provided if approved by the Contracting Officer. All copies of manuals shall be legible with no portions of the text obscured or deleted.

3. Even though the O&M Manual is referred to herein in the singular, provide the Manual in as many volumes as necessary to accommodate all the information needed to complete the Manual. It may be more appropriate to submit certain items
of equipment, such as elevators and escalators, in separate volumes.

4. Defects discovered on review will be indicated in the O&M Manual or otherwise communicated to the Contractor in writing upon return of the O&M Manual set.

5. Within 30 days after receipt of an O&M Manual marked "Approved as Noted – Correct and Resubmit" or "Disapproved", revise the Manual in accordance with the directions for revision and resubmit 6 sets of the revised Manual for review. The Contracting Officer will review and return the resubmitted O&M Manual in the same manner and time as specified above for the original submittal.

6. Within 30 days after receipt of the O&M Manual marked "Approved as Noted - Confirm", revise the Manual in accordance with revisions noted, if any, and furnish 6 sets of the O&M Manual in final form. The original 6-set submittal shall not be considered included in the 8 sets of the Manual in final form. Equipment will not be accepted until the final O&M Manuals are submitted.

7. Final copies of all manuals shall be submitted for Authority approval. Contractor developed manuals shall be provided in an Authority approved machine-readable format, suitable for microfilming. When available, manufacturer manuals and technical data shall be provided in an Authority approved machine-readable format. Final copies of all manuals shall also be provided electronically, in both their native software format and PDF format, complete with any associated appendices.

B. Format: O&M Manual(s) shall include title page, table of contents, and frontispiece; information covering description, installation, operation, preventive maintenance, corrective maintenance, overhaul, parts list, and list of recommended spare parts; and an appendix. Each separate volume shall have a title page, contents page, frontispiece, and other information specified herein.

1. Title Page: Include the name and function of the equipment, manufacturer's identification number, and the Contract Specifications number and title.

2. Table of Contents: List sections and subsection titles of the O&M Manual with reference to the page on which each starts and a list of included drawings.


4. Print Operation for O&M Manuals: Print O&M Manuals on high quality gloss paper, oil resistant with mylar reinforced binding. Pages shall be 8-1/2 by 11 inches in size or folded to that size, and placed in a 3-ring binder. Reduce drawings included with manuals to 11 inches by 17 inches and fold to open cut clear of the main text. Each binder shall not be filled more than 2/3 of its capacity. Bind each manual of each set in a heavy-duty 2 inch, 3-ring vinyl-covered binder and include pocket folders for folded sheet information. Mark identification on both the front and spine of each binder. Photo copies not acceptable.

C. Training Plan: Contractor shall submit 6 copies of the complete training plan, at least 60 days prior to the scheduled start of the course for Authority approval. The training plan shall include the following information:

1. Proposed schedule for each course, including syllabus for training and lesson plan

2. Resumes of personnel proposed to be instructors for each course

3. Statement of the purpose of the training

4. Overview of the subjects to be covered in each course

5. Overview of the hands-on experience to be included as part of each course

6. List of the manuals, As-Built Documentation, and other printed materials to be utilized as training aides

7. Description of the pre-requisite knowledge for each course

D. Training Course Program: Contractor shall submit 6 copies of the complete program for each course, at least 60 days prior to the scheduled start of the course for Authority approval. Each training program shall contain the following information:

1. Detailed outline of the material to be covered in the course and the duration in hours of the training for each topic

2. Course scheduling plan to cover all shift personnel.

3. Copies of all visual aides, manuals, As-Built Documentation, and other printed materials to be used during the course.

4. Detailed descriptions of the procedures to be performed by students during hands-on
training, including test equipment to be used.

5. Specific pass/fail criteria for the course, including a sample test, and a statement of the knowledge and skills students should possess at the conclusion of the course.

6. Instructor Evaluation Survey

E. Training Materials: Contractor shall deliver all training materials to the Authority 5 days prior to the commencement of the associated training class.

1. Delivery location of associated materials shall be coordinated with the Authority personnel.

2. Sufficient copies shall be provided to accommodate all class attendees as well as auditors.

3. The Authority reserves the right to duplicate all training material to accommodate additional personnel.

4. Additional personnel may be added to the attendance roster at no additional cost to the Authority.

PART 2 - PRODUCTS

2.1 MANUALS FOR INSTALLED EQUIPMENT AND SYSTEMS

A. Contractor shall provide new custom manuals for each piece of equipment and system provided under this Contract.

B. General requirements in addition to those specified in other sections of this contract include:

1. Manufacturer’s standard O&M Manuals, documentation, and configuration software, as applicable, provided with each furnished equipment and system.

2. Manufacturer’s Contact Information

3. Manufacturer’s Basic Product Information, including:

   a. Literature describing each piece of equipment, including drawings and diagrams, physical function description of the equipment, major assemblies and subassemblies, and giving manufacturer’s model number and drawing number.

   b. Catalogue cut sheets, illustrated parts list and parts breakdowns.

4. Prior to final acceptance, Contractor shall obtain a letter addressed to the Authority from each manufacturer of major equipment and systems stating the Authority will be informed of manufacturer’s revised operations and maintenance recommendations, callbacks, availability of new software, and similar items in regard to the equipment and systems provided under the Contract.

   a. All manufacturers’ revisions shall submitted no later than 60 days following such revision. Such revisions shall be issued by replacement pages to the final O&M Manual, or by reissue of the O&M Manual, at the Contractor’s Option.

5. Safety Procedures and Precautions

   a. Ensure safety procedures and precautions are included by using a standard highlighting method.

   b. Include procedures and precautions required to prevent damage to equipment, injury to personnel, or unsafe operational conditions.

2.2 O&M MANUALS GENERAL REQUIREMENTS

A. Organize O&M procedures in such a manner that all required preventive maintenance activities be accomplished without interference with operations. Emphasize in these procedures accessibility, ease of equipment or component removal and replacement, visual indications of component deterioration, and localization of failures.

B. Identify O&M tasks including recommended periodic maintenance, precautions to be observed during maintenance work, degree of on-line repairs, numbers, qualifications and skills of personnel, special tools and test equipment, and estimates of maintenance time.

C. Prepare O&M manuals providing detailed instruction for the operation of each installed equipment and system condition; maintenance and safety actions required to ensure the operational requirements of the systems or item of equipment. Identify any safety markings, tags or similar identifiers to be maintained on any equipment.

D. Prepare O&M manuals with vendor instructions and data covering the O&M of individual equipment and system provided. Include all configuration and software documents or CD-ROM or DVD’s supplied with the equipment. Use this data as the training material for the individuals tasked to operate the installed equipment and
E. Include in the manuals system-level step-by-step O&M procedures to be performed by journeyman operators or technicians, and provide the following elements, as required:

1. Equipment Description: Complete description of all systems with shop drawings, data sheets, bill of materials, flow, emergency instructions, spare parts listing, warranties, guarantees, wiring diagrams, recommended turn-around cycles, control and electrical circuit and wiring diagrams.

2. Installation Instructions: Installation instructions shall cover pre-installation inspection, installation, testing, and calibration; and preparation for operation, both for initial installation and for installation after overhaul.

3. Operation Information: This information describes the system operation, including operating parameters, interfaces with other systems, major equipment, and their physical and operating characteristics. The information shall also include performance specifications and operating limitations.

4. Pre-operation Checkout: Include the required steps or tasks to completely check out the system and prepare it for operation following a shutdown condition.

5. Operator’s Instructions: Operator’s instructions shall cover startup, shutdown and all procedures required to ensure safe operation. Repeat these instructions in a durable printed notice and mount in the operator's area.

6. Preventive Maintenance: Describe all maintenance to be performed on a periodic basis, e.g., cleaning, lubrication, adjustments, inspection, calibration, voltages and amperage. Prepare scheduled maintenance checklists for each unique type of maintenance significant equipment. Submit the checklists to the Authority approval prior to implementation.

7. Maintenance Information: Describe all maintenance instructions, step-by-step, that can be performed on installed equipment, including adjustments, repair, overhaul, disassembly, reassembly, replacement, and repairs that can be performed. A list of special tools which are required for the maintenance shall be included with the maintenance information.

8. System Restore: Describe step-by-step procedures for complete system restore in case of a catastrophic failure. Identify any specific tools required for system restore. Provide details of all user configurable settings for each piece of equipment.

F. Logistics Data:

1. Provide a logistics plan of O&M, including the required data on requirements for O&M logistics, support and procedures. Logistics plan shall include the following:
   a. Identification of the extent to which preventive maintenance is performed on installed equipment as opposed to corrective maintenance performed at a maintenance facility.
   b. Identification of equipment requiring special handling or unique maintenance procedures.
   c. Determination of procurement lead times based on total order and shipping time to site for critical equipment and spares, and minimum and maximum inventory requirements.
   d. Identification of O&M personnel skills levels.
   e. Identifications of training requirements.
   f. Formulate and recommend operating rules for personnel.

2. Vendor Data: Submit the following types of data and incorporate in the O&M manuals:
   a. Manufacturers' brochures, catalogs, charts, performance curves, service and parts bulletins.
   b. Complete vendor list for each system subassembly.
   c. Installation: Parts breakdowns, drawings and service instructions, removal and installation procedures.
   d. Operations: Standard and emergency operating procedures, hazards from unsafe operations, emergency release/stop functions.
   e. Preventive maintenance and inspection requirements and procedures including cleaning.
instructions, special tools and test equipment
f. Shop drawings and other special drawings such as wiring diagrams, system schematics, assembly drawings, and inter-connection wiring diagrams.
g. Performance data, e.g., maximum, minimum, and recommended speeds, capacities, voltage, amperage, wattage, temperatures, and other related operating information.
h. Disassembly and assembly procedures
i. Calibration instructions, including points of application, frequency, method of calibration, and special tools required.
j. Troubleshooting procedures.
k. Repair and overhaul instructions.
l. Include industry or generic part numbers with component parts.
m. Special tools and test equipment.

3. Special Tools and Test Equipment:
Provide a list of special tools and test equipment for each equipment item, including tools and equipment designated specifically for use with the item, or usual tools and equipment required for operation maintenance of the items but not normally available to maintenance journeyman. Include following data on the list for each item:

a. Nomenclature
b. Purpose
c. Manufacturer's part number or drawing number
d. Manufacturer's name and address
e. Quantity recommended by manufacturer
f. Unit price
g. Recommended source of supply
h. Estimated lead-time

4. Parts and Spare Parts List: Coordinating with the requirements of this section and requirements specified in Section 01790, “Spare Parts and Maintenance Materials”, provide a complete parts list and a list of recommended spare parts. For each item include the following data:

a. Manufacturer’s parts numbers and catalog item numbers if applicable, for identifying parts.
b. Contact information, name, address and telephone number(s), for both Manufacturer and local vendor of parts.
c. Parts or assemblies obtained from another manufacturer shall be identified by the name of that manufacturer and its identifying part number.
d. Size, capacity, and other characteristics of each part shall be provided as required for identification.
e. Include prices for all recommended spare parts.

PART 3 - EXECUTION

3.1 SUPERVISOR FAMILIARIZATION AND OPERATIONS TRAINING REQUIREMENTS

A. Contractor shall develop and provide Familiarization and Operations Training thoroughly describing the installed equipment and systems under this contract.

B. Personnel and Course Composition

1. Training shall consist of at least 2 classes, each class designed for 3 operational personnel supervisors, 3 maintenance personnel supervisors, and 2 auditors [16 total personnel]. Each class shall be at least 8 hours in length, unless otherwise Authority approved.

2. Auditors shall be provided the same class materials, handouts, and access to the instructor, hands-on activity or demonstration as class participants.

C. Training Goals: The goal of the Initial Familiarization and Operations Training is to provide the Authority's O&M supervisors with a high-level understanding of the installed equipment and systems sufficient for the supervisors to perform the following functions:

1. Assign maintenance personnel required for routine maintenance and troubleshooting.
2. Assist maintenance personnel with use of manuals and As-Built Documentation.

3. Evaluate actual system performance vs. intended system performance.

4. Coordinate with equipment manufacturers support personnel for obtaining warranty support and troubleshooting support.

3.2 TECHNICIAN FAMILIARIZATION AND OPERATIONS TRAINING REQUIREMENTS

A. Contractor shall develop and provide Familiarization thoroughly describing the installed equipment and systems under this contract.

B. Personnel and Course Composition

1. Training shall consist of at least 2 classes, each class designed for 12 maintenance technician personnel and 2 auditors for a total of 28 total personnel. Each class shall be at least 16 hours in length, unless otherwise Authority approved.

2. Auditors shall be provided the same class materials, handouts, and access to the instructor, hands-on activity or demonstration as class participants.

C. Training Goals: Initial Familiarization and Operations Training goal shall be to provide the Authority's O&M technicians with a high-level understanding of the installed equipment and systems, sufficient to perform the following functions:

1. Perform routine maintenance and troubleshooting.

2. Identify single points of failure and restore the affected subsystem in case of a catastrophic failure or incident.

3. Become familiar with the use of manuals and As-Built Documentation.

4. Test and evaluate actual system performance vs. intended system performance.

5. Coordinate with equipment manufacturers support personnel for obtaining warranty support and troubleshooting support.

3.3 OTHER O&M TRAINING REQUIREMENTS

A. Personnel and Course Composition: Training shall consist of at least 2 classes, each class at least 16 hours in length, and shall support up 12 technician personnel and 2 auditors in each class.

B. Course Goals: Each training course shall provide maintenance personnel with the knowledge and skills required to:

1. Gain a thorough understanding of the operation of the equipment.

2. Gain familiarity with the specific components and their role.

3. Gain familiarity with drawings and other design and installation documentation.


5. Be adept at using all tools, test equipment and built-in diagnostics and monitors.

6. Be adept at performing preventative maintenance.

7. Be adept at identifying the root cause of a subsystem failure and restoring the affected subsystem in the event of a catastrophic failure or incident.

8. Gain familiarity with the equipment or systems safety procedures and the potential for creating unsafe conditions during operation or maintenance.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 01001, “General Requirements”.

END OF SECTION 01786
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the furnishing and delivering of the spare parts and maintenance materials specified in the various sections of these Specifications as necessary to maintain the equipment and provide for emergency repairs for two years after the date of Acceptance of the Work by the Authority.

B. This Section also includes providing all keys, special tools, and test equipment required to access, start, operate, monitor, maintain, and repair the equipment.

C. Various specific and detailed requirements for parts lists, spare parts lists, spare parts, maintenance materials, keys, special tools, and test equipment are specified in the individual Sections of these Specifications, as applicable, and in the Contract Specifications.

D. Coordinate the work of this Section with the work specified in Section 01786, “Operation and Maintenance Instructions”, for Spare Parts Lists.

E. Keys for finish hardware are specified in Contract Specifications Section 08710, “Door Hardware”.

1.2 SUBMITTALS

A. General: Refer to Section 01330, “Submittals”, for submittal requirements and procedures.

B. Spare Parts Lists:

1. Prepare a form listing of recommended spare parts on a Recommended Spare Parts List (RSPL) for each individual piece of equipment that is of a maintenance significant nature.

   a. Examples of Spare Parts are:

      1) One each of every lamp used in each light fixture
      2) One each of every type of circuit breaker or fuse used in electrical panelboard or fusible disconnect switches
      3) Recharge kit for chemical ground rods
      4) Required tools for maintaining electrical equipment
      5) Spare keys for unlocking electrical panels or cabinets

b. The equipment that each spare part is associated with shall be clearly noted.

2. Evaluate parts listed on the RSPL and advise the Contracting Officer of the Spare Parts quantities (minimum/maximum) required for a 24 month operation period (this period starts at the date of final acceptance). Base the evaluation upon the schedules shown, vendor data, interchangeability between sets, remote location of the Worksite and Operations and Maintenance (O&M) analysis to support maintenance of systems. Show a zero requirement in the minimum/maximum columns when none is required for any listed item. Indicate manufacturing lead time required for major items in RSPL that are critical to operation. The schedules show minimum required spare parts. Incorporate these quantities into the RSPL submittal to the Contracting Officer.

3. Use the RSPL form in submitting other spares requirements such as consumables, furnishings, tools, and materials to the Contracting Officer for approval.

4. Purchase spare parts designated by the Contracting officer from the Spare Parts Allowance. Spare parts shall be billed at the invoiced cost from the supplier.

5. The Spare Parts List shall be organized in accordance with the Contract Specifications, by Section number and title.

   a. The Spare Parts List shall include the part’s generic name or description, its trade name, Contractor’s part number, manufacturer’s name, manufacturer’s part number, retail price, quantity, and correlation with the pertinent Contract Specifications, Contract Drawings, and Maintenance Manuals specified in Section 01786, “Operation and Maintenance Instructions”.

   b. Spare parts shall be grouped by equipment category. Replacement parts common to more than one category shall be cross-referenced and indexed. Such common parts shall have only one part number.
C. Maintenance Materials List:
   1. Prepare and submit a complete list of maintenance materials as specified in the various individual Sections of these Specifications, and in the Contract Specifications.
   2. The Maintenance Materials List shall be organized in accordance with the Contract Specifications, by Section number and title. Include the quantities to be furnished.
   3. Where maintenance materials are specified as a percentage of the materials installed, such percentages shall be translated to actual quantities of materials in the Maintenance Materials List.

D. Keys, Special Tools, and Test Equipment List:
   1. Prepare and submit a complete list of the keys, special tools, and test equipment as specified in the various individual Sections of these Specifications, and in the Contract Specifications.
   2. The Keys, Special Tools, and Test Equipment List shall be organized in accordance with the Contract Specifications, by Section number and title.

1.3 SPARE PARTS

A. Requirements:
   1. Provide specific spare parts as specified in the individual Sections of the Contract Specifications.
   2. Spare parts shall be identical to the parts installed in the Work.

B. Quantities: Except when specific quantities are specified in the individual Sections of the Contract Specifications, provide quantities based on reliability requirements, replacement lead time, the Contractor's recommendations, and the following requirements:
   1. Wear: Provide spare parts for components which may be expected to require regular replacement under normal maintenance schedules, such as mechanical parts subject to continuous operation.
   2. Consumability: Provide spare parts for components with a life-expectancy of less than 5 years.

C. One-Time Limited Service: Provide spare parts which normally require replacement after performing their function one time, such as fuses.

4. Long Lead Time: Provide spare parts for components which are not readily available from distributors, such as for custom-fabricated components. Long lead time shall be understood to mean longer than six weeks from receipt of order to delivery.

5. Exchange Assemblies: Provide assemblies which will be exchanged with malfunctioning units for installed equipment, and which must be inventoried as complete assemblies.

C. Spare parts can only be used for repairs during the warranty period with written authorization of Contracting Officer. Spare parts so used shall be replaced at Contractor's expense.

1.4 MAINTENANCE MATERIALS

A. Requirements:
   1. Provide maintenance materials as specified in the individual Sections of the Contract Specifications.
   2. Maintenance materials shall be identical to the materials installed in the Work.

B. Quantities: Provide quantities of materials as specified in the individual Sections of the Contract Specifications.

1.5 KEYS, SPECIAL TOOLS, AND TEST EQUIPMENT

A. Requirements: Provide sufficient keys, special tools and wrenches, and special test equipment and gages as required to access, start, maintain, and repair all the installed equipment, appliances, systems, and assemblies as specified in the individual Sections of the Contract Specifications.

   1. In addition to those tools specified, special tools shall include any tools not readily available from local tool supply vendors.

B. Quantities: Provide quantities of keys, special tools, and test equipment as specified in the individual Sections of the Contract Specifications.

1.6 BAR CODE

A. Spare parts with the manufacturer's or supplier's serial number or other identification shall also be identified with bar codes, coded in accordance with the Authority's Bar Coding System (AIAG Auto
Industry Code 39) or equivalent. The System details will be provided by the Contracting Officer.

1.7 PACKAGING

A. Comply with applicable requirements of Section 01600, "Product Requirements". Spare parts, maintenance materials, keys, special tools, and test equipment shall be securely packaged in boxes, with the boxes clearly labeled as to the contents. Such labeling shall include: location and description of the equipment and the item, complete listing of all items in the box, and the quantity of each item included in the box.

1.8 DELIVERY

A. Ensure that the spare parts ordered are delivered to the Worksite before final acceptance of the facility by the Contracting Officer.

B. Deliver spare parts, maintenance materials, keys, special tools, and test equipment to the warehouse location or locations specified in the Contract Specifications. Provide unloading service at the designated storage location for delivered products.

C. Prepare formal receipts for such delivered products, and have them signed by the authorized Authority Representative at the location. A copy of such receipts shall be submitted to the Contracting Officer for information and record.

1.9 STORAGE

A. Spare parts, maintenance materials, keys, special tools, and test equipment may be stored temporarily at the site of the work in suitable storage facilities until time to deliver these products to the locations designated in the Contract Specifications. Such storage shall comply with the requirements specified in Section 01600, "Product Requirements".

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Separate measurement or payment will not be made for work required under this Section except as provided for under the Spare Parts Allowance. Costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work.

B. Spare parts purchased from the Recommended Spare Parts List will be paid for under the Spare Parts Allowance. Spare parts compensated for under the Spare Parts allowance will not include those specific spare parts specified in individual Sections of the Contract Specifications and subject to the provisions of Article 1.3, Spare Parts, herein. Items purchased under the Spare Parts Allowance will not include maintenance materials specified in individual Sections of the Contract specifications.

END OF SECTION 01790
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for demolition, removal and disposal of surface and subsurface structures and facilities, including backfilling of excavations and depressions to restore site to final grade.

B. The work shall include the abandonment of utilities to be left in place and removal of pavement, sidewalks, curbs, posts, pole foundations, structural steel and concrete, concrete foundations, fences, walls, utilities, utility structures and other facilities designated to be removed or the removal of which is necessary for the accomplishment of the project as shown on the Contract Drawings and as specified herein.

C. Removal and subsequent restoration of existing facilities are specified in Section 02072, "Removal and Restoration of Miscellaneous Existing Facilities".

D. Clearing and grubbing are specified in Section 02100, "Site Preparation".

E. Track, track ballast and other railroad appurtenances removal are specified in Section 02469, "Track Demolition and Signal Equipment Removal".

1.2 DEFINITIONS

A. Demolition: Complete removal and disposal of existing facilities from areas to be cleared and grubbed and from other areas as shown.

B. Existing facilities: Includes buildings, portions of buildings, sheds, foundations, pavements, sidewalks, curbs and gutters, signs, posts, fences, bridges, abutments, piers, and other structures which may interfere with construction. Also includes utility facilities such as drainage, sewerage, manholes, inlets, and other utility facilities including underground and overhead utility appurtenances.

C. Salvage: Refer to Article entitled "Definitions" in Section 02072, "Removal and Restoration of Miscellaneous Existing Facilities".

D. Selective Demolition: Removal and disposal of portions of existing buildings.

1.3 SUBMITTALS

A. Submit Demolition Plan including procedures and operational sequence, methods and equipment for demolition, removal and disposal of structures and facilities, including salvage if required, for review and approval by the Contracting Officer. Demolition Plan shall include procedures for backfilling and shoring and underpinning, as applicable.

1. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by demolition work for discontinuance of services along with certificates of severance over an agreed time schedule.

2. Submit demolition permit from the jurisdictional agency or owner.

3. Submit traffic permit from the jurisdictional agency for transport of debris.

4. Submit permit for disposal of debris.

5. Submit written releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal. Submit releases at least 15 days prior to disposal. Releases shall be signed by owners of property on which material will be deposited.

6. Submit proposed rodent control program.

1.4 REGULATORY REQUIREMENTS AND PERMITS

A. Comply with codes and regulations of jurisdictional authorities.

B. The Contractor shall obtain special permits and licenses and give notices required for performance and completion of the demolition and removal work, hauling, and disposal of debris.

1.5 JOB CONDITIONS

A. The Authority assumes no responsibility for the condition of the existing structures to be demolished.

B. Utilities: Arrange with the appropriate utility owner for the removal, rerouting, or capping of utility and comply with its regulations.
C. Maintenance and Control of Traffic

1. Incorporate arrangements for maintenance and control of traffic as required for demolition work including road closures and hauling of debris in Traffic Control Plan as specified in Section 01570, "Maintenance and Control of Traffic". Execute Traffic Control Plan and perform other measures as required to maintain and control traffic.

2. Keep traffic areas free from debris and spillage of materials.

D. Protection and Restoration:

1. Prevent damage to above and below ground pipes, conduits, wires, cables, and structures which are not designated for removal. Repair or replace damaged items.

2. Provide protective devices as specified in Section 01500, "Temporary Facilities and Services".

3. Provide safe passageways for the public around the demolition area and conduct operations to prevent injury to the public and damage to adjacent buildings, structures, and other facilities.

4. Protect sidewalks, utilities, streets, and facilities adjacent to the work from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by demolition operations. Do not leave sidewalks, utilities, streets, and facilities adjacent to the work in a dangerous condition as a result of the demolition operation.

5. Maintain, support and restore utilities in accordance with Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities".

6. For Selective Demolition inside buildings, construct dustproof partitions to separate areas where dirty or dusty operations are performed. Protect walls and floors with suitable coverings when necessary.

E. Below Grade Conditions:

1. Drawings and related documents may represent surface and subsurface conditions at the site and adjoining areas. The known surface and subsurface conditions are as indicated, and shall be compared with actual conditions before commencement of work.

2. Existing utilities and drainage systems below grade are located from existing documents and from surface facilities such as manholes, valve boxes, area drains and other such surface fixtures. It is the responsibility of the Contractor to verify existing utilities prior to demolition.

3. If existing active services encountered are not indicated or otherwise made known to the Contractor and interfere with the permanent facilities under construction, immediately notify the Contracting Officer in writing, requesting instructions on their disposition. Take immediate steps to ensure the services provided is not interrupted, at no additional cost to the Authority and do not proceed with the work until instructions are received from the Contracting Officer.

4. Thicknesses of existing pavements are from previous construction documents, and do not imply the actual depth or thickness of the total pavement or base material, where it occurs. Remove pavement of whatever thickness as required, at no additional cost to the Authority.

F. Environmental Protection: In accordance with Section 01560, "Environmental Protection".

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials used for backfill shall conform to the requirements of Section 02220, "Grading, Excavating and Backfilling".

B. Controlled Density Fill (CDF):

1. Controlled Density Fill (CDF): Mixture of Portland cement, fly ash, aggregates, water and admixtures, which have been batched and mixed. Use CDF for inplace abandonment of utilities.

2. Proportions: For one cubic yard. Batch weights may vary depending on specific weights of aggregates.

   a. Maximum Gallons of Mixing Water per Cubic Yard: 40

   b. Lbs. of Cement per Cubic Yard: 80

   c. Lbs. of Fly Ash per Cubic Yard: 300
d. Lbs. of 3/4 Inch Coarse Aggregate per Cubic Yard: 1400

e. Lbs. of Sand per Cubic Yard: 1400

3. Batch CDF to provide a flowable, non-segregating mix, with a 5 to 8 inch slump. Provide CDF with a minimum compressive strength of 300 psi

4. CDF mixture different than the above proportions may be submitted by the Contractor to the Contracting Officer for approval.

PART 3 - EXECUTION

3.2 BUILDING DEMOLITION

A. Buildings:

1. Demolish buildings in place, unless otherwise approved by the Contracting Officer.

2. Demolish in an orderly and careful manner, as required to accommodate new work, including that required for connection to existing features. Protect existing structural members. Refer to Section 01731, “Cutting and Patching”, for additional requirements.

3. Perform demolition in accordance with applicable rules of the jurisdictional agency.

4. Rebuild and repair demolition performed in excess of that required at Contractor’s expense.

B. Undertake rodent control and extermination program in demolition areas.

C. Unless otherwise shown, take possession of and dispose of building materials, fixtures, and equipment in, attached to or belonging to, buildings and structures to be demolished.

D. Party Walls:

1. Where building wall being demolished is a party wall with another building not to be demolished, prevent damage to other building, and avoid interference with its occupants.

2. Restore and waterproof exposed party walls in accordance with applicable building code for exterior walls of particular type of construction involved.

3. Effect remedial measures for anchoring, bracing, or buttressing so that existing party walls do not become unsafe and dangerous because of demolition operation. If such work does not correct unsafe or dangerous conditions, remove and replace wall and perform necessary work to properly enclose structure that is to remain standing, at no cost to the owner of such property.

E. Cellars and Foundations:

1. Break concrete and masonry cellar floors into pieces or, where approved, punch holes of not less than one-square-foot area through full thickness of floor approximately at 10 foot centers.
2. Remove wooden cellar floors.

3. Unless otherwise shown, remove foundation and cellar walls 12 inches minimum below final grade.

4. After breaking or removing cellar floors, fill cellar spaces with durable free-draining fill material, consisting of particles no one of which exceeds 8 inches in its greatest dimension. Masonry rubble obtained from demolition work may be used if it meets this requirement. Place fill material in layers each of 8-inch loose maximum thickness, fill voids in each lift with approved, free draining material, compact each layer in accordance with Section 02220, "Grading, Excavating, and Backfilling".

5. Correct subsidence in filled areas by placing and compacting additional fill.

6. The Contracting Officer may waive the requirement to fill cellar voids where cellar structures will be subsequently excavated for construction.

### 3.3 REMOVAL OF PAVEMENTS, SIDEWALK, CURBS, AND GUTTERS

A. Demolish pavement, sidewalks, curbs, and gutters within demolition area shown to underside of pavement and dispose of resulting debris.

B. Fill resulting excavations, holes, and depressions to existing grade or alternative as shown using fill material conforming to requirements of Section 02220, "Grading, Excavating, and Backfilling".

C. Adequately drain resulting surfaces.

D. Saw cut neat lines in concrete between demolition and existing to remain.

### 3.4 SELECTIVE DEMOLITION

A. Perform Selective Demolition in accordance with Section 01731, "Cutting and Patching", and requirements specified herein.

### 3.5 BRIDGE DEMOLITION

A. Concrete, Brick or Stone Structure:

1. Unless otherwise shown on the Contract Drawings or approved by the Contracting Officer, structures or portions of structures shall be removed by breaking the material into sizes capable of being safely removed.

2. Portions of structures below the permanent ground line, which will not interfere in any manner with the proposed construction, may be left in place, but removal shall be carried at least 1 foot 6 inches below the permanent ground line and neatly squared off. Reinforcement shall be cut off flush with the surface.

B. Steel Structures:

1. Steel structures or steel portions of structures shall be dismantled in sections of such weight and dimensions which will permit convenient handling and hauling.

2. Steel may be dismantled by flame cutting or other methods approved by the Contracting Officer.

3. If existing metal bridge structures scheduled to be demolished are determined to be contaminated with lead-based paint or other hazardous materials, structures shall be disposed of as scrap metal pursuant to hazardous waste regulations including 40CFR, Part 260 through 263, (Subchapter I).

C. Timber Structures: Unless otherwise indicated, timber piles shall be either pulled or cut off at a point not less than two feet below the permanent ground line, at the Contractor's option.

### 3.6 DISPOSAL OF REMOVED MATERIALS AND DEBRIS

A. Remove debris resulting from demolition work and dispose of it in accordance with applicable laws and ordinances and as prescribed by authorities having jurisdiction.

B. Disposing by burying or burning of trash and debris on the site will not be permitted.

C. Remove debris resulting from demolition work from the site at frequent intervals so that its presence will not delay the progress of the work or cause hazardous conditions for workers and the public.

D. Removed debris shall become the property of the Contractor and shall be removed from the Authority's property and disposed of in a legal manner with written permission of property owner where such material is to be deposited. Location of disposal site and length of haul shall be the Contractor's responsibility.

E. Provide copies of permits or licenses showing compliance to state and local requirements for disposing.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Demolition described in this section will not be measured but will be paid for at the lump sum price for "Demolition".

END OF SECTION 02050
SECTION 02072
REMOVAL AND RESTORATION OF MISCELLANEOUS EXISTING FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section applies when existing surface facilities are designated to be removed and restored to their original condition in accordance with the Specifications. The work of this section includes removing, restoring, reinstalling, relocating (where shown on the Contract Plans), or replacing miscellaneous existing facilities on public and private property which are removed during construction; and salvaging materials designated to be salvaged.

1.2 DEFINITIONS
A. Miscellaneous Facilities include the following: streets, parking lots, entrance walkways, steps, sidewalks, curbs, fence walls, railing, fences, mailboxes, parking meters, benches, newspaper racks, traffic and bus signs, lighting poles, flag poles, street lighting, traffic signalization system, trash receptacles, and other facilities as indicated on the Contract Drawings.

B. Salvage: To remove and store material and equipment for future use in this or other Authority Contracts. Salvage also includes removing, storing, transporting, and turning over material and equipment to the Authority or to others for future use.

C. Restoration: To rebuild the item of work to its original condition to serve its intended purpose, or better, in its original location or as directed.

1.3 SUBMITTALS
A. Submit Demolition Plan as specified in Section 02050, "Demolition".

B. Upon delivery of salvaged items, submit the following: Inventory of all salvaged materials. When salvaged materials are delivered for storage, give 1 copy of inventory to the receiver at the delivery point and two copies to the Contracting Officer.

1.4 REGULATORY REQUIREMENTS AND PERMITS
A. Comply with codes and regulations of jurisdictional authorities.

B. Contractor shall obtain all special permits and licenses and give all notices required for performance and completion of the demolition, removal, and restoration work.

1.5 JOB CONDITIONS
A. Below Grade Conditions: Contractor shall verify locations of existing utilities and drainage system below grade. Refer to Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities", for requirements for locating and protecting utilities.

B. Maintenance and Control of Traffic
1. Incorporate arrangements for maintenance and control of traffic as required for demolition and restoration work including road closures and hauling of debris in Traffic Control Plan as specified in Section 01570, "Maintenance and Control of Traffic". Execute Traffic Control Plan and perform other measures as required to maintain and control traffic.

2. Keep traffic areas free from debris and spillage of materials.

C. Protection and Restoration:
1. Prevent damage to above and below ground pipes, conduits, wires, cables and structures which are not designated for removal. Repair or replace damaged items.

2. Provide protective devices as specified in Section 01500, "Temporary Facilities and Services Required During Construction".

3. Provide safe passageways for the public around the demolition area and conduct operations to prevent injury to the public and damage to adjacent buildings, structures, and other facilities.

D. Coordination: Plan and coordinate work in accordance with the requirements of Section 01500, "Temporary Facilities and Services Required During Construction".

PART 2 - PRODUCTS

2.1 MATERIALS FOR RESTORATION
A. New materials, unless otherwise approved, shall conform to existing undisturbed materials in quality, color, and finish. Refer to and comply with the sections of the specifications referenced in Part 3 - Execution, herein, and the requirements of the jurisdictional authority.

B. Where re-installation of salvaged signs, fences, or similar items is required, furnish new posts, hardware and accessories, and concrete footings.
PART 3 - EXECUTION

3.1 REMOVALS
A. Remove work to extent shown minimizing damage to work which is to remain in place.
B. Repair existing surfaces, damaged during work, by cleaning and restoration to match existing.
C. Unless otherwise specified, items removed but not to be salvaged will become the property and responsibility of the Contractor for disposal off-site.

3.2 SALVAGE
A. Protect finish of salvaged items during removal, transport, storage, and re-installation.
B. Clean salvaged items of foreign material and store and protect from damage in or at accessible points within right-of-way or as shown in Contract Drawings.
C. Repair or replace salvaged items which are damaged or destroyed.
D. Where salvaged items are not designated for re-installation as part of the work of the Contract, deliver such materials to the Authority’s or jurisdictional authority’s storage area. Prepare inventory of delivered salvaged items.

3.3 SIGNS, POLES, RAILINGS, AND FENCES
A. Salvage signs, flagpoles, railings, and fences where shown.
B. Provide temporary sign for each permanent sign removed in accordance with approved working drawings or Traffic Control Plan. Remove on restoration of permanent sign.
C. Reinstall items in their original locations or in new locations shown. Reinstall or replace chain-link fences in accordance with Section 02830, "Chain Link Fencing". Reinstall or replace items to equal or exceed their pre-removal condition.
D. Remove lighting poles as shown, store at the Site, and reinstall at locations shown and directed.

3.4 STEPS, WALLS, AND COPINGS
A. Salvage steps and copings of wall components where shown and rebuild them to match existing.
B. To maintain continuity of quality and appearance between existing and new construction, where new reinforcing steel, concrete, and masonry construction is necessary, provide in accordance with applicable sections of the specifications including:

1. Section 03100 – Concrete Formwork,
2. Section 03200 – Concrete Reinforcement,
3. Section 03300 – Cast-In-Place Concrete,
4. Section 03305 – Portland Cement Concrete,
5. Section 03350 – Concrete Finishing, and
6. Division 4 – Masonry.

3.5 SIDEWALKS AND CURBS
A. Restore sidewalks and curbs to lines and grades which existed originally or to new lines and grades shown.
B. Replace asphalt and concrete sidewalks and curbs to match lines, grades, thickness and construction existing prior to removal. Perform work in accordance with:

1. Sections 02230 – Base for Pavements,
2. Section 02511 – Bituminous Pavement,
3. Section 02525 – Combined Curb and Gutters, Curb Ramps, and Walks,
4. Section 02550 – Concrete Pavement,
5. Section 03100 – Concrete Formwork,
6. Section 03200 – Concrete Reinforcement,
7. Section 03300 – Cast-In-Place Concrete,
8. Section 03305 – Portland Cement Concrete, and
9. Section 03350 – Concrete Finishing.
C. Restoration of sidewalk and curb shall include compaction of subgrade and restoration of aggregate base.

3.6 STREETS, PARKING AREAS, AND DRIVEWAY PAVEMENTS
A. Unless otherwise shown, restore streets, parking area and driveway pavements to lines, grades, thickness and construction existing prior to removal or construction. Perform work in accordance with Sections:

1. Section 02230 – Base for Pavements,
2. Section 02511 – Bituminous Pavement,
3. Section 02550 – Concrete Pavement,
4. Section 03100 – Concrete Formwork,
5. Section 03200 – Concrete Reinforcement,
6. Section 03300 – Cast-In-Place Concrete,
7. Section 03305 – Portland Cement Concrete, and
8. Section 03350 – Concrete Finishing.

C. Restoration of pavement shall include compaction of subgrade and restoration of aggregate base.

3.7 JOINTS BETWEEN EXISTING AND RESTORED WORK

A. Make joints between existing and restored work structurally adequate, smooth, and compatible.
B. Use saw to cut straight line at joints between existing and new paving surfaces.

3.8 PARKING METERS

A. Parking meter heads will be removed and re-installed by the jurisdictional authority. Request and coordinate removal and re-installation of parking meter heads with the jurisdictional authority.
B. Remove and dispose of existing meter posts and install new posts for relocated meters in accordance with the requirements of the jurisdictional authority.

3.9 LIGHTING/SIGNALIZATION PEDESTALS

A. Construct temporary reinforced concrete pedestals for lighting and signalization systems in accordance with the requirements of the jurisdictional authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section with the exception of demolition work itself will not be measured but will be paid for at the lump sum price for “Surface Restoration”. “Surface Restoration” shall include removal, salvage, and re-installation of existing items; replacement of existing removed items and materials with new; repair or replacement of damaged/destroyed items; and disposal of unusable items.
B. Demolition work in this section will be paid for under Section 02050, “Demolition”.

END OF SECTION 02072
SECTION 02100
SITE PREPARATION

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies clearing and grubbing work and landscape and landscape irrigation system removal, replacement, and maintenance.

1.2 REFERENCED STANDARDS
A. American National Standards Institute (ANSI):
   1. ANSI Z60.1 - Nursery Stock.

1.3 DEFINITIONS
A. Definitions pertaining to trees, shrubs, and other plants: ANSI Z60.1.
B. Clearing: Removal from areas shown of all trees not reserved by the Authority, brush, down timber, rotten wood, rubbish and other vegetation and objectionable material from area shown and disposal of removed items off the site.
C. Grubbing: Removal from below the surface in areas shown of the natural ground of stumps, roots, logs, stubs, brush, organic materials and debris to a depth of not less than one foot below natural ground surface, and disposal of removed items off the site.
D. Trimming: This work requires the removal of branches from trees and brush that extend into the right of way and interfere with the construction. Trim trees and shrubs and apply wound paint in accordance with Section 01532, "Tree and Shrub Protection And Care", or Section 02131, "Tree Pruning", as applicable.
E. Limits: Limits of clearing and grubbing include excavation or embankment, including all ditch areas and stream or channel change areas, and other areas as shown. Clear all other areas within the easement and right of way of all rubbish and other objectionable materials, taking care not to disturb the ground surface except where rubbish or objectionable item is embedded in soil. In that case, limit soil disturbance to immediate area of item.

1.4 SUBMITTALS
A. Submit traffic permit from the jurisdictional agency for transport of debris.
B. Submit permit for disposal of debris.
C. Submit written releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal. Submit releases at least 15 days prior to disposal. Releases shall be signed by owners of property on which material will be deposited.

PART 2 - PRODUCTS

2.1 TREE WOUND PAINT
A. As specified under Section 02131, "Tree Pruning".

PART 3 - EXECUTION

3.1 TREE PRESERVATION
A. Protect and preserve trees, shrubs, and plants not to be removed in accordance with Section 01532, "Tree and Shrub Protection and Care". Protect other surface features in accordance with the General Provisions, "Protection of Existing Site Conditions."

3.2 LANDSCAPE IRRIGATION SYSTEMS
A. Coordinate with property owners when existing landscape irrigation system to be removed connects with irrigation system to remain in operation. Ensure that existing irrigation system to remain remains in operation or provide temporary irrigation until irrigation system is restored to operation.
B. Where shown, or when encountered, remove, cap, and test landscape irrigation systems in accordance with Section 02975, "Landscape Irrigation System".
C. Restore landscape irrigation system in accordance with Section 02975, "Landscape Irrigation System", when required.

3.3 CLEARING
A. Existing vegetation to remain is designated on the Contract Drawings. Trees, shrubs, and vegetation to be removed are shown on the Contract Drawings and will be marked in the field prior to construction. Remove trees, shrubs, and vegetation designated to be removed. Remove brush, down timber, rotten wood, rubbish, and other vegetation and objectionable material within the defined limits. Dispose of removed items off site.
B. Cut off trees 1 foot below natural ground surface.
C. Prune trees so as to prevent damage to trees, shrubs, and other features which are to be preserved.
3.4 GRUBBING

A. Remove from below the surface, stumps, roots, logs, stubs, brush, organic materials, and debris to a depth of not less than one foot below the natural ground surface within the defined limits, and dispose of removed items off site.

3.5 REMOVAL OF TREE BRANCHES

A. Remove tree branches which extend over neat lines of structures and are less than 20 feet above top of rail or existing surface whichever is higher.

B. Remove tree branches which create a hazardous condition.

C. Remove additional branches as directed, to present balanced appearance of tree.

D. Treat scars resulting from removal of tree branches with tree wound paint.

3.6 DISPOSAL

A. Remove trees, logs, branches, brush, stumps and other debris resulting from clearing and grubbing operations to disposal location(s) outside the Project's right-of-way.

B. Dispose of debris off the Site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.

C. Burning or burying debris on the Worksite is prohibited.

3.7 CLEAN-UP

A. Remove and dispose of protective materials, enclosures, and guards upon completion of the Work.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section will not be measured but will be paid for under the lump sum price for “Site Preparation.” “Site Preparation” will include removal of tree branches and tree wound treatment performed as a part of site preparation. Removal of tree branches to present balanced appearance to trees pruned as part of site preparation will be considered as incidental to “Site Preparation” and no additional measurement or paid will be made.

B. Demolition work discussed in this section will be measured and paid for under Section 02050, “Demolition.”

C. Tree and shrub protection and care will be paid for as specified under Section 01532, “Tree and Shrub Protection and Care”, including fencing associated with tree and shrub protection and pruning specified herein to prevent damage to trees and shrubs which are to be preserved.

END OF SECTION 02100
SECTION 02110
SURVEY MARKERS AND MONUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specifications for furnishing and installing survey control and right-of-way markers and monuments. Monuments shall be fiber-reinforced resin with integral marker, cast-in-place concrete, or precast concrete.

1.2 REFERENCE STANDARDS


1.3 SUBMITTALS

A. Shop Drawings: Submit prior to fabrication. Include list of legends.
B. Samples: Marker (disk) with sample legend.
C. Product Literature: Submit for marker, epoxy grout, and fiber-reinforced resin monument. Include installation instructions for grout and for resin monument.

1.4 QUALITY ASSURANCE

A. Source Quality Control: Prior to delivery inform the Contracting Officer when materials and markers will be ready for inspection at place of manufacture.

PART 2 - PRODUCTS

2.1 CONCRETE

A. Concrete: Mix S-7, as specified in Section 03305, “Portland Cement Concrete”.

2.2 MARKERS

A. One-piece cast aluminum, bronze, or brass containing no lead.
B. Diameter and Legend Layout: See DART Survey Monument in the Contract Drawings.
C. Stem: 3/4 inch diameter solid shaft with split flared end.
D. Top: 1/8 inch thick at the outer edges domed to 5/16 inch thickness at the center.
E. Edges and top surface free from burs or blemishes.

F. Manufacturers:
2. Surv-Kap, Inc.
4. Or approved equal.

2.3 FABRICATION

A. Legend: Provide markers as specified with imprinted or stamped legend.

1. Manufacturer to prestamp legend shown for various survey markers and monuments using characters of size and type shown.
2. Press legend into the upper surface of disk. Raised letter will not be permitted.

B. Precast concrete monuments:

1. Precast concrete, eight inches square by length shown, with 1/2 inch chamfered edges.
2. One 41 inch long, No. 4 steel reinforcing bar centered in casting.
3. One marker embedded into the top of precast concrete unit.

C. Fiber-reinforced resin markers and monuments:

1. Head: Synthetic resin-reinforced fibrous glass with lettering as shown, incised v-shaped into top, with marker cast integral in head as shown.
2. Support stem: Steel tube, 1.8 inches in diameter, 36 inches long protected by plastic sheath with helical screw and steel spike.

PART 3 - EXECUTION

3.1 METAL DISKS FOR MARKERS

A. Set survey markers or monuments at locations indicated in the Contract Drawings and as specified in Section 01722, “Field Engineering - Surveying”. If point number has not been stamped by manufacturer, stamp point numbers on completed markers.
B. When markers are set in concrete pavements, roadways, walls, and structures, set stem in drilled hole and secure with approved epoxy grout.

C. At other locations, cast markers into tops of precast monuments and cast-in-place monuments as specified; set monuments in ground at locations shown.

1. Place concrete per Section 03300, "Cast-In-Place Concrete".

3.2 PRECAST CONCRETE MONUMENTS

A. Install precast concrete monuments at locations and to elevations shown or as directed.

B. Set markers and monuments as shown. Compact bottom of excavation for monuments to prevent settlement. Backfill around monument with excavated material; compact.

3.3 FIBER-REINFORCED MONUMENTS

A. Install fiber-reinforced monuments at locations and to the elevations shown or as directed.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section for survey markers including drilling hole in concrete pavements, roadways, walls, and structures, will be measured by and paid for at the unit price for "survey marker" per each. Epoxy grouting marker in drilled hole, in precast concrete monument or in cast-in-place monument will be considered as included in the unit price for "survey marker".

B. The work described in this Section for survey monuments including precast concrete monument, cast-in-place monument, and resin monument, not including associated survey marker, will be measured by and paid for at the unit price for "survey monument" per each.

END OF SECTION 02110
PART 1 - GENERAL

1.1 DESCRIPTION
A. The work of this section includes pruning and thinning trees and shrubs and pruning girdling roots. Tree pruning work includes the following:
   1. Class III - Coarse Pruning
   2. Class IV - Cutting Back or Drop Crotch Pruning
   3. Removal of mistletoe
B. Prune and thin trees where noted on the Contract Drawings and as required by the Contracting Officer.
C. Perform associated work such as deep root feeding and disposal.

1.2 REFERENCED STANDARDS
A. American National Standards Institute (ANSI):
   1. ANSI A300 - Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance - Standard Practices

1.3 DEFINITIONS
A. Branch Collar - Wood tissue that forms around the base of a branch between the main stem and the branch. Usually as a branch begins to die the branch collar begins to increase in size.
B. Callus - New growth made by the cambium layer around all of a wound.
C. Cambium Layer - Growing point between the bark and sapwood.
D. Closure - Refers to the roll of the callus growth around the wound areas.
E. The Cut - The exposed wood area that remains after the branch has been removed.
F. Cut Back - Specified reduction of the overall size of the tree or individual branches, but may include the overall reduction of the sides as well as the top of the tree.
G. Dormant - A condition of non-active growth. Deciduous trees are considered to be dormant from the time the leaves fall until new foliage begins to appear.
H. Girdling Roots - Located above or below ground level, whose circular growth around the base of the trunk or over the individual roots applies pressure to the bark area, thereby choking or restricting the flow of sap.
I. Lifting - The removal of lower branches for under clearance.
J. Parent Stem - The main trunk system of the tree.
K. Precut or Precutting - The removal of the branch at least 6 inches beyond the finished cut, to prevent splitting into parent stem or branch.
L. Pruning - The removal of dead, dying, diseased, live interfering, objectionable and weak branches in a scientific manner.
M. Sap Flow - The definite course assumed by sap in its movement through a tree.
N. Scars or Injuries - Natural or man-made lesions of the bark in which wood is exposed.
O. Suckers - Abnormal growth of small branches usually not following the general pattern of the tree.
P. Thinning Out - The removal of live branches to reduce wind resistance and to create more space.
Q. Topping – Reduction of central leader or primary leaders and accompanying branches to reduce tree height and spread.
R. Tracing - Careful cutting of the bark along the lines of sap flow to encourage closure and to be the outline of the wound area.
S. Trimming - Same as Pruning.
T. Tree Drip Line - Imaginary line extended down to the ground from the tip of the outermost branches.

1.4 SYSTEM DESCRIPTION
A. Class III - Coarse Pruning: Coarse pruning shall consist of the removal of dead, diseased or obviously weak branches, 2 inches in diameter or greater.
B. Class IV - Cutting Back or Drop Crotch Pruning (not topping or pollarding) shall consist of the reduction of tops, sides, under branches or individual limbs. This practice is to be undertaken only in cases of utility line interference, or where certain portions of the roots or root systems have been severed or severely damaged, or when there is unusual and rapid tree growth, where it is necessary to reduce
the topsides or under branches, or for specific topiary training or dwarfing.

C. Removal of mistletoe from trees designated on drawings.

1.5 QUALITY ASSURANCE

A. Pruning shall be performed by tree company and workers who, through related training and on-the-job experience are familiar with the techniques and hazards of this work including trimming, maintenance, repairing or removal, and equipment used in such operations.

1.6 PROTECTION OF EXISTING TREES AND VEGETATION

A. Protect and care for existing trees indicated to remain in place in accordance with Section 01532, “Tree and Shrub Protection and Care”.

B. When excavation is required in tree root zones, hand excavate whenever possible and avoid cutting of roots greater than 1 inch, to the extent possible. Use machine excavation in tree root zones only where specifically permitted by the Contracting Officer. When it is not possible to avoid cutting roots, roots over 1½ inch shall be coated on the faces with acceptable dressing for horticultural use for cut or damaged plant tissues.

C. Refer to Section 01532, “Tree and Shrub Protection and Care”, for provisions for replacement of damaged plant materials and assessment of damages.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Equipment requirements listed include the following items, unless so stated.

1. Pruning tools shall be maintained in good working order, cutting edges shall be sharp.

2. Acceptable tools shall be pole pruners, hand pruners, 12 inch handsaws, or chain saws.

3. Contractor shall be proficient with the use of ropes and saddles.

2.2 DEEP ROOT FEEDING AND CHEMICAL SPRAYS

A. High pressure feeding: Peters, Rapid Gro, or approved equal, a mixture of 3-1/3 pounds per 100 gallons shall be used.

B. The process shall be liquid soil injection of 5 percent iron humus, kelp (sea weed), Sulfur, and root stimulator.

C. Chemical Spray: Preventative bore spray with a Lindan additive.

2.3 TREE AND ROOT WOUND PAINT

A. Tree wound paint shall be asphaltum dressing or orange shellac.

B. Root wound paint shall be orange shellac.

PART 3 - EXECUTION

3.1 GENERAL PRUNING DIRECTIONS

A. Use no climbing spurs or irons in pruning operations.

B. Make cuts sufficiently close to the trunk or parent limb, without cutting into the branch collar or leaving a protruding stub, so that closure can readily start under normal conditions. Clean cuts shall be made at all times.

C. Precut branches too heavy to handle to prevent splitting or peeling the bark. Where necessary in order to prevent tree or property damage, branches shall be lowered to the ground by proper ropes or equipment.

D. At direction of Contracting Officer, remove the weaker or least desirable of crossed or rubbing branches. Such removal shall not leave large holes in the general outline of the tree.

E. Treatment of cuts and wounds, where necessary, shall be with tree wound paint for cuts greater than 1/2 inch. A thin layer of dressing shall be used, and care taken to treat only the exposed wood.

F. Disinfect tools with methyl alcohol at 70 percent (denatured wood alcohol diluted appropriately with water) or hydrogen peroxide solution after each cut and between trees where there is known to be a danger of transmitting the disease on tools. Due to danger from oak wilt and oak decline, oaks (genus Quercus) shall be pruned only during cold, dry weather in winter, or hot, dry weather in mid-summer.

G. Inspect old injuries. Those not closing properly and where the callus growth is not already completely established shall be traced where required by the Contracting Officer. Where required by the Contracting Officer, for cosmetic purposes, the wound shall be treated with a thin coat of wound dressing.

H. Report girdling roots visible to the eye to the Contracting Officer. When required by the Contracting Officer, treat visible girdling roots as follows:

1. Cut root at either end.
2. Notch entire root in center with a chisel.
3. Remove entire root without injuring the bark or parent stem.

I. Report the presence of any structural weakness, disease conditions, decayed trunk or branches, split crotches or branches, in writing to the Contracting Officer.

J. Tree root cuts shall be cut flush to soil line and coated with dressing. Do not allow roots to dry out, add mulch to cover roots and keep moist.

3.2 THINNING
A. Commence thinning only upon approval by the Contracting Officer.
B. In reducing overall size, attention shall be given to the symmetrical appearance. Top is to be higher and sides reduced in order to maintain a tree-like form unless otherwise noted.
C. When thinning or cutting back trees, shape the plant typical of its species.
D. On thin bark trees, just enough limbs shall be removed to get the effect wanted without admitting too much sunlight to the trunk of the tree or the top of large branches. Care shall be taken with the following species: Live oaks, Red oaks, and other trees susceptible to sun scald; particularly those species growing in different geographical areas to that which they are native. Whenever possible, perform thinning on susceptible species only during the dormant season.
E. In lifting the lower bottom branches of trees for under clearance, take care to give a symmetrical appearance, and make no cuts so large that they will prevent normal sap flow.
F. When required by the Contracting Officer, in lieu of lifting lower branches of trees for under clearance, maintain safety of such trees by installing cabling and bracing as described in American Nurserymen Association “Pruning Standards”.

3.3 DEEP ROOT FEEDING AND CHEMICAL SPRAYING
A. Soil beneath tree canopy shall be injected on an injection grid 2 feet on center at 5 gallons per caliper inch at diameter, breast high.
B. The deep root feeding shall be verified in the field by a certified Arborist.

3.4 MISTLETOE REMOVAL
A. Using thinning-type pruning cuts, remove infected branches at their point of origin or back to large lateral branches. Infected branches need to be cut at least one foot below the point of mistletoe attachment in order to completely remove embedded haustoria (rootlike structures below bark). Field verify extent of severe pruning with Contracting Officer’s Technical Representative.
B. Disinfect tools with methyl alcohol at 70 percent (denatured wood alcohol diluted appropriately with water) or hydrogen peroxide solution after each cut of mistletoe and between trees.
C. Mistletoes infecting a major branch or the trunk where it cannot be pruned may be controlled by cutting off the mistletoe flush with the limb or trunk. Then wrap the area with a few layers of wide, black polyethylene to exclude light. Use twine or tape to secure the plastic to the limb, but do not wrap it too tightly or the branch may be damaged. In some tree species callus tissue will form under the plastic, further weakening the limb. Broadleaf mistletoe requires light and will die within a couple of years without it. It may be necessary to repeat this treatment, especially if the wrapping becomes detached or if the mistletoe does not die.

3.5 DISPOSAL OF WASTE MATERIALS
A. Waste or spoils from pruning operations shall be removed from the site and disposed of by the Contractor.

PART 4 - MEASUREMENT AND PAYMENT
4.1 GENERAL
A. The unit prices described herein for tree pruning will include all materials and equipment except for those materials and equipment listed under separate unit prices.
B. “Tree Pruning Foreman”, “Tree Pruning Technician”, “Tree Pruning General Labor”, “Small Equipment - Chainsaw”, “Small Equipment - Tree and Brush Chippers”, “Crew Truck”, and “Dump Truck HAulor” will be measured and paid for at the unit prices per hour. The unit price per hour for “Crew Truck” and “Dump Truck Hauler” shall include vehicle, fees, fuel, operator, and associated costs. Equipment will be paid for the actual hours in use.
C. Dumping fees will be measured and paid for at the unit price per trip for “Dumping Fees”.
D. Deep root feeding chemicals will be measured and paid for at the unit price per gallon.
E. Tree pruning required under Sections 02100, “Site Preparation”, 02900, “Landscaping - General”, 02950, “Landscape Planting”, and 02981 Landscape Maintenance - Irrigated Areas”, will not be measured and paid for at the unit prices specified herein but will be paid for under the lump sum prices for “Site Preparation” and “Landscaping” and unit price for “Landscape Maintenance”.

END OF SECTION 02131
SECTION 02140
DEWATERING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specifications for designing, furnishing, installing, maintaining, operating, and removing temporary dewatering systems as required to lower and control water levels and hydrostatic pressures during construction.

B. This section also includes testing, treating, and disposing of pumped water.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A536 - Standard Specification for Ductile Iron Castings

2. ASTM C33 - Standard Specification for Concrete Aggregates

3. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120


1.3 DEFINITION FOR PIEZOMETERS

A. Piezometers for general monitoring:

1. Instruments consisting of a wellpoint, standpipe, and filter layer in which groundwater levels are sounded for general monitoring of the adequacy of dewatering.

2. Locations shown for piezometers are suggested and can vary as approved.

B. Control piezometers:

1. Piezometers used to supplement those used for general monitoring in mined earth and mixed face tunnel applications.

2. Control piezometers are identical in construction and installation to piezometers shown and specified for general monitoring.

C. Design dewatering system to take into account locations designated on the Contract Drawings where general lowering of groundwater will not be permitted and locations where there are limitations with respect to lowering groundwater laterally.

3. Control piezometer locations shown have been preselected, as determined by nature of specific groundwater problem areas peculiar to the project. Control piezometers are used to establish and verify drawdown requirements shown to be achieved in advance of tunneling, as specified.

4. Locations shown for control piezometers can be varied as field conditions necessitate, but under no circumstances by more than 5 feet, unless otherwise approved.

1.4 DESIGN CRITERIA

A. The Contractor shall be responsible for the design and adequacy of the dewatering system. Select dewatering system to accomplish groundwater control as specified and as required by the Contracting Officer.

B. Design the dewatering system to perform as follows:

1. Provide dewatering system which will effectively reduce hydrostatic pressure and lower groundwater levels below excavation levels including underpinning pits, but excluding mined tunnels, as necessary for safe and proper prosecution of the Work and which will result in obtaining stable, substantially dry subgrade, for prosecution of subsequent operations.

2. Design and provide dewatering system for tunnels for the specific means and methods planned to construct tunnel as necessary for safe and proper prosecution of the Work.

3. Design dewatering methods so that after initial development, the quantity and size of soil particles will decrease until no soil particles are present in the water being pumped, after 12 hours initial pumping.

4. Methods of dewatering may include sump pumping; single or multi-stage well point systems; eductor and ejector type systems; deep wells; and combinations thereof.
1.5 SUBMITTALS

A. Working Drawings: Type of dewatering system proposed, showing arrangement, location, and depths of proposed system, complete description of equipment and materials to be used, procedure to be followed, complete description of system to treat effluent prior to discharge into a storm sewer, standby equipment, standby power supply, procedures for detection of movement, types and sizes of filters, design calculations demonstrating adequacy of design, and proposed location(s) of points of discharge of water.

B. Documentation:

1. Permits from jurisdictional agencies.
2. Records of observations of dewatering system, groundwater piezometers, observation wells, and settlement markers. Submit observation records promptly, regularly and as directed. Submit records of dewatering system, groundwater piezometers, and observation wells on forms provided by the Contracting Officer throughout the period that dewatering system is in operation.
3. Qualification of specialists responsible for groundwater control on mined earth tunnel projects.

1.6 PERMITS AND REGULATORY REQUIREMENTS

A. Obtain permits from jurisdictional agencies.
B. Comply with the requirements of Section 01560, "Environmental Protection".
C. Comply with EPA requirements.

1.7 JOB CONDITIONS

A. Subsurface Conditions: Results of subsurface investigations and groundwater level readings are available from the Authority.
B. Coordination with Other Contractors:

1. Coordinate installation and operation of dewatering system and piezometers with others concerned and with other Authority contractors, if applicable.
2. If an adjoining Authority contract requires installation of portions of the dewatering system or piezometers within Contract limits, allow access to the Site for this work and facilitate the work.

PART 2 - PRODUCTS

2.1 PIEZOMETERS

A. Standpipe: PVC, rigid, Schedule 40, ASTM D1785; minimum inside diameter 1.875 inches.
B. Standpipe Slip Coupling: PVC, ASTM D2466.
C. Well Screen:

1. PVC.
2. Free of metallic components.
3. Continuous-slot construction.
4. Slot size: 0.006 to 0.020 inch.
5. Minimum inside diameter: 1.875 inches.
6. Johnson-UOP, Inc.; Thorofare, N.J.; or equal.
D. Well Screen Pipe Cap: PVC.
E. Solvent Cement: ASTM D2564.

2.2 FILTER FABRIC

A. Composed of polypropylene and polyethylene continuous-filament fibers.
B. Constructed as a random, non-woven fiber mixture.
C. Fibers held together by heat bonding.
D. In accordance with Paragraph “Geotextile Filter Fabric” of Section 02700, “Storm Sewer Systems”.

2.3 REINFORCED TAPE

A. Continuous plastic film.
B. Continuous linear filament reinforcement.
C. Pressure-sensitive adhesive.
D. Maximum width: 1/4 inch.
E. Mystik, Borden Co.; Scotch, 3M Company; or equal.

2.4 CURB COCK BOX

A. Cast iron: ASTM A536.
B. Inside diameter 3.0 inches, length 23 inches.
C. Locking cover with 'DART' logo as shown.
DEWATERING

2.5 FILTER MEDIUM
A. Fine aggregate: ASTM C33.

2.6 GROUT
A. Neat Cement Grout: As approved based on the requirements of Section 03305, "Portland Cement Concrete".

2.7 CONCRETE
A. Lean Concrete: In accordance with Mix M-1 in Section 03305, "Portland Cement Concrete".

PART 3 - EXECUTION

3.1 GENERAL
A. Select and install dewatering system to accomplish groundwater control as specified and as required by the Contracting Officer.
B. Conduct dewatering operations to prevent in designated locations the general lowering of groundwater and lowering groundwater laterally, as applicable.
C. Take approved measures to minimize movement of adjacent areas caused by dewatering operations.
D. Take measures to prevent damage to properties, buildings, structures, sewers, and other utility installations, pavements, sidewalks, and work resulting from groundwater pumping including measures in accordance with Section 02150, "Underpinning, Support and Restoration of Structures".
E. Modify system if, after installation and while in operation, it causes or threatens to cause damage to existing buildings, structures, utilities, and facilities.
F. Select, install, and maintain water treatment facilities, as necessary, prior to discharging water from the construction areas into the storm drainage. Prior to discharging water in storm sewer, treat the effluent as required under Section 01560, "Environmental Protection".
G. Do not allow deleterious substances within the water to discharge into the storm sewer system or outfall area.
H. Keep area free of standing water during periods of dry weather.

3.2 SURFACE DRAINAGE
A. Intercept and divert surface drainage away from excavations, piezometers, and observation wells by use of dikes, curb walls, ditches, pipes, sumps, or other means.
B. Design surface drainage systems to prevent erosion, unwanted water flow, and erosion on or off the Site. Refer to Section 01562, "Soil Erosion and Sediment Control", for related requirements.
C. Remove surface drainage system when no longer required.
D. Remove debris and restore site(s) to original conditions.

3.3 DRAINAGE OF EXCAVATED AREAS
A. Provide and maintain ditches of adequate size to collect surface, subsurface, and seepage water which may enter excavations. Divert water into sump so that it can be drained or pumped into a treatment facility prior to water running into drainage channels or storm sewers as approved by the jurisdictional agency.
B. Install settling basins, treatment system, or other approved apparatus, as necessary, to reduce the amount of fines, particles, or effluent which are carried by water that is diverted into storm sewers.
C. Should storm sewer become blocked or its capacity restricted by dewatering operations, make arrangements with jurisdictional agency to clean sewer and appurtenances at the Contractor's expense.
D. When no longer necessary, backfill and seal drainage ditches, sumps, and settling basins with approved material in accordance with requirements of Section 02220, "Grading, Excavation and Backfilling".

3.4 DEWATERING
A. Install dewatering system in accordance with approved working drawings. When control piezometers are used in conjunction with a predrainage dewatering system, space dewatering units so that control piezometers fall halfway between the two closest units.
B. Demonstrate by approved methods, that no soil particles are present in the water being pumped, after 12 hours of initial pumping.
C. Dispose of precipitation and subsurface water away and clear of the Worksite. Keep excavation dry.
D. Maintain continuous and complete effectiveness of the installation.

E. Maintain the water level at such an elevation that no damage to a structure can occur because of excessive hydrostatic pressure.

F. If necessary and approved, reduce the extent of dewatering in order to maintain a minimum water level of 5 feet below the prevailing level of backfill which is being placed, provided that the water level does not result in an uplift pressure exceeding 80 percent of the downward pressure produced by the weight of structure and its backfill in place.

G. At locations of control piezometers where mined earth tunnel sections occur, draw the water level down as shown at least 48 hours in advance of tunnel excavation using specified methods.

H. For tunnels, do not reduce nor stop dewatering until a permanent lining has been installed and approved.

3.5 PIEZOMETERS

A. Prior to dewatering operations, install piezometers of a type as shown at specified locations or as directed, and to the depths shown or approved.

B. Construction:

1. Assemble required number of workable lengths of standpipe sections using solvent cement and couplings.

2. Cement a well screen to the bottom of standpipe.

3. Cement a well screen cap to the bottom of well screen.


C. Installation:

1. Drill a minimum 8 inch diameter hole without using drilling mud.

2. Maintain stable bore hole prior to and during installation of piezometer. Use borehole casing where required to maintain stable borehole.

3. Position and center the standpipe and well screen assembly in the hole using a centralizer, if necessary, with a minimum annular space of 2 inches. Couple and cement previously prepared lengths of standpipe in order to position bottom of piezometer at the required depth.

4. Withdraw casing gradually as filter medium is placed in order to ensure against collapse of hole.

5. In like manner, withdraw casing gradually, as backfill of neat cement grout is tremied into place.

6. Set curb cock box flush with ground surface using lean concrete.

7. Do not use fire hydrants as water source unless an authorized meter with a backflow prevention device is used.

D. Prove proper functioning of piezometers prior to dewatering. In the presence of the Contracting Officer, demonstrate that each is functioning properly by adding or removing water and measuring the rates of fall and rise of water levels in standpipes.

E. While dewatering system is in operation, periodically prove continued proper functioning of each piezometer and observation well by performing rising or falling head tests on a schedule as directed.

F. Take an initial set of reference water level readings to determine the prevailing stable groundwater condition prior to dewatering. Thereafter, maintain and submit records of observations as specified.

G. Depending upon subsurface conditions, operate dewatering system so that the groundwater level in piezometer is maintained continuously within the prescribed limits to ensure adequacy of drawdown.

H. Protect and maintain piezometers and observation wells in good operating condition until completion of the Contract.

I. Promptly replace any piezometer that is damaged or destroyed.

J. Terminate piezometer readings when so directed.

3.6 PORTIONS OF SYSTEM TO BE LEFT IN PLACE

A. Leave such portions of dewatering system in place as are required to remove water from the areas of adjacent contracts areas when required in the Contract Documents.
B. Upon completion of the Work, leave piezometers in place and in working condition, with secured covers. Finish piezometer casings flush with pavement or finish grade.

3.7 PORTIONS OF SYSTEM TO BE REMOVED

A. Upon completion of the Work, unless otherwise directed, demolish well by pulling out or drilling out PVC piezometer standpipe and screen. Backfill void with sand-cement grout from bottom to 2 feet below ground surface. Remove and dispose of cock box, concrete pad, concrete plug and other debris in accordance with Section 02050, "Demolition".

B. Backfill remaining space with compacted earth and cap as necessary and restore surface to its original condition in accordance with Section 02220, "Grading, Excavation and Backfilling".

3.8 DETECTION OF MOVEMENT

A. Install settlement markers on each footing, building corners, wall or surrounding structures capable of being read to an accuracy of 0.005 foot. Record readings not less than once a week. Stop work, notify Contracting Officer, and take immediate action if movement of the structure occurs.

B. Take measurements prior to installing dewatering system to establish base elevations.

C. Measure to ascertain if dewatering operations has caused or is causing movement in adjacent areas.

D. Provide protective benchmark for vertical control that is not subject to movement for use as reference.

3.9 MONITORING

A. Observe and record average flow rate and time of operation of each pump used in dewatering system. Where necessary, provide appropriate devices, such as flow meters, for observing flow rates. Record data on a form provided by the Contracting Officer during the period the dewatering system is in operation.

B. Monitor quality of discharge from dewatering system to determine if soil particles are being removed by system.

C. Observe and record elevation of groundwater in piezometers and the previously installed observation wells on the form furnished by the Contracting Officer, during the period that the dewatering system is in operation. Sound depth to bottom of each piezometer and observation well monthly to ensure that fine soil particles are not penetrating screen and building up in standpipe.

D. During initial period of dewatering, make specified observations daily, seven days a week depending on field conditions. If, after, dewatering operations have stabilized, reduce observations to longer intervals as directed.

3.10 REPAIR AND REPLACEMENT

A. Damage, disruption, erosion, or interference to work area and adjacent facilities resulting from dewatering operations shall be restored to original or better condition at the Contractor’s expense.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will not be measured separately for payment, and all costs in connection therewith will be considered incidental to the excavation or earthwork to which the dewatering pertains.

END OF SECTION 02140
SECTION 02150
UNDERPINNING, SUPPORT, AND RESTORATION OF STRUCTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specifications for providing shoring, underpinning, sheeting, piling, and lagging as required to safeguard adjacent structures and property from settlement and damage including prevention of cave-ins and earth slough.

B. This section also covers the work necessary to restore job conditions equivalent to that prior to the start of Work.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):


B. International Organization for Standardization (ISO):

1. ISO 17025 - General Requirements for the Competence of Testing and Calibration Laboratories

1.3 DEFINITIONS

A. Underpinning: Permanent supporting structure designed to transmit foundation loads to lower bearing levels necessary to securely maintain structure being underpinned. Also includes restoration of structure upon completion of work. Grouting is not an acceptable means of underpinning. Grouting may be considered a method of temporary support.

B. Temporary support: Construction required and designed to prevent movement of the structures until the completion of underpinning, and during maintenance or other construction work.

C. Maintenance: Maintenance consists of construction methods short of underpinning such as temporary footing or column jacking, compaction grouting, consolidation grouting, ground reinforcement, or other means to limit structural settlement to the displacement limits specified. Maintenance shall include restoration of the structures upon completion of such work.

D. Restoration: Correction by repair or replacement of structure which is damaged, removed, or altered by the Contractor in furtherance of his operation equivalent to condition existing prior to start of Work unless otherwise shown or specified.

E. Structures: Structures shall be defined as including buildings, surface and underground structures that may be affected by the Contractor's operations.

F. Structure categories:

1. Category 1 Structures: Structures for which underpinning is required.

2. Category 1A Structures: Structures for which the installation of maintenance systems is required.

3. Category 2 Structures: Structures that are likely to be affected by construction operations, the Contractor has the option of supporting temporarily, underpinning, or installing maintenance systems. The decision rests solely with the Contractor who is entirely responsible for results.

4. Category 3 Structures: Structures that may be affected by construction operations. The structures may not initially require underpinning, temporary support, or installation of maintenance systems. The decision rests solely with the Contractor who is entirely responsible for the results.

G. Displacements:

1. Displacements are vertical movements or, if data are available, the resultant of vertical and horizontal movements measured at either the exposed surface of a structure or within the soil overburden within 5 feet of the structure foundation.

2. Displacements are movements that result from the Contractor's operations that occur prior to, during, or after underpinning, or installation of temporary support or maintenance systems.

3. Monitor construction to detect movements. Structures will be reclassified into a category requiring more restrictive measures of protection if extreme displacement limits defined hereafter are exceeded.

H. Owner: As used herein “owner” shall be understood to mean the owner of the property outside the Project's right-of-way and area.
1.4 DESIGN REQUIREMENTS

A. The design and installation of underpinning, temporary support, and maintenance systems of structures is the sole responsibility of the Contractor.

B. Prior to designing underpinning, temporary support, and maintenance systems, verify by field investigation foundation loads, locations, sizes, and conditions of existing structures and footings requiring underpinning and temporary protection. Verify locations of existing utilities.

C. Prior to the start of tunnel, shaft, or trench excavation, prepare working drawings and calculations, and submit to the Contracting Officer for approval.

D. Working drawings and computations shall be signed and sealed by the Contractor's engineer whose qualifications are specified under “Quality Assurance” herein.

E. Obtain additional information necessary for the design, including test borings and foundation plans.

F. Provide vibration isolation and other noise and vibration migrations where required by Contract Documents, agreements with owners, and elsewhere as required to prevent damage to structures and contents.

1.5 DISPLACEMENT LIMITS

A. The displacement limits and the required action to be taken in the event a limit is reached are defined as follows for each structure category where not indicated on the Contract Drawings:

B. Structure Category 1:

1. Extreme Displacement Trend Limit: Trend of lateral and/or vertical displacements that indicates that 1/2 inch displacement will be exceeded.

2. Action to be taken: Cease excavation and/or other construction operations that result in further settlement until corrective measures are implemented.

C. Structure Category 1A:

1. Extreme Displacement Trend Limit: Trend of lateral and/or vertical displacements that indicates that 1 inch displacement will be exceeded.

2. If remedial methods of maintenance fail to arrest further displacements, reclassify to Structure Category 1. Cease excavation and other construction operations that result in further settlement until structure is underpinned.

D. Structure Category 2:

1. Extreme Displacement Trend Limit: Trend of lateral and/or vertical displacements that indicates that 1 inch displacement will be exceeded.

2. Action to be taken: Install maintenance systems to prevent further displacements.

3. If maintenance system does not prevent displacements, reclassify to Structure Category 1A. Cease excavation and other construction operations that result in further settlement until modified maintenance systems are installed to arrest further displacements.

E. Structure Category 3:

1. Displacement Trend Limit: Trend of lateral and/or vertical displacements that indicates that 1/2 inch displacement will be exceeded.

2. Action to be taken: Increase frequency of monitoring of all Category 3 structures that may be affected by the Contractor's operations.

3. Extreme Displacement Trend Limit: Trend of lateral and/or vertical displacements that indicates that 3/4 inch displacement will be exceeded.

4. Action to be taken: Reclassify to Structure Category 1A.

1.6 SUBMITTALS

A. Working Drawings and Computations:

1. Submit working drawings showing method, staging, and necessary details, including computations for construction of underpinning and temporary support of each structure on which work is to be accomplished, as well as vibration isolation and method of transferring structural load to piles.
2. Prepare and submit a written schedule and procedure, along with detailed drawings of the proposed excavations, shoring, and underpinning work for review.

3. Submit details of shop assemblies when required for restoration of structures.

B. Documentation:

1. Submit written understandings with each structure’s owner signed by the owner signifying owner’s agreement.

2. Submit copies of agreements, rights, permits, and consents necessary to effect underpinning work before starting work on each affected structure.

C. Certificate of Design: Prior to beginning any tunnel, shaft, or trench excavation, submit a Certificate of Design for underpinning, temporary support, and/or maintenance systems as specified hereunder.

D. Monthly Certification: Submit certification signed and sealed by the Contractor’s engineer that the work during the previous month was put in place and is performing in accordance with the design prepared by the Contractor’s engineer. Document within the certification any changes or deviations from the design and the basis for such changes. Submit a copy of this certification to the Contracting Officer no later than the 5th day of each month for work performed during the previous month.

E. Reports of Field Quality Control: Refer to Article entitled “Field Quality Control” herein. Submit weekly description and record of examinations of structures classified in Categories 1, 1A, or 2. Submit weekly reports of monitoring and inspection of underpinning, temporary support, and maintenance systems.

F. Monitoring Program: Submit readings to Contracting Officer at the end of each day that readings are made. Submit readings in tabular and graphical form to allow displacement trend to be observed.

G. Submit qualifications of the Contractor’s engineer proposed for the design of underpinning, support, and maintenance systems.

1.7 QUALITY ASSURANCE

A. Perform underpinning operations with qualified personnel under continuous supervision of a Professional Engineer, licensed in the State of Texas, and experienced in such work.

B. Qualifications of Contractor’s Engineer: Design of underpinning, temporary support, and maintenance systems shall be prepared by a Professional Engineer licensed in the State of Texas whose qualifications include 10 years of documented experience in the design and construction of underpinning, temporary support, and maintenance systems. Submit proof of licensing and qualifications to Contracting Officer. Contractor’s engineer shall be qualified to substantiate extent of underpinning work.

1.8 CONSENTS, PERMITS AND APPROVALS

A. In addition to the General Provisions Paragraph, “Permits And Responsibilities,” obtain in the Contractor’s own name, agreements, rights, permits, and consents necessary to effect underpinning work. Obtain permits required by jurisdictional agencies. Permits shall name property owner and the Authority as co-applicants, when applicable, and the Contractor as their agent. Submit copies to Contracting Officer.

1.9 JOB CONDITIONS

A. Protection: Provide barricades as specified in Section 01500, “Temporary Facilities and Services,” including temporary canopies, decks, and other structures intended for protection of pedestrians, the segregation of vehicular traffic, and to prevent public access to hazardous areas.

B. Coordination with Structure Owners:

1. Prior to starting work on structure, confer with owner or owner’s authorized representative, and obtain concurrence with underpinning procedures and sequence of operations including the following items:

   a. Means of access to the construction area.

   b. Permitted areas of operations.

   c. Time restrictions for performance of work which may disturb occupants.

   d. Scheduling of time and durations of outages of utilities and other services to premises as well as of operation of systems within premises.

2. Notify the Contracting Officer three days prior to intended conferences with owner.
PART 2 - PRODUCTS

2.1 PILING
   A. In accordance with Section 02360, “Driven Piles”.

2.2 SHORING AND BRACING
   A. Provide heavy timber posts, beams, planks, boards, pipe struts, pin piles and accessories as required.

2.3 LAGGING AND SHEETING
   A. Provide heavy timber boards, planking or sheathing as required. Lagging boards shall be secured in place by steel H-piles with boards inserted between the H-flanges.

2.4 CONCRETE AND GROUT
   A. In accordance with Section 03305, “Portland Cement Concrete”, Mix S-1, 4,000 psi.
   B. Grout: As specified in Section 03305, “Portland Cement Concrete”. Type to be specified by Contractor's Engineer.

2.5 REINFORCEMENT
   A. In accordance with Section 03200, “Concrete Reinforcement”.

2.6 STRUCTURAL STEEL
   A. In accordance with Section 05120, “Structural Steel - Bridges”.

2.7 VIBRATION ISOLATION
   A. Closed-cell neoprene isolation board conforming to ASTM D1056, Grade SC E 45 BMZ
   B. No cracks after exposure to air containing 100 ppm of ozone for 100 hours at 104 degrees F with samples under 20 percent strain tested in accordance with ASTM D1149.
   C. Water absorption: Not exceeding one percent by weight.
   D. Bonding Adhesives for Vibration Isolation Material: As recommended by the vibration isolation material manufacturer.

2.8 EQUIPMENT
   A. Capacity of jacks and jacking equipment shall exceed that required for the imposed loads and shall be provided with calibration gages.
   B. Provide proof that equipment has been calibrated by company that meets requirements of ISO 17025.

PART 3 - EXECUTION

3.1 GENERAL
   A. Underpinning, temporary support, or maintenance systems shall be constructed in accordance with designs prepared by the Contractor's engineer.
   B. Maintain safety, stability, and integrity of structures of whatever nature regardless of location, which may be affected by this work.
   C. Verify locations and maintain existing utility facilities as specified in Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

3.2 TEMPORARY PARTITIONS AND CLOSURES
   A. Build where shown and as required by property owner, closed, dustproof, weatherproof, and burglarproof temporary partitions and closures of suitable materials to isolate the site from remainder of the structure. Comply with local building code requirements.
   B. Provide emergency exits, with appropriate hardware.
   C. Provide temporary protection against dust and damage from underpinning operations.
   D. Remove temporary protective installations upon completion of work and restore area.

3.3 EXCAVATION
   A. Excavate underpinning pits in accordance with Section 02220, “Grading, Excavating, and Backfilling”.
   B. Support excavated surfaces in accordance with Section 02160, “Support of Excavation”.
   C. Provide and maintain protective fencing and decking in accordance with Section 01533, “Temporary Decking”.
   D. Dewatering: In accordance with Section 02140, “Dewatering”.

3.4 UNDERPINNING
   A. Perform pinning, shoring, cribbing, and posting, as necessary, to ensure that movements damaging to the structure do not occur prior to and during underpinning operations.
B. Place dry pack mortar, concrete, and reinforcing steel in accordance with Sections 03100, 03200 and 03300.

C. Install structural steel shapes in accordance with Section 05120, "Structural Steel-Bridges".

D. Install piling where shown in accordance with Section 02360, "Driven Piles".

E. When jacking piles, establish adequate controls to detect movement of structure being underpinned. Maintain suitable equipment and methods continuously available to contain movement should it occur.

F. Remove obstructions encountered when installing steel shell piling by drilling or spudding. Blasting is prohibited. Comply with General Provisions, "Differing Site Conditions".

G. Test installed piling where shown and take remedial action necessary to obtain loading.

H. Use underpinning piles for underpinning purposes only, unless approved.

I. Transfer structural load to piles in accordance with approved procedures.

J. When transfer of loading has been completed and approved, clean pits of foreign matter.

3.5 CONCRETE PIERS, WALLS, AND END CAPS

A. Install underpinning walls, piers, and pile caps as indicated on approved working drawings, with the bottom at the indicated bearing elevation and the top approximately three inches below the structure to be underpinned. Dry pack the space within three days after concrete placement is completed. Do not remove support of existing structure until concrete piers, walls, or pier caps have attained design strength.

3.6 VIBRATION ISOLATION

A. Place vibration isolation material where shown using boards supplied in lengths sufficient for one-piece installation. Apply bonding adhesive at rate recommended by manufacturer of board.

3.7 BACKFILL

A. Place concrete backfill to limits shown.

B. Place and compact earth backfill in accordance with Section 02220, "Grading, Excavating, and Backfilling".

3.8 DETECTION OF MOVEMENT

A. Implement monitoring program as specified in Section 02316, "Geotechnical Instrumentation". Provide, install, and maintain monitoring equipment to detect horizontal or vertical movement of structures.

B. Inscribe or firmly affix on each column, pile cap, or wall to be underpinned or supported, visual methods of determining movements. Method used is optional but to be capable of being read to within 0.005 foot.

C. Take readings daily or more often, if necessary, during progress of underpinning or support operations, and for a period of four weeks after completion of such operations. Frequency of readings may be reduced at specific location(s) with prior approval.

3.9 FIELD QUALITY CONTROL

A. Examination of Structures: Conduct examination of structures classified in Categories 1, 1A, and 2 accompanied by a designated representative of the Contracting Officer. Examine and record by photographs or videotapes the exterior and accessible interior surfaces adjacent to construction, and the sidewalk and/or roadway pavement adjacent to these structures and to construction. Underground pipelines and utilities classified in Categories 1, 1A, or 2 shall be exempted from this examination unless required elsewhere in the Contract Documents.

B. Monitor and inspect the construction and installation of all underpinning, temporary support, and maintenance systems. Monitoring and inspection shall include, at a minimum, weekly inspections of the system(s) by the Contractor's engineer. Refer to Article entitled "Submittals" herein for requirements for monthly certification.

3.10 RESTORATION AND CLEAN-UP

A. Repair damage to structures caused by work, whether caused by displacement or other construction activities, and to restore structures to condition existing prior to start of work.

B. Restore ground and building surfaces to their original condition.

C. Remove debris and construction materials. Leave Site in a neat presentable condition in accordance with Section 02100, "Site Preparation".
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section including underpinning of columns and underpinning of walls, floors, and decks will not be measured but will be paid for at the lump sum price for “Temporary Support, Maintenance, and Restoration”.

B. Settlement measurement, excavation, backfilling, dewatering, and other work described in this section will be included in the lump sum price for “Temporary Support, Maintenance, and Restoration”.

END OF SECTION 02150
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies support for cut-and-cover, open cut, and shaft excavation for facilities other than utility trenches. The design and installation of support of excavation is the sole responsibility of the Contractor.

B. Support for utility trenches is specified under Section 02221, “Utility Excavation and Backfill.”

1.2 REFERENCED STANDARDS

A. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A416/A416M - Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
   3. ASTM A722/A722M - Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
   4. ASTM D4380 - Standard Test Method for Density of Bentonitic Slurries

1.3 SUPPORT SYSTEM DESIGN REQUIREMENTS

A. Support system shall consist of soldier piles and lagging, sheet-piling, or slurry-trench concrete walls, secured in place by means of bracing members such as wales, struts, shores, and ground anchors.

B. Design of support systems shall be performed by and working drawings and computations shall be signed and sealed by the Contractor’s engineer who shall be a Professional Engineer licensed in the State of Texas.

C. The design shall be in accordance with the recommendations of the Geotechnical Report and shall consider surcharges due to adjacent buildings, traffic, construction loads, and any other loading which may increase the lateral pressure on the support system.

D. Specified slopes shall take into account the time the excavation is to be open, and shall be adequate to safeguard nearby structures and utilities. Adequate erosion protection shall be provided.

E. The design shall be in accordance with recognized design standards such as ACI and AISC and provide adequate safety factors.

F. Utility supports shall be as required by the applicable utility company. Refer to Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

G. The design and construction of the system shall be as required to prevent loss of ground which would affect nearby structures and utilities.

H. Design of support systems shall be coordinated with design of underpinning and support of structures specified in Section 02150, “Underpinning, Support, and Restoration of Structures”.

I. Approval of Contractor’s plans and methods of construction does not relieve the Contractor of the responsibility for adequacy of support.

1.4 SUBMITTALS

A. Working Drawings and Calculations:
   1. Submit a proposed design and calculations, prepared and sealed by a Professional Engineer registered in the State of Texas, to the Contracting Officer.
   2. Submit the Contractor’s excavation support system equipment fabrication and installation procedures.

B. Documentation:
   1. When the proposed support system for excavation extends beyond the vertical projection of the property lines shown and into the adjoining property, obtain permission of owner in writing.
   2. Submit copies of permits with drawings.

C. Mix Designs: Submit proposed mix designs and test data indicating that proposed mixes comply with specified requirements. Test data shall not be more than 6 months old.

D. Obtain approval of submittals by the Contracting Officer prior to initiating excavation.
1.5 REGULATORY REQUIREMENTS
A. Design and perform support of excavation work in accordance with OSHA Safety and Health Standards and Texas Trench Excavation Safety Law.

1.6 JOB CONDITIONS
A. Location of Underground Facilities and Structures:
1. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.
2. Verify locations of existing utilities in accordance with Section 02760, "Maintenance, Support and Restoration of Existing Utility Facilities".
B. If existing utility facilities interfere with proposed method of support, notify the Contracting Officer. Do not modify the support system or relocate such facilities prior to receiving written approval.

PART 2 - PRODUCTS

2.1 STEEL SHEET PILING
A. Continuous interlocking type with cross section selected for intended use in accordance with Section 02360, "Driven Piles", except that welding shall be as per AWS D1.1/D1.1M.

2.2 SOLDIER PILES
A. In accordance with Section 02360, "Driven Piles", and Section 02375, "Drilled Shaft Foundation Piers".

2.3 CONCRETE
A. In accordance with Section 03300, "Cast-In-Place Concrete", and Section 03305, "Portland Cement Concrete", Mix S-1.

2.4 REINFORCEMENT
A. In accordance with Section 03200, "Concrete Reinforcement".

2.5 TIMBER LAGGING
A. Structural grade, minimum allowable flexural stress of 1,100 psi.

2.6 STRUCTURAL STEEL
A. In accordance with Section 05120, "Structural Steel - Bridges": ASTM A36 minimum.

2.7 ROCK BOLTS
A. Materials required shall be clearly identified on Contractor’s working drawings and approved by the Contracting Officer.
B. Steel Bars: Uncoated high strength steel bar for prestressing concrete in accordance with ASTM A722.

2.8 GROUND ANCHORS
A. In accordance with Section 03365, "Prestressed Concrete".
B. Steel bars: ASTM A722.
C. Steel strand: Uncoated stress relieved or low relaxation strand conforming to ASTM A416.

2.9 ANCHORAGES AND COUPLINGS FOR GROUND ANCHORS
A. In accordance with Section 03365, "Prestressed Concrete".

2.10 GROUT
A. In accordance with Section 03365, "Prestressed Concrete". Type to be specified by Contractor’s Engineer who is designing the system.

2.11 BENTONITE POWDER
A. In accordance with ASTM D4380.

2.12 MIXES
A. Lean Concrete: Portland cement and mineral or soil aggregate proportioned so that concrete achieves 1000 psi compressive strength at 28 days.
B. Concrete for Slurry Trench Walls: Tremie concrete of strength necessitated by design, with the following additional requirements:
1. Minimum cement factor: Seven bags per cubic yard.
2. Water-cement ratio: As necessary for strength and durability.
3. Sand proportion: As necessary to produce optimum results.
5. Slump: 6 inches plus or minus 1 inch.
6. With water-reducing or fluidizing agents as necessary.

C. Bentonite Slurry:
1. Stable suspension of powdered bentonite, or equal, and natural silts and clays in water.
2. Density: 64 pcf minimum, 85 pcf maximum.
3. Marsh funnel flow rate: 40 seconds minimum, 80 seconds maximum viscosity.
4. Fluid loss: 0.85 ounces maximum in 30 minutes.
5. pH: 7.0 to 11.0
6. Shear strength:
   a. By shearometer: 0.3 to 2.25 Lbf.
   b. By fan viscometer: 0.9 to 90 Lbf.

3.2 SHEETING, SHORING, AND PILING

A. Install soldier piles by pre-boring or other pre-excavation methods. Install soldier piles only in those areas where approved. Install piles vertical within tolerance of 1 foot from plumb per each 100 feet. Take appropriate measures to stabilize excavation to preclude loss of ground. Provide pre-bored holes for soldier piles adequate to accommodate pile section as approved. Extend hole to necessary depth below top of subgrade.

B. Carry bottom of support system to depth below main excavation to be adequate to prevent lateral movement. In areas where additional excavation is required below main excavation subgrade, make provisions to prevent movement of main excavation supports.

C. Minimum pile penetration for multiple layered horizontal bracing support systems shall be determined as follows:
   1. Install soldier piles so that tips are at least 5 feet below top of subgrade.

D. After seating soldier piles in pre-excavated holes, encase piles with concrete (Mix S-1) specified herein, up to lowest point of excavation adjacent to pile location. Fill remainder of hole with lean concrete, completely encasing pile.

E. Use timber lagging, steel sheeting, or precast reinforced concrete members secured in place for sheeting of excavations.

F. Do not permit height of unlagged face to exceed 15 inches if water flows from face of excavation or if soil in face moves toward excavation area.

G. Carefully perform excavation for installation of sheeting to minimize formation of voids. Separate sheeting members only to extent necessary to permit packing behind them.

H. Pack behind sheeting as installation progresses to establish tight contact between excavation face and sheeting. Pack openings between sheeting members with straw or other suitable material to allow free drainage of water without loss of soil or sand packing.

I. If unstable material is encountered during excavation, take suitable measures to contain it in place and prevent ground displacement which may cause damage.

J. Maintain sufficient quantity of material on hand for sheeting, shoring, bracing, and other operations for protection of work, and for use in case of accident or emergency.
K. Support System for Vertical Shafts Which Penetrate Soil/Rock Interface:

1. Soldier piles:
   a. Install soldier piles to obtain tip elevations as approved by the Contracting Officer based on examination of coring results.
   b. For shafts where pilot core borings indicate top of unweathered bedrock varies by more than 3 feet in elevation, set tips of soldier piles at least 10 feet below lowest point of top of unweathered bedrock.
   c. In drilling soldier pile holes, use equipment that has the capacity to penetrate materials having an average unconfined compressive strength of six to eight kips per square inch and that may reach even greater values in some locations.

2. Ring beams and lagging or liner plate: If shaft excavation is supported by ring beams or liner plates, install rings or liner plate to at least 10 feet below average elevation of top of unweathered bedrock, as approved by the Contracting Officer based on examination of the rock in the advancing excavation.

L. After work is completed, work will be surveyed to establish completed conditions for monitoring purposes in accordance with Section 01722, "Field Engineering - Surveying".

3.3 SLURRY WALLS

A. Slurry Trench Equipment:
1. Use equipment capable of removing from trench foreign material embedded in soil as well as natural materials, including boulders, where necessary. Arrange equipment to permit free vertical passage of slurry within trench and to prevent development of suction or pressure.
2. Furnish trench inspection tools adequate to ensure that trench has been excavated to dimensions shown on approved working drawings and that cuttings and foreign material have been removed.
3. Use slurry mixing equipment capable of producing with mechanical agitation a stable suspension of bentonite and water.
4. Transport slurry to panels by temporary pipeline or other approved methods.
5. Furnish slurry circulation equipment to provide circulation and agitation of the slurry throughout full depth of excavated panels. Do not agitate slurry by air.
6. Use slurry reclaiming equipment which will remove detrimental quantities of excavated material from slurry to ensure use of clean slurry in trenches. Recirculate reclaimed slurry to trenches in a continuous operation regardless of slurry density. Monitor slurry and control its capability of retaining solid particles in suspension.

B. Field Quality Control:
1. Make tests on samples of in-place slurry to determine density, viscosity, filtration, and sand content in accordance with ASTM D4380.
2. Maintain quality of bentonite slurry compatible with soil characteristics of trench walls.

C. Construction:
1. Construct slurry trench walls by displacement of bentonite slurry with tremie concrete.
2. Construct walls of reinforced concrete or plain concrete embedded with structural steel. Where soldier piles are used in construction of walls, it is permissible to consider piles as reinforcement.
3. Provide sufficient embedment of walls below subgrade of excavation to prevent loss of ground due to piping under wall or lateral movement of wall.
4. Perform preparatory work to discover, protect, maintain, relocate and restore utility facilities and other obstructions in vicinity of slurry walls.
5. Use construction methods ensuring that slurry materials employed during trench excavation and placing of tremie concrete are contained and controlled to prevent leakage and spillage of slurry and excavated materials into basements, vaults, utilities, and other facilities.
6. Excavate slurry wall trenches in panels of width and depth shown on approved working drawings with maximum panel.
length of 18 feet. Reduce panel length when excavating adjacent to facilities sensitive to settlement.

7. Maintain level of slurry in panels no more than 5 feet below top of trench during excavation operations and until tremie placement is essentially completed.

8. Progress construction with no more than one unexcavated panel and one tremie-filled panel with concrete cured at least 72 hours, between two slurry panels under active excavation.

9. Keep slurry circulated or agitated during drilling and excavating and immediately prior to concreting. Continuously maintain slurry requirements even during nonworking periods and stoppages. If stoppage occurs in the operation causing slurry in panel to remain uncirculated and unagitated for more than 24 hours, backfill panel until operation can be resumed.

10. Place concrete by tremie method either by gravity flow or by pumping. As soon as possible after placement of concrete is commenced, position and maintain the bottom of the pipe not less than 5 feet below the upper surface of concrete being placed. Equip tremie pipe with bottom valve or other device to prevent mixing of slurry with concrete inside tremie pipe. Aluminum pipe is prohibited.

11. Inspect trenching in the presence of the Contracting Officer prior to concreting. Ensure that settled cuttings and excavated material have been removed.

12. Start placement of concrete in panels within 12 hours after completion of panel excavation and proceed continuously until concreting is completed.

13. When wales are used, obtain tight bearing between wales and wall and ample bearing area with wedges and dry pack for load transfer.

14. Accomplish preloading by approved procedures. Transfer load by jacking applied symmetrically to braces without introducing eccentricity.

15. Introduce jacking load into braces immediately after each tier of braces has been installed and before excavation has progressed more than 2 feet below bottom of bracing tier. Make provision to fix preload into each brace by shim plates, wedges, blocking, or other approved device.

16. After concrete invert slab has been placed and attains sufficient strength to receive loads from slurry walls, remove tiers of bracing above invert level, provided the following conditions exist:
   a. Remaining tiers are capable of resisting total load calculated from trapezoidal pressure diagrams shown.
   b. Calculated deflection of the walls between tiers of bracing, assuming forces indicated by the trapezoidal pressure diagrams, does not exceed 1/2 inch.

17. Construct tight joints between adjacent pours of concrete in slurry wall to minimize loss of fines from retained earth. Take necessary care to accomplish this in terms of properly excavating trench and cleaning abutting face of hardened concrete or surfaces of structural members if used. Provide approved method of water stopping.

18. Seal leaks encountered in walls as excavation progresses, if leaks are of sufficient size to permit penetration of fines and loss of ground. Procedures may include grouting outside or through wall.

19. Dispose of unsuitable excavated material and debris in accordance with Section 02220, "Grading, Excavating, and Backfilling".

20. Dispose of slurry waste offsite by means of sealed tanks and in accordance with the regulations of the jurisdictional agencies.

3.4 WALES, STRUTS, AND ANCHORS

A. Install and maintain primary support members in tight contact with each other and with surface being supported.

B. Preloading:
   1. Except for ground anchors and slurry wall bracing, preload primary bracing members including struts, shores and similar members
at installation to 50 percent of design load, which for this purpose is maximum load that bracing member will have to carry. Preload tiebacks and slurry walls as specified for those installations.

2. Use procedures that produce uniform loading of bracing member without appreciable eccentricities or overstressing and distortion of members of wall system.

3. Make provisions for permanently fixing load in each member using steel shims or wedges welded into place.

4. Accomplish preloading by jacking support in place against soldier piles or wales.

5. Do not use wooden wedges to preload bracing member.

6. Include in preloading system means to determine within five percent amount of preload induced into bracing members.

C. Excavate to no more than 2 feet below point of support about to be placed. Install support and preload immediately after installation and prior to continuing excavation.

D. When removing struts, do not increase vertical spacing unless invert slab has been in place for at least 48 hours and support system is adequate to safely support adjacent structures and works.

3.5 SUPPORT SYSTEM WITH TIEBACKS

A. Install tieback system in accordance with approved working drawings. Install anchorage in soil no closer than a plane extending upward at an angle of 45 degrees to the horizontal from outer limit of lowest depth of excavation.

B. Stress tiebacks to proof loads equal to 140 percent of maximum design load and maintain proof load for 30 minutes prior to reducing to design load. Reject tiebacks which lose more than five percent of proof load during 30 minute period.

C. Apply proof loads in increments of five tons at one minute intervals and provide means to measure load application with accuracy of plus or minus five percent.

D. After reducing tieback load to design load, encase anchors in grout maintaining design load until anchors are fixed in place.

E. In transfer of loads from jacks to support system, use fixation method which will limit load loss to no more than five percent of design load.

F. Preliminary and Creep Tests on Tiebacks:

1. Reapply proof loads equal to 140 percent of design load at each level of support in excavation on first installation on each side of excavation at horizontal intervals not exceeding 500 feet and wherever there is significant difference in soil in which tiebacks are installed.

2. As specified for proof loading, apply proof loads in increments of five tons at one minute intervals. Provide means to measuring load applications with an accuracy of plus or minus five percent of design load. Maintain proof load for 24 hours prior to reducing it to design load.

3. Make records of axial movement with incremental applications of load as well as amount and time of load fall-off with no pumping of jack or axial movement during 24 hour period that proof load on tieback system is maintained. If during 24 hour period axial deformation of tieback system exceeds 0.02 inch or decrease in jack pressure without pumping is more than five percent after correcting for temperature changes during the test period, redesign tieback system to satisfy requirements.

G. Rock Bolts:

1. Tension rock bolts to their design load as approved to permit checking of each loading by the Contracting Officer.

2. If grouted rock bolts are used, after loading has been approved, pressure-grout each permanent rock bolt in place using methods and equipment which will ensure elimination of air from bolt hole.

3. If fully resin-encapsulated bolts are used, use slow setting resin to allow the Contracting Officer sufficient time to approve loading prior to gelation.

H. Vertical Support System with Tiebacks:

1. Install piles or other vertical support system members incorporated in a system utilizing tiebacks so that they are capable of resisting vertical components of tieback loads without significant settlement during excavation and construction.

2. Install vertical support members so that settlements will not be caused by construction. In general, install members to be end-bearing in stratum below maximum depth of excavation and capable of
carrying total vertical loads without assistance of skin friction at depth of excavation.

3.6 **LAGGING**

A. Unless otherwise required, provide timber lagging of 3 inches minimum thickness where it spans soldier piles placed at distances 5 feet to 7 feet on centers and for excavation depths up to 25 feet. Increase minimum lagging thickness to 4 inches for excavation below 25 feet in depth.

B. For other conditions and types of lagging, submit design details for approval.

3.7 **SUPPORT OF EXCAVATION AT INTERFACES**

A. Construct, maintain, and remove all or parts of support system at limits of the Contract, at interface with the Authority's adjacent contracts, as may be necessitated by construction schedules and sequence of operations of respective contracts.

B. In the event excavation is commenced at an interface prior to the commencement of excavation on adjacent contract, design, construct, and maintain end support system making provisions as follows:

1. Install near face of cofferdam on line separating contracts. Allow no part of support system to project into the next contract except thickness of supporting wall, e.g. soldier piles and lagging, and tiebacks if approved.

2. Provide support system adequate to support backfill and restoration loads with installation of a reasonable bracing system by adjacent contractor during excavation for his contract.

C. If excavation has commenced on adjacent contract at interface prior to excavation on this Contract, make provisions as follows: Coordinate removal of such portions of cofferdam which have been installed in adjacent contract and support and maintain remainder as necessary to effect juncture of contracts.

3.8 **FIELD QUALITY CONTROL**

A. Tests:

1. Conduct tests and obtain approval prior to use of tieback system for excavation support.

2. The Contracting Officer may furnish and install certain instruments to monitor performance of tieback or rock-bolt system.

B. Remove components of support system which penetrate or encroach on permanent structure without endangering stability of support.

C. Welding: In accordance with Section 05120, "Structural Steel - Bridges".

D. Provide and maintain convenient access and appropriate means for the Contracting Officer to accomplish these observations.

3.9 **REMOVAL OF SUPPORTING SYSTEM**

A. When removing support of excavation system, wholly or in part, do not disturb or damage adjacent buildings, structures, construction, or utility facilities. Fill voids immediately with lean concrete or with approved backfill compacted to density specified in Section 02220, "Grading, Excavating, and Backfilling".

B. Leave first support immediately above invert slab of subway structure in place for at least 48 hours after placement of invert concrete. Leave support immediately above top of roof slab of structure in place for at least seven days after placement of roof slab concrete unless the Contracting Officer approves earlier removal.

C. Remove other supports above roof structure only after backfill has been placed and compacted to required density to within 6 feet of bottom of support.

D. Except as specified below, remove supporting system to depth of 6 feet below surface. Remove supporting systems at intersections of streets and at temporary access ramps to a depth of 8 feet.

E. Where top of Authority structure extends into 6 foot or 8 foot limit, remove adjacent supporting systems to a depth flush with the top of the Authority structure or 1 foot below the surface, whichever is greater. Increase removal depths where necessary to accomplish work in this Contract.

**PART 4 - MEASUREMENT AND PAYMENT**

4.1 **GENERAL**

A. The work specified in this section as support systems for excavation over 5 feet in depth will not be measured directly, but shall be considered as incidental to other items of work.
B. Support of excavation if required for depths not exceeding 5 feet will not be measured, but considered incidental to excavation.

C. Support of excavation for utility trenches will be measured and paid for as specified in Section 02221, "Utility Excavation and Backfill".

END OF SECTION 02160
SECTION 02220
GRADING, EXCAVATING AND BACKFILLING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies grading, excavating, constructing embankments and backfilling for roadways, and structures, and disposing of excess excavated material.

B. For utility excavation and backfill, see Section 02221, "Utility Excavation and Backfill".

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C33 - Standard Specification for Concrete Aggregates

2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))


5. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

6. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity

7. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles


15. ASTM D6023 - Standard Test Method for Unit Weight, Yield, Cement Content and Air Content (Gravimetric) of Controlled Low Strength Material (CLSM).

B. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised (NCTCOG Standard Specifications).

C. Texas Department of Transportation, Standard Specifications for Construction of Highways, Streets, and Bridges (TxDOT Standard Specifications).

1.3 DEFINITIONS

A. Grading consists of the following:

1. Excavation of earth, concrete, asphalt paving, and rock for grading.

2. Shaping and constructing embankments and fills.

B. Earth excavation: Excavating in materials of whatever nature except rock as defined below.

C. Rock excavation: Excavating material in place which cannot be loosened nor broken down by using earth excavating equipment and which requires rock excavating equipment for its removal.

D. Borrow: Materials obtained by the Contractor from designated or approved sources other than required excavation.

E. Approved material: Materials for embankment, fill, and backfill specified herein as approved for the particular application by the Contracting Officer.
F. Surplus excavated material: Approved excavated material which is not used in embankments or as fill within the Project Limits.

G. Unsuitable material: Material which does not meet specified requirements for use for embankment fill, backfill, general site fill, trench backfill or wall backfill; and is prohibited for use in the Work.

H. Undercut Excavation: Unsuitable material excavated below contract elevation.

I. Common Excavation: Excavation below existing ground line to Contract specified grade.

J. Authorized excavation: Excavating to neat lines and limits shown and specified; excavating unsuitable material when required by the specifications.

K. Unauthorized or excess excavation: Excavated materials which would otherwise be left in place, but removal of which is required because the Contractor's operations have rendered them unstable; excavation which is not specified as authorized excavation, such as excavation beyond neat lines and bottoms of footings as shown on the Contract Drawings, or excavations made by the Contractor for the Contractor's convenience.

L. Unclassified Street Excavation: Required excavation within the limits of streets, alleys, parking lots, stations, trackway, and Authority right-of-way (except excavation specifically described and provided for elsewhere in the specifications), the removal and proper utilization or disposal of all excavated material within those limits; and the shaping and furnishing of all earthwork in conformity with the lines and grades of the streets, alleys, parking lots, stations, trackway, and Authority right-of-way as shown on the Contract Drawings.

M. Unclassified Common Excavation: Excavation, regardless of the material encountered, below existing ground line to Contract specified grades which is neither unclassified street excavation nor unclassified structural excavation.

N. Unclassified Structural Excavation: Structural excavation and removal of materials encountered, regardless of their nature or the manner in which they are removed, necessary for the construction of structures which shall be from finish grade in areas of cut, and from natural grade in areas of fill.

O. Authorized Unclassified Overexcavation: Excavation beyond the neat lines shown on the plans when authorized by the Contracting Officer for the purpose of removing unsuitable subgrade materials. Does not include materials described as "Unauthorized or excess excavation".

P. Embankment, Fill and Backfill: Placement of approved materials to specified controls from original grade or authorized excavated grade (not including stripping) to contract elevations.

Q. Salvage: Materials shown to be salvaged in accordance with Section 02072, "Removal and Restoration of Miscellaneous Existing Facilities" and Division 1, GENERAL REQUIREMENTS.

1.4 SUBMITTALS

A. Test Results: At least seven calendar days in advance of desired date of approval, submit test results of material proposed for fill, backfill, controlled low strength material (flowable fill), and embankment certifying that the material complies with the Specifications. Tests shall be performed by an independent testing laboratory approved by the Authority and complying with Section 01450, "Quality Control".

B. Submit sample, specification data, and manufacturer's installation instructions for non-woven filter fabric to the Contracting Officer for approval.

C. Submit manufacturer and model number of power-actuated compactors proposed for use in confined areas adjacent to structure.

D. Submit documentation of permits for disposal of excavated material:

E. Submit written releases from each property owner where excavated material will be deposited absolving the Authority from responsibility in connection with such disposal. Submit releases at least seven calendar days prior to disposal of material. Releases shall be signed by owners of property on which material will be deposited.

1.5 REGULATORY REQUIREMENTS

A. Perform excavation work in accordance with OSHA Safety and Health Standards and Texas Trench Excavation Safety Law.

1.6 JOB CONDITIONS

A. Existing Drainage:

1. Refer to Section 01562, "Soil Erosion and Sediment Control", for related requirements.

2. Preserve, protect, and maintain existing operable drains and sewers during grading operations.

B. Refer to Section 01500, "Temporary Facilities and Services Required During Construction" for requirements for barricades and other protective devices.

C. Location of Underground Facilities and Structures:
1. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.
2. Verify locations of existing utilities in accordance with Section 02760, "Maintenance, Support and Restoration of Existing Utility Facilities".

D. Toxic, Hazardous, and Combustible Substances:
1. Comply with the requirements of Section 01560, "Environmental Protection".
2. During excavation, provide equipment and carry out such tests as necessary to detect presence of toxic, hazardous, and combustible substances. Refer to Special Provisions, "Environmental Testing," for related requirements.
3. Take action to safeguard persons and property in accordance with rules and regulations of jurisdictional agencies and utility owners.
4. Promptly notify utility owners when problems concerning their facilities become apparent.

E. Ramps:
1. Construct temporary ramps as necessary to provide access to work area.
2. Locate such access ramps in Contractor's storage, operations, and access areas or within excavation for structure and maintain traffic as specified.
3. Support ramp excavation in accordance with Section 02160, "Support of Excavation".
4. When ramps are in use, station properly equipped flagmen at ramp entrances to keep unauthorized vehicles and persons from entering work area.
5. When work necessitating entrance or exit of vehicles via ramps is not being performed, protect entrances and exits of ramps by warning signs and barricades in accordance with the General Requirements.
6. Upon completion of work necessitating use of ramps, remove support elements of ramp system in accordance with Section 02160, "Support of Excavation" and backfill excavated ramp areas.

F. Excavation Near Surface and Underground Structures: Control excavation in areas near all structures including buildings, underground and overhead utilities, bridges, pavement, and track to maintain stability and function of structures. If underpinning is necessary, perform excavation work in accordance with Section 02150, "Underpinning, Support, and Restoration of Structures" so that condition of surrounding area remains unimpaired.

PART 2 - PRODUCTS

2.1 MATERIALS FOR EMBANKMENT, FILL, AND BACKFILL

A. Embankment Fill:
1. Well graded soil-aggregate mixture comprising stone, gravel, sand, lean clay, fat clay, or combinations of such materials.
2. Prohibited material: Organic matter, debris, cinders, frozen material, and as required by the jurisdictional agencies.
3. Liquid Limit: 70 percent maximum when placed in embankments with side slopes equal to or steeper than 4 Horizontal to 1 Vertical (4H:1V). For slopes flatter than 4H:1V, liquid limit shall not exceed that of native soils present where fill will be placed.
4. Plasticity Index: Between 7 and 40 percent when placed in embankments with side slopes equal to or steeper than 4 Horizontal to 1 Vertical (4H:1V). For slopes flatter than 4H:1V, plasticity index shall not exceed that of native soils present where fill will be placed.
5. Particle Size: 4 inches maximum, but not exceeding 1 inch within one foot of finished grade.

B. Select Fill:
1. For use for retaining wall backfill.
2. Clayey sand or sandy clay, or silty fine sand, free of roots, grass, trash or other organic
material, contaminated soils, debris, or other materials that would prevent proper compaction of select fill.

3. Plasticity Index: Not to exceed 15 percent.
4. Liquid Limit: Not to exceed 40 percent.

C. Structural Select Fill:
1. For use at flatwork subgrades, trench backfill, and where indicated on the Contract Drawings.
2. Clayey sand, sandy clay, or Austin Chalk Limestone, free of roots, grass, trash, and other organic material. Crushed stone or gravel stone up to 4 inches maximum size is permissible, but not exceeding 1 inch in size within 0.5 feet of finished grade.
3. Clayey Sand or Sandy Clay:
   a. Plasticity Index between 5 and 15 percent.
   b. Liquid Limit not to exceed 40 percent.
4. Austin Chalk Limestone:
   a. Gradation:
      | Grain Size | Percent Retained |
      |------------|-----------------|
      | 4 inches   | 0               |
      | 1.75 inches| 0-45            |
      | No. 4      | 35-75           |
      | No. 40     | 50-85           |
   b. Plasticity Index: Maximum 20 percent.

D. Controlled Low Strength Materials (Flowable Backfill):
1. Mixture of natural sand or manufactured sand, cement, and/or fly ash, and water. Flowable mixture shall have a minimum slump of 5 inches.
2. Materials used shall be granular with 100 percent passing a 3/4 inch sieve.
3. Plasticity Index: Not to exceed 12 percent.
4. Cement content shall be minimum 100 lbs per cubic yard unless otherwise indicated on the Contract Drawings.
5. Unconfined compressive strength per ASTM D4832 shall be between 250 and 450 psi after 28 days unless otherwise indicated on the Contract Drawings.

E. Cement Treated Base
1. Mixture of crushed stone or crushed concrete, binder, cement, and water to produce a base course per TxDOT Standard Specifications, Item 276, “Portland Cement Treated Base (Plant Mixed)”.
2. Crushed stone shall be Type A, Grade 1, per TxDOT Item 247, “Flexible Base,” unless otherwise indicated on the Contract Drawings.
3. Cement treated base shall be Strength M, 500 psi at 28 days, with minimum cement content of 5 percent unless otherwise indicated on the Contract Drawings.
4. Cement treated base shall be plant mixed.

2.2 NON-PUMPING SUBBASE
A. As specified in the NCTCOG Standard Specifications, as revised.

2.3 PERVERSIOUS MATERIAL
A. Natural, clean, free draining sand conforming to the requirements of ASTM C33 except the following:
   1. Material passing Size 100 sieve not to exceed eight percent.
   2. Material passing Size 200 sieve not to exceed five percent.

2.4 SOIL DRAINAGE MATERIAL
A. Clean, crushed, rock, gravel, with 1-1/2 inches maximum particle size and maximum two percent by weight passing Size 4 sieve. Crushed concrete shall not be used as a soil drainage material.

2.5 IMPERVIOUS MATERIAL
A. Lean clay and fat clay material with minimum 65 percent by weight passing Size 200 sieve.
B. Plasticity Index: 30 percent minimum, determined in accordance with ASTM D4318.

2.6 NON-WOVEN FILTER FABRIC
A. Use non-woven material for subgrade stabilization at locations indicated on the Contract Drawings.
B. Shall adhere to the following requirements:

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST PROCEDURES</th>
<th>MINIMUM ALLOWABLE VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, lbs.</td>
<td>ASTM D4632</td>
<td>350</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>ASTM D4632</td>
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</tr>
<tr>
<td>Puncture Strength, lbs.</td>
<td>ASTM D4833</td>
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<tr>
<td>Mullen Burst Str., psi</td>
<td>ASTM D3786</td>
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<tr>
<td>Trapezoidal Tear, lbs</td>
<td>ASTM D4533</td>
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<tr>
<td>Abrasion Res, % Str. Ret.</td>
<td>ASTM D4886</td>
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<tr>
<td>Coeff. of Perm., cm/sec</td>
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<td>Flow Rate, gpm/sf</td>
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<td>Permittivity, 1/sec</td>
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<td>Apparent Opening Size</td>
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<tr>
<td>Thickness, mils</td>
<td>ASTM D5199</td>
<td>120</td>
</tr>
</tbody>
</table>

2.7 SOURCE OF MATERIALS

A. Use materials excavated under this Contract for embankment, fill, and backfill if they meet specified requirements. If sufficient material meeting these requirements is not available from this Contract, obtain material meeting specified requirements.

B. If borrow areas are provided by the Contracting Officer within the right-of-way, dress and shape such areas to ensure positive drainage when borrow operations are completed.

C. Use only material whose quality, source, and zone of placement in the fill have been approved.

PART 3 - EXECUTION

3.1 GENERAL

A. The existing topographic features used in the design of this project are based on aerial mapping. The Contractor shall use appropriate equipment in sufficient quantity and size to perform the work as specified and shown.

B. Keep haul routes clean in accordance with the General Requirements and in accordance with Section 01560, “Environmental Protection”.

C. Storage of Excavated Material In Floodways: The Contractor shall not store or deposit surplus excavation or any other material in any area designated as a Flood Plain or along natural drainage ways. Materials so deposited shall be removed and the area restored to its natural condition at the sole expense of the Contractor.

3.2 EARTH EXCAVATION

A. Excavate in sequences and stages which will not impair permanent facilities or temporary facilities, and surfaces.

B. Excavate to neat lines or set back lines for mixed face conditions and grades shown. If approved, slopes may be flattened as a matter of expediency.

C. When excavation has reached required grades, notify the Contracting Officer, who will make an inspection of conditions. Where excavation to the finished graded section results in a subgrade or slopes of unsuitable materials, remove such materials below the grade as shown on Contract Drawings, as specified herein, or as directed. Replace unsuitable material with approved fill material and compact as specified in Article 3.10, herein.

D. When excavation has reached required grades for roadways, trackbeds, mechanically stabilized earth (MSE) wall subgrade, retaining wall subgrade, and other subgrades, the Contracting Officer will require the Contractor to proof roll the exposed surface using a fully loaded 20 ton rubber tired truck to detect all soft and compressible areas. If soft and compressible areas are detected, perform the following additional steps:

1. Excavate and remove materials from soft and compressible areas until suitable materials are encountered.

2. Replace these overexcavated areas with approved materials to reestablish final grade for the subgrade consisting of soils similar to the existing surrounding soils and zones of proposed fill above subgrade.

3. Proof roll exposed surfaces and continue detection, removal, and replacement of unsuitable foundation materials until stabilized and suitable subgrade is established.

4. Perform overexcavation, if required by the Contracting Officer, to remove rock, ballast, boulders, debris, and other unsuitable foundation materials encountered below specified limits of excavation for new subgrade.

E. Prepare subgrade for placement of additional fill as specified in Article 3.7 herein.
F. Preparation of Subgrade Below Sub-ballast: Refer to Article 3.8, herein.

G. Support sides of excavation as specified in Section 02160, "Support of Excavation".

H. Protect, support, and maintain utility facilities as specified in Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities".

I. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to the facility owner.

J. Maintain excavation free from water in accordance with Section 02140, "Dewatering".

K. Remove excavated materials to fill, embankment, stockpile, or disposal locations. Keep temporary placement of excavated materials at least two feet from the edge of excavation.

L. Fill unauthorized and excess excavations with approved materials and compact as specified. Perform material and compaction tests in accordance requirements of this Section.

3.4 REMOVAL OF SUBSURFACE OBSTRUCTIONS

A. Remove subsurface obstructions where indicated in the Contract Documents and when required by the Contracting Officer.

B. Prior to removal of parts of subsurface obstructions, which extend into Contract limits, build permanent closure walls where shown around such obstructions to separate areas to be left intact from areas to be removed.


3.5 EMBANKMENT, FILL, AND BACKFILL

A. Place, compact, and test embankment, fill, and backfill in 8-inch loose layers, for entire width except as otherwise specified herein. Note, all fill and backfill under the Contract shall be compacted in layers as specified herein with the exception of sub-ballast. Install sub-ballast for the trackbed as specified in Section 02451, "Sub-Ballast".

B. Do not allow accumulation of large pieces of material at one location. Fill voids and crevices with finer materials.

C. Compaction in Confined Areas and Adjacent To Structures:
   1. In confined areas, use approved power-actuated compactors to achieve required density.
   2. Compact embankment, fill, and backfill materials within 5 feet of retaining walls, abutments, and other structures, using lightweight compactors.
   3. Do not overstress structures.
   4. Obtain Contracting Officer's approval prior to backfilling against new structures. Refer to Article 3.5Q, herein for detailed requirements for the timing of backfill operations against new cast-in-place concrete structures.

D. Prior to compaction, adjust moisture content of material within specified limits as specified in Article 3.10, herein, by drying or watering either at material source or on fill.

E. Leave struts, braces, lagging, and timbersheathing in place as long as needed to support excavation and adjacent facilities and structures. Remove
these struts and braces, and similar supports at appropriate time during or before backfilling.

F. Where utility facilities and structures are supported in place, use special equipment and techniques as required to achieve the compaction specified in Article 3.10, herein, under and around the utility facilities and structures.

G. Backfill coated pipe so as not to damage coating by using 6 inch minimum layer of pervious material or stone free soil under and over the pipe.

H. Do not place backfill on subsurface structures until requirements for curing and waterproofing have been complied with and, if required, until test cylinders for particular structure indicate that concrete has attained specified compressive strength.

I. When backfilling against structures, place material approximately simultaneously on both sides of structures to equalize opposing horizontal pressures.

J. When backfilling on tops of structures, place material in 6 inch lifts.

K. Under concrete floors and other slabs on grade, place drainage material directly on prepared subgrade which meets density and elevation requirements specified in Article 3.10, herein.

L. Prior to placing embankment against slope greater than one foot vertical to four foot horizontal, cut benches into existing slope. Height of bench shall not exceed 2 feet unless otherwise approved.

M. Maintain embankment, fill, and backfill in stable, well-drained condition.

N. Where approved by the Contracting Officer, Contractor may dispose of surplus excavated material by widening embankments and flattening slopes.

O. Where pervious material will be exposed to erosion, cover it with 12-inch layer of approved impervious material compacted in place.

P. Backfill for soil reinforcement of Mechanically Stabilized Earth (MSE) walls shall be as specified in Section 02872, “Mechanically Stabilized Earth Retaining Wall.” Backfill material beyond the limits of MSE wall soil reinforcement shall be “Embankment Fill” as specified in this Section.

Q. Backfilling Against Cast-In-Place Concrete Structures: Obtain Contracting Officer’s approval prior to backfilling. Backfill shall be placed as soon as practicable following the attainment of the required compressive strength and lapse of time specified in Table 02220-1, except as otherwise noted on the Contract Drawings. In no case shall backfilling occur later than 30 days after the concrete placement unless the excavated openings are maintained in a drained condition. Excavation openings shall be made as dry as practicable at the time of backfilling by dewatering method in accordance with Section 02140, “Dewatering.” Backfill shall be placed in such a manner as to deter the impoundment of water and to facilitate existing drainage.

R. Controlled Low Strength Flowable Backfill:
   1. Mix flowable mixture in a pug mill, concrete mixer, or transit mixer.
   2. Minimum temperature at point of delivery 50 degrees F.
   3. Protect from freezing for a period 36 hours after placement.
   4. Allow the flowable mixture to set prior to placement of any overlying material.

3.6 BORROW

A. For additional quantities, when required and approved, obtain borrow materials from approved or designated sources.

B. Provide appropriate drainage for borrow operations and excavate in accordance with the approved plans.

C. Perform no surplus excavation in borrow operations. Avoid excavation of unsuitable materials.

3.7 PREPARATION OF GROUND AS SUBGRADE

A. Where the subgrade is on original ground; in soil cut; where embankment and fill is less than 1 foot, fulfill compaction and moisture requirement as specified in Article 3.10, herein, for 8 inches minimum below final subgrade.

B. If necessary, scarify original ground and adjust moisture content prior to compacting.

C. Sand or other granular leveling material shall be specifically prohibited beneath pavement areas.

3.8 PREPARATION OF SUBGRADE BELOW SUB-BALLAST

A. After excavation and embankment have been completed in accordance with these specifications, the Contractor shall prepare the subgrade beneath the sub-ballast as follows:
1. For clayey soils with a Plasticity Index greater than 15, provide 6 inches of lime stabilization in accordance with Section 02243, “Soil Stabilization: Lime Treatment”.

2. Where different backfill materials or foundations exist below the sub-ballast due to rock, walls, or other structures, provide a uniform depth of 24 inches of similar select or specified fill materials beneath the sub-ballast and place filter fabric between the prepared and proof rolled subgrade and the sub-ballast. Limits of proposed filter fabric on subgrade as indicated on the Contract Drawings are approximate. The actual longitudinal and lateral extents may vary. Install fabric in accordance with manufacturer’s installation instructions.

3.9 FINISHING

A. Construct subgrades in landscape areas as follows:
   1. Plant areas: 0.4 foot below established finished grade.
   2. Lawn areas: 0.2 foot below established finished grade.

B. On completion of work, clean ditches and channels.

C. Slope and shape borrow areas to provide positive drainage.

D. Remove unsuitable and surplus excavated materials to locations outside the Project's right-of-way in accordance with Section 02100, “Site Preparation”.

E. Leave site in neat, presentable condition.

3.10 COMPACTION

A. Maintain moisture content of embankment, fill, and backfill material during compaction within minus 2 to plus 3 percent of optimum moisture content of material.

B. Compact each layer of embankment, fill, and backfill to 95 percent of maximum dry density as determined in accordance with ASTM D698, with moisture content within tolerance specified.

C. Compact each layer of fill below cast-in-place retaining walls and mechanically stabilized earth retaining walls that are 15 feet or higher to 95 percent of maximum dry density as determined in accordance with ASTM D1557, with moisture content within tolerance specified.

D. Compact fill below retaining walls less than 15 feet high to 95 percent of maximum dry density as determined in accordance with ASTM D698.

3.11 DISPOSAL

A. Dispose of waste material, trash and debris off site. Obtain written permission and releases from owner of the property where such waste materials are to be deposited and in accordance with the codes and regulations of the jurisdictional authorities. Submit copies of this information to the Contracting Officer prior to proceeding with the work.

3.12 FIELD QUALITY CONTROL

A. Allowable Tolerances:
   1. Construct finished subgrade to vary not more than 0.05 foot above or 0.10 foot below elevation shown.
   2. Construct finished grade: 0.1 foot plus or minus of the elevation shown.

B. Test Method: Determine the maximum dry density and the optimum moisture content in accordance with ASTM D698, except where specified to be in accordance with ASTM D1557.

C. Compaction Test Frequency:
   1. For each fill area less than 5,000 square feet, perform a minimum of three tests for each layer of compacted fill.
   2. For fill areas in excess of 5,000 square feet, perform a minimum of one test for every 5,000 square feet for each layer of compacted fill.
   3. For all subgrades, perform a minimum of one test for every 5,000 square feet.

D. Testing shall be at the expense of the Contractor.

E. Testing shall be performed to requirements for testing laboratories established in Section 01450, “Quality Control”.

F. Controlled Low Strength Material Flowable Backfill Test Frequency:
   1. One set of three cylinders shall be made for each 100 cubic yards or fraction thereof of Controlled Low Strength Material per ASTM D5971 placed in single day.
   2. Compressive strength shall be measured in accordance with ASTM D6023.
3. When indicated on plans or requested by Contracting Officer, unit weight, yield, cement content and air content of Controlled Low Strength Material shall be determined in accordance with ASTM D6023.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. General:

1. Measurement associated with Grading, Excavation and Backfill will be from ground line after clearing and grubbing. Clearing and grubbing is paid for under Section 02100, Site Preparation, and is not measured under this Section.

2. Where compaction is required, no measurement shall be made prior to the specified compaction of the work complete-in-place.

3. Except as otherwise specified herein, the work described in this Section including fill, backfill, compaction, and quality control will not be measured separately, and all costs in connection therewith will be considered incidental to the corresponding pay items of work.

B. Subgrade:

1. Subgrade, slopes, and foundation preparation will not be separately measured for payment, but all costs in connection therewith will be considered incidental to the material structure to be placed or constructed.

2. Undercut Excavation: In the preparation of the subgrade when unsuitable material must be removed from an area where undercut is not shown on the Contract Drawings, excavation of such undercuts will be measured by the cubic yard of “Undercut Excavation.” Replacement of the excavated unsuitable material by approved material and compaction as specified shall not be measured separately, and all costs in connection therewith shall be considered incidental to the work related to the excavation of undercuts.

C. Excavation:

1. Excavation will not be classified and will not be measured except when provided herein. Excavation shall include removal of all materials encountered regardless of their nature or the manner in which they are removed. There will be no extra compensation for rock excavation.

2. Measurement of undercut excavation and authorized unclassified overexcavation will not include compensation for expansion of materials, but will be based on excavation volume in its original position (insitu).

3. Unclassified street excavation: Authorized unclassified street excavation will not be measured.

4. Unclassified common excavation will not be measured.

5. Structural excavation shall not be measured for payment, but will be considered subsidiary to the other items of work. Unless the limits of excavation are indicated on the Contract Drawings, structural excavation shall be below the lower of the existing ground line or common excavation line to the bottom of the footing as indicated on the Contract Drawings. Such excavation shall be limited by vertical planes two feet outside the neat lines of the structural footings.

   a. Structural facilities include retaining walls, concrete slope paving, noise barrier wall, sign foundations, manholes, drainage structures, abutments, column foundations, footings and other structures.

   b. No measurement will be made of any excavation necessary for placing forms or falsework except as provided herein.

   c. No measurement or separate payment will be made for removal and disposal of materials from drilled shafts for foundation piers and all such work shall be subsidiary to completion of drilled shafts.

6. Refer to Section 02221, “Utility Excavation and Backfill”, for measurement and payment provisions for utility trench excavation.

D. Embankment, Fill, and Backfill:

1. Embankment (fill) will not be measured separately for payment but shall be considered subsidiary to Unclassified Street Excavation and Unclassified Common Excavation.
2. Backfill necessary for the structural facilities will not be measured for payment, but shall be considered subsidiary to other items of work.
   a. Structural facilities include retaining walls, concrete slope paving, noise barrier wall, sign foundations, manholes, drainage structures, abutments, column foundations, footings, and other structures.

3. Refer to Section 02221, “Utility Excavation and Backfill”, for measurement and payment provisions for utility trench backfill.

4. Measurement for backfill of authorized unclassified overexcavation other than with on-site material will be made as specified for the material required specifically in that area as approved.

5. Select fill, not incidental to work specified elsewhere, will not be measured.

E. Borrow: Borrow quantities will not be measured.

F. Pervious material, not incidental to work specified elsewhere, will be measured by the cubic yard complete-in-place.

G. Soil drainage material, not incidental to work specified elsewhere, will be measured by the cubic yard complete-in-place.

H. Impervious material, not incidental to work specified elsewhere, will be measured by the cubic yard complete-in-place.

I. Non-woven filter fabric shall be measured by the square yard of surface area covered, complete-in-place, as installed by the manufacturer's recommendations.

J. Measurement, when applicable, of excavation, embankment, fill, backfill, and borrow will not include any additional quantities due to the action of the elements or the carelessness of the Contractor, such as additional quantities caused by slips, slides, cave-ins, silting, or unauthorized overexcavation.

K. Excavation for the Contractor's convenience or unauthorized excavation outside the limits indicated in the Contract Documents, and backfill of such excavations will not be measured for payment.

L. Re-excavation and re-handling of stockpiled material will not be measured for payment, but will be considered incidental to the earthwork to which it pertains.

M. Demolition and Disposal:

1. Removal of existing facilities, such as, parking surfaces, sidewalks, curbs, etc., will be considered under Section 02050, “Demolition”, and will not be measured under this Section.

2. Disposal of surplus excavated materials and unsuitable materials will not be separately measured for payment, but costs in connection therewith will be considered incidental to the work described in this Section.

4.2 PAYMENT

A. Payment will be made for the following items at the lump sum and unit prices.

1. Undercut excavation, per cubic yard.

2. Unclassified Street Excavation, per lump sum.

3. Unclassified Common Excavation, per lump sum.

4. Authorized Unclassified Overexcavation, per cubic yard.

5. Select fill, per lump sum.

6. Borrow, per lump sum.

7. Pervious material, per cubic yard.

8. Soil drainage material, per cubic yard.

9. Impervious material, per cubic yard.

TABLE 02220-1
BACKFILLING REQUIREMENTS

<table>
<thead>
<tr>
<th>Structural Elements</th>
<th>Time in Days</th>
<th>Percentage of f'c*</th>
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<tbody>
<tr>
<td>Deck Slabs</td>
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<td>60</td>
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<tr>
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<td>60</td>
</tr>
<tr>
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<tr>
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<td>7</td>
<td>80</td>
</tr>
<tr>
<td>Concrete Encasements</td>
<td>2</td>
<td>30</td>
</tr>
</tbody>
</table>

* Refer to Section 03305, "Portland Cement Concrete", for compressive strength (f'c) values for each type of concrete placement; in particular, refer to Article entitled, "Concrete Mix Designs".

END OF SECTION 02220
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies trench excavation, trench support systems, and trench backfill for utility excavations. Unless a design for the support system is shown in the Contract Documents, design and installation of trench support systems is the responsibility of the Contractor.

B. Pipe and conduit installation and bedding or encasement requirements are shown on the Contract Drawings and specified in applicable sections of the specifications.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):


2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

B. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised (NCTCOG Standard Specifications).

1.3 SUPPORT SYSTEM REQUIREMENTS

A. Comply with support system design requirements specified in Section 02160, “Support of Excavation”.

B. Provide positive trench excavation support for all trenches in excess of five vertical feet in depth.

C. Provide positive trench excavation support for all trenches less than five vertical feet in depth where determined by site or soil conditions, or when directed by the Contracting Officer.

1.4 SUBMITTALS

A. Documentation:

1. Submit shop drawings of manufactured trench boxes (including reinforcement details).

2. Submit copies of permits with drawings.

B. Trench Safety Plan: Submit for approval a trench safety plan signed and sealed by a Professional Engineer qualified to do such work and licensed in the State of Texas.

C. Working Drawings and Calculations: Submit working drawings and calculations for devices used to provide trench safety such as trench shields and shoring systems signed and sealed by a Professional Engineer licensed in the State of Texas.

D. Test Results: Submit test results indicating that flowable backfill meets specified requirements. Test results shall be less than 6 months old.

1.5 REGULATORY REQUIREMENTS

A. Design and perform trench excavation and support of excavation work in accordance with OSHA Safety and Health Standards Texas Trench Excavation Safety Law.

1.6 JOB CONDITIONS

A. Location of Underground Facilities and Structures:

1. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.

2. Verify locations of existing utilities in accordance with Section 02760, “Maintenance, Support and Restoration of Existing Utility Facilities.”

B. If existing utility facilities interfere with the proposed method of support, notify the Contracting Officer. Do not modify the support system, nor modify or relocate such facilities without the approval of the Contracting Officer.

PART 2 - PRODUCTS

2.1 TRENCH BOX

A. Furnish box with a manufacturer’s depth certification plate permanently attached to the inside face of the box. At a minimum, the certification plate will provide the following information:

1. Manufacturer’s name, model, and serial numbers.

2. Maximum depth of excavation and soil conditions for which the box is certified.
2.2 MANHOLE BOX
   A. Furnish fabricated manhole box which meets, at a minimum, the requirements specified for the trench box specified above, unless otherwise shown or noted.

2.3 STEEL SHEETPILING
   A. Continuous interlocking type with cross section selected for intended use and imposed loads in accordance with Section 02160, "Support of Excavation".

2.4 CONCRETE
   A. In accordance with Section 03305, "Portland Cement Concrete", Mix S-2.

2.5 REINFORCEMENT
   A. In accordance with Section 03200, "Concrete Reinforcement".

2.6 TIMBER LAGGING
   A. Structural grade, mill stamped with minimum allowable flexural stress of 1,100 psi in accordance with Section 02160, "Support of Excavation".

2.7 STRUCTURAL STEEL
   A. In accordance with Section 05120, "Structural Steel - Bridges": ASTM A36 minimum.

2.8 IMPORTED TRENCH BACKFILL
   A. Imported trench backfill shall consist of either of these two materials, at the Contractor's option:
      1. Select fill in accordance with Section 02220, "Grading, Excavating, and Backfilling".
      2. Flowable backfill as specified in Section 02220, "Grading, Excavating, and Backfilling", Paragraph 2.1 D.

PART 3 - EXECUTION

3.1 TRENCH EXCAVATION
   A. Perform excavation for utility trenches in all materials, including rock, to the line and grade shown.
   B. Proceed with caution in areas of utility facilities exposing them by hand excavation or other means acceptable to utility owner. Protect, support, and maintain existing utilities in the trench excavation in accordance with Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities".
   C. Where conditions do not allow sloping of excavation, install either an approved manufactured or approved Contractor fabricated trench box, manhole box, sheeting, shoring, or bracing, in accordance with approved submittals.
      1. Support trench excavation within the property limits either by sheeting, lagging, or trench box as specified; or by lay back excavation; as approved by the Contracting Officer. Lay back side slopes on trench excavation only with the approval of the Contracting Officer.
      2. Support trench excavation outside the property limits by sheeting, lagging, trench box, or manhole box, as approved.
   D. Where necessary to prevent unacceptable deformation of the trench sidewalls, slopes, or when directed by the Contracting Officer, backfill the voids between the exposed sidewall, slope, and the exterior faces of the trench or manhole boxes. Backfill with approved materials and in accordance with Section 02220, "Grading, Excavating, and Backfilling".
   E. Where conditions require, pre-excavate for trench support installation.
   F. Permit no equipment, construction materials, and stockpiled excavated materials in the proximity of the trench perimeters in excess of the approved load limits.
   G. For rainy weather and where site conditions warrant, take precautions and prevent surface-water run-off from entering the excavation. Perform dewatering in accordance with Section 02140, "Dewatering".
   H. If ground water is encountered, control the water in accordance with Section 02140, "Dewatering", to prevent or eliminate seepage in the excavation invert, or through the excavation sidewalls or slopes.
   I. Provide means of exit, in trenches 5 feet, or deeper, which ensures a 25 foot maximum lateral movement when exiting.
   J. Maintain trench supports (sheeting, shoring, bracing, or trench boxes) in place until the work is completed.
K. Provide protective devices and barricades as specified in Section 01500, "Temporary Facilities and Services".

3.2 SHEETING, SHORING, AND PILING

A. Install soldier piles and sheet piling as specified in Section 02360, "Driven Piles".

B. Where required, use timber lagging or steel sheeting secured in place for sheeting of trench excavations. Install lagging and sheeting as specified in Section 02160, "Support of Excavation".

C. Follow excavation closely with placement of sheeting and lagging as specified in Section 02160, "Support of Excavation".

D. Do not allow maximum height of unsheeted or lagged face of trench excavation to exceed 4 feet in predominantly clayey soils and 3 feet in sandy soils.

3.3 WALES, STRUTS, AND BRACING

A. Use wales, struts, or bracing as required, to provide primary support of trench excavation faces retained by soldier piles, sheeting or sheet piles.

B. Install primary support as specified in Section 02160, "Support of Excavation".

C. When primary support is required by site conditions, excavate to no more than 2 feet below the point of support about to be placed. Install support and preload immediately after installation and prior to continuing excavation.

D. When removing struts, do not increase vertical spacing unless invert slab has been installed for at least 48 hours, and support system is adequate to safety support adjacent structures and works.

3.4 LAGGING

A. Unless otherwise required, install lagging as specified in Section 02160, "Support of Excavation".

B. For other conditions and types of lagging, submit design details for approval.

3.5 TRENCH OR MANHOLE BOX

A. Excavate trenches to be supported by either trench or manhole box in accordance with Section 02220, "Grading, Excavating, and Backfilling".

B. Set trench or manhole box in place prior to initiating work within the excavation.

C. Where necessitated by site or Contract conditions, and when approved by the Contracting Officer, stack or extend boxes in accordance with the manufacturer's recommendations.

D. Where conditions permit, slope bank above the top of box to the approved angle of repose.

E. Unless otherwise approved by the Contracting Officer, immediately after removal of trench or manhole boxes, backfill excavation and compact in accordance with Section 02220, "Grading, Excavating, and Backfilling" or backfill with flowable backfill as specified herein.

F. When trench excavation remains open, install protective devices and barricades as specified in Section 01500, "Temporary Facilities And Services Required During Construction".

3.6 WELDING

A. Welding: Perform all welding in accordance with Section 05120, "Structural Steel - Bridges".

3.7 REMOVAL OF SUPPORTING SYSTEM

A. When removing support of trench excavation system, wholly or in part, do not disturb nor damage adjacent buildings, structures, construction, and utility facilities. Fill voids immediately with lean concrete in accordance with Section 03305, "Portland Cement Concrete", Mix M-1 or with approved backfill compacted in layers to density all as specified in Section 02220, "Grading, Excavating, and Backfilling".

B. When invert concrete is placed, leave support in place for at least 48 hours after concrete placement.

C. Except when using trench boxes, remove supports only after backfill has been placed and compacted to required density, as specified in Section 02220, "Grading, Excavating, And Backfilling".

D. Except as specified below, remove supporting system to depth of 6 feet below surface.

1. Remove supporting systems at intersections of streets and at temporary access ramps to a depth of 8 feet.

2. Where tops of existing and constructed structures extends over 5 feet limit, remove adjacent supporting systems to a depth flush with the top of the structure or 1 foot below the surface, whichever is greater.
3. Increase removal depths where necessary to accomplish this Work.

3.8 BACKFILL

A. Backfill trenches in the public right of way in accordance with the requirements of the jurisdictional agency.

B. Backfill trenches outside the public right-of-way with excavated material, but do not use organic matter, debris, cinders, nor frozen material. When needed, utilize imported trench backfill as specified herein.

C. Place and compact backfill in maximum 8 inch loose layers. Compact backfill to 95 percent of maximum dry density as determined in accordance with ASTM D698.

D. Compact backfill at moisture contents within minus 2 to plus 3 percent of optimum moisture as determined by ASTM D698.

E. Where utility facilities and structures are supported in place, use special equipment and techniques to achieve specified compaction, as per Section 02220, "Grading, Excavating, And Backfilling", under and around them.

3.9 FIELD QUALITY CONTROL

A. Trench Backfill Compaction Test Frequency:

1. For trench lengths less than 150 feet, minimum of one test for each layer of trench backfill.

2. For trench lengths in excess of 150 feet, perform a minimum of one test for every 150 linear feet for each layer of trench backfill.

3.10 CLEAN-UP

A. Remove trench support system as trench is backfilled.

B. Dispose of excess material in an approved manner in accordance with Section 02100, “Site Preparation”.

C. Do not store equipment or materials in the street, on public property, or on private property without written permission of the jurisdictional authority or owner of the private property.

3.11 DISPOSAL

A. Dispose of waste material, trash and debris off site. Obtain written permission and releases from owner of the property where such waste materials are to be deposed and in accordance with the codes and regulations of the jurisdictional authorities. Submit copies of this information to the Contracting Officer prior to proceeding with the work.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section including excavation and backfill (with the exception of support system for utilities exceeding 5 feet depth), will not be measured or paid for directly, but all costs in connection therewith will be considered subsidiary to the utility work. There will be no extra compensation for rock excavation.

B. Support system for excavation for utilities (including excavation for trenches and manholes) exceeding a depth of 5 feet will be measured and paid for at the unit price per linear foot of “Trench Support System”.

C. Support of excavation for utilities if required for depths not exceeding 5 feet will not be measured or paid for directly, but considered subsidiary to the utility work.

D. Maintenance, support, and relocation of existing utility facilities will be paid for under Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

END OF SECTION 02221
SECTION 02230
BASE FOR PAVEMENTS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section includes specifications for furnishing, placing, shaping, and compacting aggregate base on previously constructed subgrade.

1.2 REFERENCED STANDARDS
A. Texas Department of Transportation (TxDOT)
   a. Item 247 – Flexible Base
2. TxDOT Manual of Testing Procedures
   a. TEX-113-E - Laboratory Compaction Characteristics and Moisture-Density Relationship of Base Materials.

1.3 SUBMITTALS
A. Certified Test Results: At least seven calendar days in advance of desired date of approval, submit certified test results performed by an independent testing laboratory certifying that the proposed base material complies with the specifications. Test results shall not be more than 30 days old.
B. Source of Material: Not less than 10 calendar days prior to the beginning of work of this Section, submit name and location of source of material to be used.
C. Documentation: Submit delivery tickets from each load delivered to the Worksite which include, as a minimum the supplier, material and its composition, and material weight.

PART 2 - PRODUCTS

2.1 FLEXIBLE BASE:
A. General: Flexible base shall be in accordance with Item 247, TxDOT Standard Specifications.
B. Physical Requirements:
   1. Type: Type A, crushed or broken aggregate.
   2. Gradation: Grade One.

2.2 SOURCE QUALITY CONTROL
A. Once the material has been approved, do not change source of supply without authorization, and then only after receiving approval of the new source material.
B. Approval of a source of supply does not relieve the Contractor from the obligation to furnish material which conforms to the specified requirements.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install and compact in accordance with TxDOT Standard Specifications Item 247. Compaction shall be not less than 98 percent density as determined in accordance with TEX 113-E at plus or minus 2 percent optimum moisture as determined by TEX 113-E.

3.2 MAINTENANCE
A. Maintain base density and grade for pavement in specified conditions until succeeding pavement course is placed.

3.3 FIELD QUALITY CONTROL
A. Contractor shall perform field tests to determine compliance with requirements for compaction and moisture content of aggregate base. Testing frequency shall be as specified in Section 02220, “Grading, Excavating, and Backfilling”.
B. Contractor shall measure thickness of the aggregate base (refer to Section 01450, "Quality Control"). Perform a minimum of one test for each unit of 2000 square yards of aggregate base installed at a location selected by the Contracting Officer. For units of aggregate base less than 2000 square yards, perform a minimum of one test. In that unit where the base is deficient by more than 1/2 inch in thickness, the deficiency shall be corrected to meet the required grade and thickness using a method approved by the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. Work described in this Section will not be measured but will be paid for at the lump sum price for “Base for Pavements” for each thickness of flexible base indicated on the Contract Drawings.
B. No additional payment will be made for any base of a thickness exceeding that required by Contract Drawings.

END OF SECTION 02230
SECTION 02242
SOIL STABILIZATION: PORTLAND CEMENT TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the stabilization of subgrade, subbase, and base through the addition of Portland cement. The work includes furnishing and applying cement, mixing, placing, wetting, and compacting materials to achieve the required density, finishing, curing, protection, and maintenance of the completed course.

B. This item includes work in native soil, embankment, bases, and existing paving structures.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft·lb/ft³ (600 kN·m/m³))

B. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised (NCTCOG Standard Specifications).

C. Texas Department of Transportation (TxDOT), Manual of Testing Procedures:
   1. Tex-120-E - Section 20 - Soil-Cement Testing

1.3 DESIGN REQUIREMENTS

A. Design Mix Criteria: Minimum design strength is shown on the Contract Drawings. Preliminary tests, using soil samples collected from the area to be stabilized, in accordance with TxDOT Test Method Tex-120-E, shall be performed to establish percent of Portland cement to be used, and confirm that the proposed mix design achieves the minimum design strength as shown on the Contract Drawings.

1.4 SUBMITTALS

A. Submit proposed mix design and preliminary test results demonstrating that mix design achieves minimum design strength required. Refer to Article entitled “Design Requirements” herein for preliminary test requirements. After approval of the mix design strength make no change in the mix without written authorization from the Contracting Officer.

B. Submit technical data for type of cement to be used.

C. Submit plan for method, equipment and procedure to be used for stabilization work.

1.5 JOB CONDITIONS

A. Do not prepare or place cement stabilization treatment if the ambient temperature is below 40 degrees F and falling.

B. When approved by the Contracting Officer, the mix may be prepared when the ambient temperature is above 35 degrees F and rising.

PART 2 - PRODUCTS

2.1 MATERIALS FOR FILL

A. Approved material as defined and in accordance with Section 02220, “Grading, Excavating, and Backfilling”. Fill materials to receive soil cement shall be “select fill” as defined in Section 02220, “Grading, Excavating, and Backfilling”.

B. Portland Cement: Either Type I, II or III Portland cement in accordance with Section 03305, “Portland Cement Concrete”. The Contractor, at his option, may use bulk cement, provided that the Contracting Officer's approval of the apparatus for handling, weighing, and spreading the cement is obtain prior to the start of the work.

C. Water: Potable, free of organics and other deleterious materials which will affect hardening of the treated soil.

PART 3 - EXECUTION

3.1 GENERAL

A. Cement treated subgrade shall be compacted to at least 95 percent of maximum dry density as determined by ASTM Test Method D698 at moisture content within minus 2 and plus 4 percentage points of optimum.

B. When Portland cement is added to the base, subbase, or soil materials provided under pertinent specifications, the specification applicable to that item shall govern except that manipulation of the materials and application cement shall be as required herein.
3.2 PREPARATION

A. Prior to placing base or subbase material, shape the subgrade to conform to the typical sections, lines, and grades shown in accordance with Section 02220, “Grading, Excavating, and Backfilling”.

B. Remove unsuitable soil and other material in accordance with Section 02220, “Grading, Excavating, and Backfilling”.

C. Prepare subgrade in accordance with Section 02220 “Grading, Excavating and Backfilling”.

3.3 APPLICATION

A. Streets and pavements, where required to have cement treated subgrade, shall receive the depth of Cement Treated Subgrade indicated on the Contract Drawings.

B. Guideways shall receive 8-inches of Cement Treated Subgrade where indicated on the Contract Drawings.

C. Cement shall not be used to stabilize soil subgrades where the total soluble sulfates in the soils to be treated are greater than 0.3 percent or 3,000 parts per million (ppm) by soil weight. The soluble sulfate level shall be determined by Test Method TEX-620J.

3.4 COMPACTION

A. Compact cement stabilized subgrade to at least 98 percent or as otherwise required by the jurisdictional authority of maximum dry density as determined in accordance with ASTM D698, except as otherwise specified, with moisture content within minus 2 to plus 4 of optimum.

B. For TxDOT pavements, compact to 95 percent of optimum density as determined by Test Method TEX 120-E, Part II.

3.5 FIELD QUALITY CONTROL

A. Allowable Tolerances:

1. Construct finished grade to 0.1 foot plus or minus of the elevation shown on plans.

2. Cement stabilized soils shall have 100 percent of soil particle sizes passing 1-3/4 inch sieve and minimum of 60 percent of particle sizes passing No. 4 sieve. Non-slaking aggregates retained on No. 4 sieve shall be removed prior to performing tests.

3. Cement stabilized depths shall be within plus or minus 1/4-inch of specified thickness.

B. Test Method:

1. Determine the maximum dry density and the optimum moisture content of cement stabilized soils in accordance with ASTM D698.

2. In TxDOT right-of-way, determine the maximum dry density and the optimum moisture content of cement stabilized soils in accordance with Test Method TEX-120-E.

C. Compaction Test Frequency:

1. In railroad guideways and two lanes of roadway pavement, one density and moisture test, one soil gradation test, and one cement depth check shall be performed every 300 linear feet.

2. In parking lots, one compaction density and moisture test, one gradation test, and one cement depth check shall be performed for each 5,000 sq. ft.

D. Testing shall be at the expense of the Contractor.

E. Testing shall be performed to requirements for testing laboratories established in Section 01450, “Quality Control”.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this Section, cement treatment for materials in place, will be measured by and paid for at the unit price per square yard of “Cement Manipulation” to lines as shown on the typical sections for the each thickness indicated on the Contract Drawings. Payment will include materials with the exception of Portland cement which will be measured and paid for separately.

B. Portland cement incorporated in the cement treatment will be measured by and paid for at the unit price per ton of “Portland Cement for Soil Stabilization”.

END OF SECTION 02242
SECTION 02243
SOIL STABILIZATION: LIME TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section includes specifications for stabilization of base and subbase through the addition of hydrated lime or lime slurry. The work includes furnishing, applying, mixing, placing, and compacting of lime in base or subbase and finishing, curing, protection, and maintenance of the completed course.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
B. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised (NCTCOG Standard Specifications).
C. Texas Department of Transportation: Standard Specifications for Construction of Highways, Streets, and Bridges (TxDOT Standard Specifications).
D. Texas Department of Transportation, Texas Test Methods (TEX):
   1. TEX-121- E - Section 21 - Soil-Lime Testing.
   2. TEX-600-J - Section 2 - Sample and Testing Hydrated Lime, Quicklime and Commercial Lime Slurry.
   3. TEX 620-J - Section 15 - Determining Chloride and Sulfate Content in Soils.

1.3 DEFINITIONS
A. Type A, Hydrated Lime, a dry powdered material consisting essentially of calcium hydroxide.
B. Type B, Commercial Lime Slurry, a liquid mixture of essentially hydrated lime solids and water in slurry form.

1.4 DESIGN REQUIREMENTS
A. Design Mix Criteria:
   1. Optimum lime content shall be determined in accordance with ASTM D6276.
   2. Field application rate for soils with a Plasticity Index of 40 percent or less shall be the optimum lime content plus one percentage point by soil weight.
   3. Field application rate for soils with a Plasticity Index greater than 40 percent shall be the optimum lime content plus 1.5 percentage points by soil weight.

B. Lime application rates in the right-of-way of another jurisdictional authority shall meet requirements of that jurisdictional authority.

1.5 SUBMITALS
A. Submit proposed design mix of lime or lime slurry stabilization including percentages of hydrated lime or lime slurry to be used and optimum lime content test results demonstrating that mix design achieves minimum soil pH required. Refer to Article entitled “Design Requirements” herein for lime application rate requirements.
B. Submit technical data for type of lime to be used.
C. Testing shall be performed to requirements for testing laboratories established in Section 01450, “Quality Control”.

PART 2 - PRODUCTS

2.1 MATERIALS
A. Hydrated lime and lime slurry shall meet the physical and chemical properties as described in TxDOT Item 264 and as tested in accordance with TEX-600-J.
B. Type A, Hydrated Lime: In accordance with Item 264 of the TxDOT Standard Specifications: Hydrated Lime and Lime Slurry, unless otherwise approved.
C. Type B, Commercial Lime Slurry: In accordance with Item 264 of the TxDOT Standard Specifications: Hydrated Lime and Lime Slurry, unless otherwise approved.

1. Grade 1: Dry Solids Contents: Minimum 31 percent by weight of the slurry.
2. Grade 2: Dry Solids Contents: Minimum 35 percent by weight of the slurry.
SOIL STABILIZATION: LIME TREATMENT

3. Grade 3: Dry Solids Contents: Minimum 46 percent by weight of the slurry.

D. Water: Potable and free of odor, organics, and deleterious materials which may affect hardening of the treated soil.

PART 3 - EXECUTION

3.1 GENERAL

A. Construction within DART right-of-way shall be in complete accordance with the NCTCOG Standard Specifications. Construction within the right-of-way of other jurisdictional authorities shall conform to the requirements of the jurisdictional authority.

B. When lime is added to the base, subbase, or soil materials provided under pertinent specifications, the specification applicable to that item shall govern except that manipulation of the materials and application and mixing for lime shall be as required herein.

3.2 PREPARATION

A. Prior to placing base or subbase material, shape the subgrade to conform to the typical sections, lines, and grades shown in accordance with Section 02220, "Grading, Excavating and Backfilling".

B. Remove unsuitable soil and other material in accordance with Section 02220, "Grading, Excavating and Backfilling".

C. Prepare subgrade in accordance with Section 02220, "Grading, Excavating and Backfilling".

3.3 APPLICATION

A. Streets and pavements, where required to have lime treated subgrade, shall receive the depth of Lime Treated Subgrade indicated on the Contract Drawings.

B. Guideways shall receive 8-inches of Lime Treated Subgrade where indicated on the Contract Drawings.

C. Lime shall not be used to stabilize soil subgrades where the total soluble sulfates in the soils to be treated are greater than 0.3 percent or 3,000 parts per million (ppm) by soil weight. The soluble sulfate level shall be determined by Test Method TEX-620J.

3.4 COMPACTION

A. Compact lime stabilized subgrade to at least 98 percent or as otherwise required by the jurisdictional authority of maximum dry density as determined in accordance with ASTM D698, except as otherwise specified, with moisture content within minus 2 to plus 4 of optimum.

B. For TxDOT pavements, compact to 95 percent of optimum density as determined by Test Method TEX 121-E, Part II.

3.5 FIELD QUALITY CONTROL

A. Allowable Tolerances:

1. Construct finished grade to 0.1 foot plus or minus of the elevation shown on plans.

2. Lime stabilized soils shall have 100 percent of soil particle sizes passing 1-3/4 inch sieve and minimum of 60 percent of particle sizes passing No. 4 sieve. Non-slaking aggregates retained on No. 4 sieve shall be removed prior to performing tests.

3. Lime stabilized depths shall be within plus or minus 1/4-inch of specified thickness.

B. Test Method:

1. Determine the maximum dry density and the optimum moisture content of lime stabilized soils in accordance with ASTM D698.

2. In TxDOT right-of-way, determine the maximum dry density and the optimum moisture content of lime stabilized soils in accordance with Test Method TEX-121-E.

C. Compaction Test Frequency:

1. In railroad guideways and two lanes of roadway pavement, one density and moisture test, one soil gradation test, and one lime depth check shall be performed every 300 linear feet.

2. In parking lots, one compaction density and moisture test, one gradation test, and one lime depth check shall be performed for each 5,000 sq. ft.

D. Testing shall be at the expense of the Contractor.

E. Testing shall be performed to requirements for testing laboratories established in Section 01450, "Quality Control".
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Base, subbase, and soil materials provided under other Sections of the Specifications will be measured and paid for under those other Sections. The manipulation of the materials and application and mixing for lime as specified in this Section will be measured and paid for as specified herein.

B. The work of this Section, lime treatment, will be measured by and paid for at the unit price per square yard of "lime manipulation" to lines as shown on the typical sections for each thickness indicated on the Contract Drawings. Measurement will include all materials (including cover materials for curing) with the exception of lime, which will be measured and paid for separately.

C. Lime incorporated in the lime treatment will be measured by and paid for at the unit price per the ton of "Lime" of each type.

1. When Type A, Hydrated Lime is used, the quantity of lime will be measured by the ton dry weight.

2. When Type B, Commercial Lime Slurry is used, the quantity of lime shall be calculated from the required minimum percent "dry solids content" based upon the use of Grade 1, Grade 2, or Grade 3 as follows:

   a. Grade 1: The "Dry Solids Content" shall be 31 percent delivered on the road.

   b. Grade 2: The "Dry Solids Content" shall be 35 percent delivered on the road.

   c. Grade 3: The "Dry Solids Content" shall be 46 percent delivered on the road.

END OF SECTION 02243
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Geogrid reinforcement and geotextile separation of sub-ballast course and subgrade in the construction of rail track systems. Design requirements for geogrid reinforcement and geotextile, such as geogrid and geotextile types, sub-ballast thickness, subgrade preparation and associated details, shall be as shown on the contract drawings. Work consists of:

1. Providing supplier representative for pre-construction conference with the Contractor and the Contracting Officer.
2. Furnishing geogrids and geotextile as specified herein and required by the Contract Drawings.
3. Storing, cutting, and placing geogrids and geotextiles in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the Contract Drawings or as established by the Contract Administrator.

B. Alternates: Alternate geogrid materials shall not be used unless submitted to the Contracting Officer and approved in writing by the Contracting Officer at least 14 days prior to the bid letting. In order to be considered, submittal packages for alternate geogrid materials must include:

1. Independent certified test results stating that the alternate geogrid material satisfies the performance requirements in Paragraph 1.4B of this Section and the Torsional Stiffness requirements in Article 2.2 of this Section.
2. A list of 10 comparable projects that are similar in terms of size and application, are located in the United States, and where the results of using the specific alternate geogrid material can be verified after a minimum of 3 years of service life.
3. A sample of the alternate geogrid material and certified specification sheets.
4. Recommended installation instructions.
5. Additional information as required by the Contracting Officer.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO HB-17 - Standard Specification for Highway Bridges

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM D4354 - Standard Practice for Sampling of Geosynthetics for Testing
2. ASTM D4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon ARC Type Apparatus
3. ASTM D4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics
4. ASTM D5732 - Standard Test Method for Stiffness of Nonwoven Fabrics Using the Cantilever Test
5. ASTM D5818 - Standard Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage

C. Corps of Engineers (COE):

1. Methodology for Measurement of Torsional Rigidity.

D. Geosynthetic Research Institute (GRI):

1. GRI GG1- Standard Test Method for Geogrid Rib Tensile Strength
2. GRI GG2 - Standard Test Method for Geogrid Junction Strength

E. U.S. Environmental Protection Agency (EPA):

1. EPA 9090 - Compatibility Test for Wastes and Membrane Liners

1.3 DEFINITIONS

A. Geogrid: A biaxial polymeric grid formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow
interlocking with surrounding soil, rock, or earth and function primarily as reinforcement.

B. Geotextile: A non-woven product consisting of polymer fibers made into a flexible, porous fabric by standard weaving machinery or matted together in a random manner.

C. Minimum Average Roll Value: Value based on testing and determined in accordance with ASTM D4759.

D. True Tensile Strength in Use: True tensile strength at indicated strain levels measured as true resistance to elongation when initially subjected to load determined in accordance with ASTM D6637 without deforming test materials under load before measuring such resistance or employing “secant” or “offset” tangent methods of measurement so as to overstate tensile properties.

E. Junction Efficiency: Load transfer capability determined in accordance with GRI GG1 and GG2 as modified by AASHTO HB-17, and expressed as a percentage of ultimate tensile strength.

F. Flexural Stiffness (also known as Flexural Rigidity): Resistance to bending force determined in accordance with ASTM D5732, using specimens of width two ribs wide, with transverse ribs cut flush with exterior edges of longitudinal ribs (as a “ladder”), and of length sufficiently long to enable measurement of the overhang dimension.

G. Torsional Stiffness (also known as Torsional Rigidity or Secant Aperture Stability Modulus): Resistance to in-plane rotational movement measured by applying a 20 kg cm moment to the central junction of a 9 inch by 9 inch specimen restrained at its perimeter (COE Methodology for measurement of Torsional Rigidity). Values shown are minimum average roll values.

H. Resistance to Installation Damage: Resistance to loss of load capacity or structural integrity when subjected to mechanical stress in installation in a clayey sand (SC), a well graded sand (SW), and crushed stone classified as a poorly graded gravel (GP). The geogrid shall be sampled in accordance with ASTM D5818 and load capacity shall be determined in accordance with ASTM D6637. Values shown are typical values.

I. Resistance to Long Term Degradation: Resistance to loss of load capacity or structural integrity when subjected to chemically aggressive environments measured via EPA 9090 immersion testing. Values shown are typical values.

J. Resistance to UV Degradation - Resistance to loss of load capacity or structural integrity when subjected to 500 hours of ultraviolet light and aggressive weathering in accordance with ASTM D4355.

1.4 SUBMITTALS

A. Submit geogrid and geotextile product samples approximately 4 inches by 7 inches or larger.

B. Submit geogrid and geotextile product data sheets and certifications from the Manufacturer that the geogrid and geotextile products supplied meet the requirements of Article 2.2, of this Section.

C. Submit Manufacturer’s installation instructions and general recommendations.

1.5 QUALITY ASSURANCE

A. Pre-Construction Conference: Prior to the installation of the geogrid, the Contractor shall arrange a meeting at the site with the geogrid material supplier and, where applicable, the geogrid installer. The Authority and the Contracting Officer shall be notified at least 3 days in advance of the time of the meeting. A representative of the geogrid supplier shall be available on an as needed basis during construction.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection

1. Prevent excessive mud, wet concrete, epoxy, or other deleterious materials from coming in contact with and affixing to the geogrid materials.

2. Store at temperatures above 20 degrees F.

3. Rolled materials may be laid flat or stood on end.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. An approved source of geogrid is The Tensar Corporation, Morrow, GA or approved equal.

B. Substitutions: See Section 01600, “Product Requirements” and Paragraph 1.1B, of this Section.

2.2 MATERIALS

A. Geotextile: The geotextile shall conform to the requirements in Article 2.4, of Section 02450, “General Track Construction”.

B. Submitgeogrid and geotextile product data sheets and certifications from the Manufacturer that the geogrid and geotextile products supplied meet the requirements of Article 2.2, of this Section.
B. Geogrid: The geogrid shall have the following characteristics:

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>UNITS</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture Dimensions in Use</td>
<td>mm (in)</td>
<td>33 (1.3)</td>
</tr>
<tr>
<td>Minimum Rib Thickness in Use</td>
<td>mm (in)</td>
<td>0.76 (0.03)</td>
</tr>
<tr>
<td>True Tensile Strength in Use at 2% Strain</td>
<td>kN/m (lb/ft)</td>
<td>6.6 (450)</td>
</tr>
<tr>
<td>True Tensile Strength in Use at 5% Strain</td>
<td>kN/m (lb/ft)</td>
<td>13.4 (920)</td>
</tr>
<tr>
<td>Ultimate Tensile Strength</td>
<td>kN/m (lb/ft)</td>
<td>19.0 (1,300)</td>
</tr>
<tr>
<td>Junction Efficiency</td>
<td>%</td>
<td>93</td>
</tr>
<tr>
<td>Flexural Stiffness</td>
<td>mg-cm</td>
<td>250,000</td>
</tr>
<tr>
<td>Aperture Stability</td>
<td>m-n/deg</td>
<td>0.32</td>
</tr>
<tr>
<td>Resistance to Installation Damage</td>
<td>%SC/%SW/%GP</td>
<td>95/93/90</td>
</tr>
<tr>
<td>Resistance to Long-Term Degradation</td>
<td>%</td>
<td>100</td>
</tr>
<tr>
<td>Resistance to UV Degradation</td>
<td>%</td>
<td>100</td>
</tr>
</tbody>
</table>

D. Correct orientation (roll direction) of the geogrid shall be verified by the Contractor. Geogrid and geotextile may be temporarily secured in place with staples, pins, sand bags or backfill as required by fill properties, fill placement procedures or weather conditions or as directed by the Contracting Officer.

3.4 SUB-BALLAST PLACEMENT OVER GEOGRID

A. Sub-ballast shall be placed in lifts and compacted as directed under Section 02451, “Sub-Ballast”. Sub-ballast shall be placed, spread, and compacted in such a manner that minimizes the development of wrinkles in the geogrid and/or movement of the geogrid.

B. A minimum loose sub-ballast thickness of 6 inches is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the sub-ballast and damaging the geogrid. Rubber-tired equipment may pass over the geogrid reinforcement at slow speeds (less than 10 mph) when integrally-formed geogrids are used. When coated geogrids or geogrids composed of small-diameter fibers are used, rubber-tired equipment shall not be allowed directly on the geogrid. Sudden braking and sharp turning movements shall be avoided.

3.5 REPAIR

A. Any geogrid or geotextile damaged during installation shall be replaced by the Contractor at no additional cost to the Authority.

B. Coated geogrids shall not be used if the coating is torn, shedding, cracked, punctured, flawed or cut, unless a repair procedure is carried out as approved by the Contracting Officer. The repair procedure shall include placing a suitable patch over the defective area or applying a coating solution identical to the original coating.

3.6 PROTECTION

A. Follow the Manufacturer’s recommendations regarding protection from exposure to sunlight.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Geogrid reinforcement of sub-ballast will be measured by and paid for at the unit price for “Geogrid Reinforcement of Sub-Ballast” per square yard. Geotextile under Geogrid will be considered as incidental to “Geogrid
Reinforcement of Sub-Ballast® and will not be measured for payment.

END OF SECTION 02246
SECTION 02271
DITCH LINING AND SLOPE PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies installing ditch lining and slope protection.

1.2 REFERENCED STANDARDS
A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO T85 - Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate
   2. AASHTO T96 - Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
   3. AASHTO T104 - Standard Method of Test for Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
B. American Concrete Institute (ACI):
   1. ACI 305R - Hot Weather Concreting
   2. ACI 306.1 - Standard Specification for Cold Weather Concreting
   3. ACI 347 - Guide to Formwork for Concrete
C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C32 - Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale)
   2. ASTM C33 - Standard Specification for Concrete Aggregates
   3. ASTM C97 - Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
   5. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete
   6. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3))

1.3 SUBMITTALS
A. Product Data: Submit product data including manufacturer’s literature, test data, mix designs, and source for the proposed materials, as applicable to the work:
   1. Bricks
   2. Concrete Masonry Units
   3. Stone Riprap
   4. Gabions Wire and Stone
   5. Aggregates for Aggregate Filter and Sand Cushion
   6. Filter Fabrics
B. Mix Designs: Submit mix designs for proposed concrete in accordance with Section 03305, “Portland Cement Concrete” and Section 03300, “Cast-in-Place Concrete”.
C. Certification: Certifications for aggregates, admixtures, and cement to be utilized for the placement of concrete, grout, and mortar. These certifications shall be less than six months old for the initial submittal and shall be submitted quarterly for approval by the Contracting Officer.

1.4 QUALITY ASSURANCE
A. After approval of source, do not change source without Contracting Officer’s approval.

1.5 JOB CONDITIONS
A. Placement of grout or mortar is prohibited when the temperature is below 40 degrees F or predicted to fall below 40 degrees F unless suitable covering and heat are provided to maintain the work and materials above 40 degrees F for a continuous period of 72 hours.

PART 2 - PRODUCTS

2.1 CONCRETE WORK
A. Formwork: Section 03100, “Concrete Formwork”.
B. Reinforcing Steel: Section 03200, “Concrete Reinforcement”.
2.2 AGGREGATES AND SAND CUSHION

A. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4, typical. Where shown, use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.

B. Aggregate for Typical Grout and Mortar: As specified in Section 03305, "Portland Cement Concrete."

C. Aggregate for Stone Riprap Grout: The aggregate shall be a mixture of clean sand and gravel, or of crushed stone and sand, or of chat and sand, as approved. Finer aggregate may be used provided the ratio of cement to the material passing the No. 4 sieve is not greater than 1 to 3 by volume. The mixture shall be uniformly graded from coarse to fine and meet the following gradation requirements:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 3/4 inch sieve</td>
<td>100</td>
</tr>
<tr>
<td>Passing No. 4 sieve</td>
<td>40 to 60</td>
</tr>
</tbody>
</table>

D. Aggregate filter:

1. Coarse aggregate, ASTM C33, Size 357.

2. Use only tough, durable materials free of thin, flat, elongated, soft friable particles, and free of organic matter.

E. Sand cushion for concrete block: Section 03305, "Portland Cement Concrete".

2.3 BRICK

A. Brick: ASTM C32; solid brick; Grade SS; 2-1/4 inches by 3-3/4 inches by 8 inches.

2.4 CONCRETE MASONRY UNITS

A. Concrete Masonry Units: Section 04220, "Concrete Masonry Units".

2.5 GABIONS

A. Wire mesh: Galvanized steel wire of 0.105 minimum diameter, 60,000 pounds per square inch tensile strength, and galvanized at rate of 0.80 ounces per square foot. Wires twisted to form non-raveling hexagonal openings of uniform size, not to exceed 4-1/2 inches in length or 8 square inches in area of mesh opening. Horizontal dimension uniform, not to exceed 36 inches. Gabion dimensions shall not vary more than 3 percent from manufacturer's stated size.

B. Tie devices: Malleable iron or steel, producing frictional force of 160 pounds per foot of spacing. Sized to conform to requirements of jurisdictional agency.

C. Stone: Durable, free from cracks and seams, unweathered, weighing between 4 pounds (4 inch average diameter) and 30 pounds (8 inches average diameter); except 5 percent may vary more or less; and 50 percent to exceed 10 pounds. Stone size shall conform to the following table:

<table>
<thead>
<tr>
<th>Basket Thickness (Inches)</th>
<th>Size of Stones (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3 to 5</td>
</tr>
<tr>
<td>9, 12, 18</td>
<td>4 to 7</td>
</tr>
<tr>
<td>36</td>
<td>4 to 12</td>
</tr>
</tbody>
</table>


2.6 STONE RIPRAP

A. Stone shall be hard durable and free of fractures; angular in shape; weather-resistant; and free from overburden, spoil, shale and organic material. Stone shall meet the following requirements:

1. Water absorption: 3.0 percent maximum when tested in accordance with AASHTO T85.

2. Specific gravity: 2.5 minimum when tested in accordance with AASHTO T85.

3. Resistance to abrasion: Grade B maximum when tested in accordance with AASHTO T96.

4. Soundness: 20 percent maximum loss when tested in accordance with AASHTO T104.

B. Size: Weight distribution of pieces provided as determined by ASTM C97 and in accordance with the following: Class I: Stone used in this class shall weigh from 50 to 150 pounds with at least 60 percent weighing 100 pounds or more, except that approximately 10 percent of the stone may weigh 50 pounds or less.

C. Size for 18 inches: Weight distribution of stone riprap, as determined by ASTM C97, shall fall within the following requirements:

<table>
<thead>
<tr>
<th>Wt (percent smaller than)</th>
<th>Upper Wt (Lbs)</th>
<th>Lower Wt (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>275</td>
<td>110</td>
</tr>
<tr>
<td>50</td>
<td>80</td>
<td>53</td>
</tr>
<tr>
<td>15</td>
<td>40</td>
<td>17</td>
</tr>
</tbody>
</table>

D. Size for 36 inches: Weight distribution of stone riprap, as determined by ASTM C97, shall fall within the following requirements:

<table>
<thead>
<tr>
<th>Wt (percent smaller than)</th>
<th>Upper Wt (Lbs)</th>
<th>Lower Wt (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>649</td>
<td>260</td>
</tr>
<tr>
<td>50</td>
<td>192</td>
<td>130</td>
</tr>
<tr>
<td>15</td>
<td>96</td>
<td>41</td>
</tr>
</tbody>
</table>
2.7 GEOTEXTILE FILTER FABRIC  
A. As specified in Section 02700, “Storm Sewer Systems”. Application type: Erosion Protection.

2.8 FILTER BLANKET  
A. Aggregate conforming to the following gradation:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 inch</td>
<td>100</td>
</tr>
<tr>
<td>1-1/2 inch</td>
<td>95-100</td>
</tr>
<tr>
<td>1 inch</td>
<td>80-90</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>35-70</td>
</tr>
<tr>
<td>1/2 inch</td>
<td>25-60</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>15-30</td>
</tr>
</tbody>
</table>

2.9 MORTAR AND GROUT MIXES  
A. General Requirements:
   1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
   2. Add sufficient water as specified to produce approved consistency as specified herein under “Proportions.”
   3. Do not mix in amount exceeding that which can be used within 1 hour after introduction of water.
   4. Do not retemper mix that has begun to set or use such mix in the work.
   5. Where shown, specified, or directed, mix pigment into dry mix to attain color selected by the Contracting Officer. Pigment not to exceed 10 percent of dry batch weight of cement.

B. Proportions:
   1. Typical Mortar: 1 part Portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
   2. Typical Grout: 1 part Portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.

3.1 SLOPE PROTECTION  
A. Excavate or fill slopes to the required cross section, lines, and grades.

3.2 STONE RIPRAP  
A. Complete stone riprap placements in conjunction with slope construction without appreciable lag which may subject the surface to erosion.

B. Place stone riprap after placing and compacting aggregate filter or after placing geotextile filter fabric.

C. Place stone riprap by machine to full course thickness in one operation upward from bottom of slope. Prevent displacement of underlying materials. Dumping of stone riprap or rolling stones down the slope is prohibited.

D. Fill spaces between larger stones to produce nearly even surface with minimum of voids. Manually supplement machine placement of stone to choke in voids.

E. Rearrange individual stones as necessary to ensure that finished configuration conforms to lines, grades and thickness shown.

F. Place geotextile filter fabric as specified in Section 02700, “Storm Sewer Systems”, if required.

G. Surface Grouting:
   1. After completion of the riprap, rock fill, or rock blanket, the surface shall be grouted, when required, at the rate of a 1 sack batch of grout to 2 square yards of surface covered except that if the finer aggregate is used, a 1 sack batch shall cover approximately 1-1/2 square yards. The
surface shall be swept clean of surplus grout with a stiff broom, using the major portion of the grout to fill the voids between the stones. The grout shall be cured by any of the methods specified for concrete pavement, except that transparent membrane shall be used in lieu of pigmented membrane.

2. During cold weather, the limitations and protection requirements of Section 03305, "Portland Cement Concrete", and ACI 306.1 shall apply to the grouting.

3. During hot weather the limitations and protection requirements of Section 03305, "Portland Cement Concrete" and ACI 305 shall apply to the grouting.

3.3 GABIONS

A. Prepare ground surface to be smooth and even where gabions will be installed.

B. Place geotextile filter fabric as specified in Section 02700, "Storm Sewer Systems" on prepared surface.

C. Assemble gabions and tie together in accordance with manufacturer's instructions.

D. Fill gabions in lifts of 12 inches maximum. Install tie devices in all units with exposed faces, spaced in accordance with requirements of jurisdictional agency.

E. Ensure stone fill is placed without voids larger than approximately smaller stones. Hand-place stones in exposed faces.

3.4 CAST-IN-PLACE CONCRETE

A. Use wood or steel forms. Place in accordance with ACI 347

B. Concurrent with setting of forms either wet the prepared subbase with water or cover the prepared subbase with a layer of polyethylene or other approved impervious material, in accordance with the ASTM C171.

1. Overlap polyethylene sheeting a minimum of 12 inches and tape.

2. Maintain cover intact until concrete is placed.

C. Place reinforcing steel or wire mesh as shown.

D. Provide and install dowel bars where shown in accordance with Section 02550, "Concrete Pavement."

E. Locate expansion and contraction joints where shown in accordance with Section 02550, "Concrete Pavement."

F. Unless otherwise shown, give surface wood float finish.

G. Protect, cure, and test concrete in accordance with Section 03300, "Cast-In-Place Concrete."

3.5 CONCRETE MASONRY UNITS

A. Place 2-inch layer of sand cushion on previously prepared slope at plus or minus 2 percent optimum moisture content.

B. Set units firmly by hand in sand cushion with long dimension parallel to base of slope so as to produce even surface.

C. Lay blocks with open 3/8-inch joints and with joints staggered as shown on plans.

D. Completely fill joints with mortar.

E. Protect and cure newly laid blocks for 7 days using wet cotton mats or wet burlap.

F. Lay blocks when the temperature is 40 degrees F or above.

3.6 PAVING BRICK

A. On the previously prepared slope compacted at plus or minus 2 percent optimum moisture content, place concrete base of thickness shown.

B. Give concrete base smooth screed finish.

C. Clean base, dampen, and lay 1-inch thick mortar bed.

D. Lay bricks with long dimension parallel to base of slope, with open 3/8-inch joints and with joints staggered.

E. Bed bricks firmly in mortar bed so as to produce even surface free from depressions or high spots.

F. Fill joints completely with mortar.

G. Protect and cure newly laid brick for a period of 7 days using wet cotton mats or wet burlap.

3.7 SODDING

A. Place sod as specified in Section 02931, "Seeding and Sodding- Non-Irrigated Areas."

3.8 FIELD QUALITY CONTROL

A. Maximum Surface Variation Tolerances:

1. Concrete Masonry Unit: Plus or minus 1/2 inch from grade, specified or shown, in 25 feet.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section will not be measured but will be paid for at the lump sum prices for the respective slope protection work.

B. Stone riprap slope protection will be paid for at the lump sum price for "Stone Riprap".

C. Surface grouting placed in conjunction with stone riprap will be paid for at the lump sum price for “Surface Grouting.”

D. Gabions will be paid for at the lump sum price for “Gabion Structures”.

E. Cast-in-place concrete slope paving will be paid for at the lump sum price for “Slope Protection - CIP Concrete” for each thickness indicated.

F. Concrete masonry unit slope paving will be paid for at the lump sum price for “Slope Protection - Concrete Masonry Units” for each type of unit indicated.

G. Paving brick slope paving will be paid for at the lump sum price for “Slope Protection - Paving Brick” for each type of paver indicated.

H. Sodding used as ditch lining will be paid for in accordance with Section 02931, “Seeding and Sodding - Non-Irrigated Areas”.

I. Grading and compaction of slopes and excavation associated with ditch lining and slope protection will be paid for as specified in Section 02220, “Grading, Excavating, and Backfilling”.

J. Prices paid for ditch lining and slope protection will include sand cushion, aggregate filter, filter fabric, grout, mortar, and reinforcement.

END OF SECTION 02271
SECTION 02275
GEOGRID WALL REINFORCEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies geogrid reinforcement and appurtenant materials for construction of the geogrid reinforced soil retaining wall in landscaped areas. This system is not to be used to retain fills subject to automobile or rail traffic surcharge loading. The design and installation of geogrid reinforcement is the sole responsibility of the Contractor.

B. Geogrid specified here is installed as part of modular retaining wall system specified in Section 02870, "Modular Retaining Wall Units".

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
   3. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
   4. ASTM D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density

B. Geosynthetic Research Institute (GRI):
   4. GRI GG4 - Determination of the Long-Term Strength of Stiff Geogrids.

1.3 DEFINITIONS

A. Geogrid is an open mesh grid structure specifically fabricated for use as soil reinforcement.

B. Unit fill is a free draining granular material, used within the concrete units. See Section 02870, "Modular Retaining Wall Units".

C. Reinforced fill is the soil which is used as fill for the reinforced soil mass.

1.4 DESIGN REQUIREMENTS

A. Design of geogrid reinforced modular retaining wall shall be performed by and working drawings and computations shall be signed and sealed by the Contractor's engineer who shall be a Professional Engineer registered in the State of Texas.

B. Working Drawings shall include all details, dimensions, and cross sections necessary to construct the wall.

C. Working Drawings shall include plan and elevations of each wall. Plan and elevations shall be developed in accordance with the lines and grades shown in the Contract Drawings.

D. Elevation view of the wall shall indicate the following information:
   1. Elevation at the top of the wall, at all horizontal and vertical break points, and at least every 25 feet along the wall;
   2. Elevations at the top of leveling pads and footings;
   3. Distance along the face of the wall to all steps in the footings and leveling pads;
   4. Designation as to the type of panel or module;
   5. Length, size, and number of mesh or strips and the distance along the face of the wall to where changes in length of the mesh or strips occur; and
   6. Location of the original and final ground line.

E. Plan view of the wall shall indicate the following information:
   1. Offset from the construction centerline to the face of the wall at all changes in horizontal alignment;
   2. Limit of the widest module; and
   3. Mesh or strip and the centerline of any drainage structure or drainage pipe which is behind or passes under or through the wall.

F. Working Drawings shall also include the following notes, data, and details, as applicable:
   1. General notes required for design and construction of the wall.
   2. Horizontal and vertical curve data affecting wall construction.
3. A listing of the summary of quantities provided on the elevation sheet of each wall for all items including incidental items.

4. Cross sections showing limits of construction and in fill sections, limits, and extent of select granular backfill material placed above original ground.

5. Limits and extent of reinforced soil volume.

6. Details including any reinforcing bar bending details. Bar bending details shall be in accordance with Contract Documents.

7. Details for foundations and leveling pads, including details for steps in the footings or leveling pads, as well as, allowable and actual maximum bearing pressures.

8. Details of modules and facing elements. The details shall show all dimensions necessary to construct the element, all reinforcing in the element, and the location of reinforcement element attachment devices embedded in the facing.

9. Details for construction of the wall around drainage facilities, overhead sign footings, and abutment piles.

10. Details of elastomeric expansion joints.


12. Details of underdrains showing location, size, and connections to manholes and storm sewers.

G. Design computations: The method of analysis shall be a tie back wedge method as described in AASHTO Task Force 27 "Guidelines for the Design of Mechanically Stabilized Earth Walls". Submit computations on 8-1/2 inch by 11 inch pages.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Geogrid shall be stored above 20 deg. F.

B. Prevent mud, wet cement, epoxy, and like materials which may affix themselves to the gridwork from coming in contact with the geogrid material.

PART 2 - PRODUCTS

2.1 GEOGRID

A. Geogrid shall be a dimensionally oriented and stable structure. The geogrid shall have an ultraviolet resistant finish which is inert to biological degradation. Also, it shall be resistant to naturally encountered chemicals, alkalies, and acids. Geogrid design properties and values shall be determined by the test methods in the following table.

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Units</th>
<th>CMD Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Modulus</td>
<td>GRI</td>
<td>lb/ft</td>
<td>Values as needed for design</td>
</tr>
<tr>
<td>Junction Strength</td>
<td>GRI</td>
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</tr>
<tr>
<td>Long term Creep Strength</td>
<td>GRI</td>
<td>lb/ft</td>
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</tr>
<tr>
<td>Coefficients of Interaction</td>
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</tbody>
</table>

2.2 REINFORCED FILL

A. The reinforced fill material shall be free of debris and consist of the following inorganic soil type. The maximum particle size shall be 4 inches. There shall be less than 20 percent by weight of particles greater than 1-1/2 inch.

B. Soils consist of fine grained (greater than 30 percent by weight passing U.S. standard sieve No. 200) silts and clays, with a liquid limit less than 50, and an plasticity index less than 25 in accordance with Section 03305, "Portland Cement Concrete".

2.3 FOOTING MATERIAL

A. Footing material shall be Mix S-7, unreinforced concrete, as per Section 03305, "Portland Cement Concrete".

PART 3 - EXECUTION

3.1 FOUNDATION SOIL PREPARATION FOR REINFORCED SOIL AND RETAINING WALL ZONE

A. Excavate foundation soil as required for installation of the retaining wall assembly shown on the approved working drawings. Take precautions to minimize excavations. Excavations shall be performed in accordance with Section 02220, "Grading, Excavating, and Backfilling".
3.2 RETAINING WALL ERECTION

A. Erect wall as specified in Section 02870, "Modular Retaining Wall Units".

B. Obtain Contracting Officer’s examination of foundation soil to ensure that the actual foundation soil strength meets or exceeds assumed design bearing strength. Remove soils not meeting required strength and replace with soil meeting the assumed design bearing strength. Foundation soil shall be tested in accordance with Section 02220, "Grading, Excavating, and Backfilling".

C. Fill over-excavated areas compacted backfill material and proof-roll foundation soil prior to fill and geogrid placement. The compacted backfill shall meet the requirements of Section 02220, "Grading, Excavating, and Backfilling".

D. Place footing as shown in the approved working drawings with a minimum thickness of 6 inches.

E. Install footing materials, as specified herein, upon prepared foundation soil.

F. Footing shall be level to ensure complete contact of retaining wall unit and shall be grouted with structural non-shrink grout in accordance with Section 03305, “Portland Cement Concrete”. Gaps shall not be allowed.

3.3 GEOGRID INSTALLATION FOR RETAINING WALLS

A. Install geogrid at the wall height and horizontal location shown on the approved working drawings in accordance with the procedure specified herein.

B. Lay geogrid horizontally on compacted backfill and pin to the concrete wall units.

C. Lay geogrid at the proper elevation and orientation as shown in the wall details and approved working drawings.

D. Roll out geogrid perpendicular to the wall. Verify orientation (direction) of the geogrid prior to proceeding with installation.

E. Hook geogrid over pins, pull taut, and anchor before pushing toward unit placed above the geogrid.

F. Remove slack in the geogrid at the wall unit connection using a method approved by the Contracting Officer.

G. Place unit fill in accordance with Section 02870, "Modular Retaining Wall Units".

H. Pull geogrid taut and free of wrinkles prior to placement of backfill. Secure geogrid in place with staples, pins, sandbags, or backfill as required by fill properties, fill placement procedures, and weather conditions.

I. Overlaps:
   1. Do not overlap geogrid in the strength direction. The strength direction is that length of geogrid perpendicular to the wall face and shall be one continuous piece of material without defects.
   2. Adjacent sections of geogrid shall be placed side to side.

3.4 FILL PLACEMENT

A. Place reinforced wall fill material in 8-inch lifts and compact to a minimum 95 percent of Standard Proctor Density.

B. Soil with a well-defined moisture-density relationship shall be compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698 with oversize corrections where warranted) between – minus 3 and plus 2 percentage points of the optimum moisture content.

C. Fine aggregate free-draining soils that do not have a well-defined moisture-density curve shall be compacted to a relative density of at least 70 percent as determined by test methods ASTM D4253 and D4254. Granular backfill shall be compacted at a moisture content that will allow the desired density to be achieved.

D. Where the backfill material consists of more than 30 percent retained on the 0.75 inch sieve and sand cone or nuclear density measurements can not be made, a method specification shall be used to control compaction. The method specification shall be based on a test compaction section to establish the number of passes required to where there is no visible change in the test lift thickness caused by the steel drum roller. The method specification shall define the lift thickness and fill moisture content requirements for the approved steel drum roller. The number of passes required for compaction shall not be less than four.

E. Pretension geogrid by hand to remove wrinkles. Place, spread, and compact backfill in such a manner that eliminates the development of wrinkles and movement of the geogrid.

F. Utilize only hand operated compaction equipment within 3 feet of the wall face.

G. Place backfill from the wall outward to ensure that the geogrid remains taut.

H. Prevent damage to geogrid from tracked and rubber-tired equipment.

1. Operate no tracked construction equipment directly on the geogrid. Establish a minimum backfill thickness of 9 inches over geogrid prior to operation of tracked vehicles over the geogrid. Minimize turning of tracked vehicle to prevent tracks from displacing the fill and damaging the geogrid.
2. Move rubber-tired equipment at slow speeds (less than 10 mph) when passing over the geogrid reinforcement. Avoid sudden breaking and sharp turning.

I. Provide surface drainage during and after construction of the wall to minimize water infiltration of the reinforced soil zone.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will not be measured or paid separately, but all costs in connection therewith will be considered incidental to the work specified under Section 02870, "Modular Retaining Wall Units".

END OF SECTION 02275
PART 1 - GENERAL

1.1 DESCRIPTION

A. The work specified in this section consists of furnishing, installing, monitoring, reading, and interpreting data, maintaining, and removing geotechnical instrumentation. Geotechnical instrumentation specified herein shall be provided during open-cut, cut-and-cover, and tunnel excavation operations; underpinning installation and related excavation; and other elements of the work as required in the Contract Documents.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   3. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   4. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

1.3 SYSTEM DESCRIPTION

A. For purposes of this section, geotechnical instrumentation shall consist of movement detection instruments, internal bracing and anchor load instrumentation, and ground water monitoring devices.

B. Select appropriate instruments to detect the movement of ground and structures during construction.

C. Develop an instrument monitoring system intended to provide early information to permit timely implementation of proper remedial measures, when and as required, to prevent damage to structures, facilities, and utilities.

D. Locate instruments and design and implement monitoring program to document the ground movement, if any, that takes place during excavation.

E. Locate settlement reference points on and about any structure which may be affected by excavation performed as part of the Contract. Design and implement monitoring program to document any horizontal or vertical movement of structure.

F. Determine exact location of the instruments including settlement reference points to be installed in the field with approval of the Contracting Officer.

G. Be responsible for interpretation of instrumentation data as input to evaluating excavation performance and controlling settlements to prevent damage to structures, facilities, and utilities.

H. Implement remedial measures, including modification of construction procedures, as necessary.

I. Settlement reference points shall be located as indicated in the Contract Documents.

J. The Contracting Officer will also interpret the instrument monitoring data and will make the interpretation available to the Contractor.

1.4 SUBMITTALS

A. Working Drawings: Submit Working drawings of instrumentation location layout and details at least 21 days before installation. Show proposed locations if they differ from those indicated and describe instrumentation components. Indicate methods of installation and maintenance for instrumentation systems.

B. Documentation:
   1. Submit manufacturer's catalogs and printed installation instructions for instruments furnished.
   2. Submit, within 24 hours of completion of equipment installation, 3 copies of installation notes, initial readings, and monitoring data taken immediately after installation.

C. Certification:
   1. Submit certification of calibration for equipment used.

D. Monitoring Documentation:
   1. Unless otherwise provided by the Contracting Officer, submit proposed forms to be used for recording observations, monitoring and reporting of data. Submit a sample showing proposed format for recording of readings, calculations and plots.
2. Submit the following within 12 hours after monitoring any instrument:
   a. A copy of the data sheet containing a cumulative history of all readings, including weather conditions at time of each reading.
   b. A copy of the plot of measured value versus time, which also includes a time history of construction activity likely to influence such readings. (e.g., depth of excavation, presence of heavy equipment on or near decking.)

3. Submit weekly a brief narrative of instrumentation activity for the preceding week, in a format approved by the Contracting Officer.

4. Submit samples as specified.

E. Mix Designs: Submit proposed inclinometer casing grout mix designs.

F. Closure Report: Upon removal of instrumentation, submit report certifying that removal of the upper casings, plugging of holes, and restoration of surfaces has been accomplished as specified.

1.5 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Select a firm regularly engaged in the manufacture of monitoring instrumentation of the type specified herein.

2. Equipment: Incorporate into the Work geotechnical instrumentation systems which essentially duplicate geotechnical instrumentation systems in satisfactory use for a period of 5 years prior to the bid opening of this Project.

3. Personnel:
   a. Employ a Professional Engineer, licensed in the State of Texas, specialized in geotechnical engineering, and experienced in installation of instruments of the type specified in this Section, to supervise and direct instrument installation technicians and to be responsible for instrument installation monitoring, reduction, and interpretation of instrumentation monitoring data.
   b. Employ qualified installation technicians who have previous experience in installation of instruments of the type specified herein.

C. Employ qualified technicians working under the direction of the Professional Engineer who have previous experience in supervision and monitoring instruments of the type specified in this Section.

d. Qualified personnel, whose qualifications are specified herein, shall be available on Site at all times during work that would affect geotechnical instrumentation.

1.6 JOB CONDITIONS

A. Disclosure of Instrumental Data: Do not disclose instrumentation monitoring data to third parties and do not publish instrument monitoring data without the prior approval of the Contracting Officer.

B. Location of Underground Facilities and Structures:

1. Mark boring locations for cased instruments on the ground surface before actual drilling, and verify location of existing utilities. Change location of borings, as required, to avoid damage to utilities. If proposed boring location is within 24 inches of marked utility, expose that facility by hand excavation between drilling.

2. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.

3. Verify locations of existing utilities in accordance with Section 02760, “Maintenance, Support and Restoration of Existing Utility Facilities”.

PART 2 - PRODUCTS

2.1 INCLINOMETER CASINGS

A. Provide casing with wall thickness sufficient to withstand external ground pressure and sufficiently flexible to accurately reflect horizontal ground movement. Provide inclinometer casings in earth of either:

1. Semi-rigid acrylonitrile-butadiene-styrene (ABS) plastic; 3.34 inches nominal outside diameter; provide in minimum lengths of 5 feet.

2. ASTM B221, 6063 T6, extruded aluminum alloy, epoxy-resin coated, 3.38 inches nominal outside diameter; provide in minimum lengths of 5 feet.

B. Provide casing with 4 internal longitudinal grooves, equi-spaced. Provide alignment of the grooves equal to or better than 1 degree in 10 feet.
C. Provide casing with upper casing couplings of the telescoping type with a 6-inch gap designed to close if settlement occurs. Provide casing with a bottom coupling of the rigid non-telescoping type. Provide casing couplings capable of supporting the weight of 125 feet of inclinometer casing freely suspended inside a drill hole.

D. Unless otherwise approved, do not use uncoated aluminum casings.

### 2.2 INCLINOMETER CASING GROUT

A. Provide grout of low-shear-strength (10 to 20 psi) lean concrete bentonite mixture.

### 2.3 INCLINOMETER CASING GROUND SURFACE PROTECTION

A. For inclinometer casings within unpaved work areas provide an 8 inch inside diameter, 5-1/2 feet long, ASTM A53 black steel pipe, threaded at one end, with a black malleable iron threaded, removable, locking type cap at the surface.

B. For inclinometer casings within paved areas, provide a minimum 6 inch inside diameter, 23 inches long, ASTM A48, Class 30 cast iron valve box with locking type cover, as indicated. Provide 2 wrenches for covers.

### 2.4 INCLINOMETER PROBES

A. Provide inclinometer probes with 24 inch wheel base and at least 150 feet of waterproof cable externally marked in 1 foot intervals.

B. Furnish inclinometer probes and read-out indicators in numbers sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

### 2.5 DEEP BENCHMARKS

A. Provide outer casings of ASTM A53, extra strong steel pipe: Nominal diameter of 4 inches.

B. Provide inner casings of ASTM A53, extra strong steel pipe: Nominal diameter of 2 inches.

C. Provide steel spiders to center the inner pipe.

D. Provide heavy grease at spiders.

E. Provide benchmark tops of necessary components as indicated.

F. In accordance with Section 03305, "Portland Cement Concrete", provide sand-cement grout. Proportion the grout mix containing 3 parts sand to 1 part of cement by weight; with a water cement ratio not to exceed 1.5.

G. Provide traffic covers in accordance with jurisdictional authority’s requirements and as approved by the Contracting Officer.

### 2.6 HEAVE MARKERS

A. Provide heave markers, as approved by the Contracting Officer.

### 2.7 SETTLEMENT REFERENCE POINTS

A. Structural Surfaces:

1. Provide settlement reference points that are either decals, graduated tape strips, scribe marks, concrete nails, PK nails, pins, optical targets, or combinations thereof.

2. Provide 3-piece expansion anchors consisting of an outer lead alloy sleeve, an inner lead alloy wedge nut and a stainless steel cap head bolt. Adjust for horizontal or vertical installation as field conditions require and as approved by the Contracting Officer. Provide graduated strips on columns.

B. Ground Surfaces:

1. In areas that are not paved but which may be subject to light traffic, provide metal plugs and capped pipe embedded in 6 inches by 6 inches by 8 inches concrete.

2. In areas protected from traffic (including construction traffic) where no pavement or structure exists, provide 2 inches by 2 inches hardwood stake with PK nail as a reference point.

3. Provide reference points that are chisel marks, concrete nails, round-headed bolts for precision, or combination thereof as field conditions require on street curbs, basement slabs, and pavements.

C. Provide protective housing of 4-inch inside-diameter pipe and flush lid for heavy traffic areas where reference points are at least 1 inch below surface.

### 2.8 DEEP SUBSURFACE SETTLEMENT INDICATORS

A. Provide deep subsurface settlement indicators consisting of steel pipe casing of 3 inch outside diameter; 1 inch inside diameter black steel pipe conforming to the requirement of ASTM A53, welded extra strong; stainless steel pipe cap for read point; 1/8 inch steel plate for spiders; 1/2 inch thick by 6 inch diameter steel plate for cover; grease and oakum packing for annular space; and assembled in accordance with the approved Working Drawings.
B. Provide protective ASTM A48, Class 30, cast iron curb boxes with locking type cover as indicated. Furnish 2 wrenches for covers.

2.9 LEVEL MONITORING DEVICES

A. Provide liquid settlement system to measure elevation changes between 2 points. One on a building column or wall and the other a fixed point outside the building. The points shall be connected by a flexible liquid column tubing with T-fitting at each column and the branch tube clamped or attached to the column with a scale marking the liquid level. Use clear plastic and brass fittings.

2.10 TILTMETERS

A. Provide tiltmeter sensors, read out indicators, and tiltmeter base plates.

B. Provide grout or epoxy resin, as approved by the Contracting Officer.

C. Furnish tiltmeter sensors and read-out indicators in numbers sufficient to ensure the constant availability of functioning units on the Site in case of loss or failure of the prime units.

2.11 TAPE EXTENSOMETER

A. Provide tape extensometer and anchor points for measurement of change in tunnel diameters.

B. Provide eyebolt for attachment to the tunnel lining that is compatible with the tape extensometer. Use a method of attachment suitable for the type of lining installed and which provides a firm installation that is protected from damage and can sustain a blow struck by a 16 ounce hammer without 0.005 inch change in the tape extensometer measurement.

C. Provide a tape extensometer standard having nominal length of 24 inches and constructed of a wide-flange section not less than 4 inches in depth and conforming to ASTM A36 structural steel. The tape shall have minimum length equal to diameter of the tunnel.

2.12 BOREHOLE EXTENSOMETERS

A. General:

1. Provide mechanical rod-type extensometers as follows:
   a. With multiple anchor positions;
   b. A fixed reference head;
   c. A protective cover;
   d. A removable readout;

   e. Corrosion resisting;
   f. Insensitive to blasting and traffic vibrations;
   g. Able to operate in water;
   h. Designed to resist freezing of rods, guides, and reference head caused by intrusion of grout, dirt, and mineral precipitates; and
   i. Able to operate correctly regardless of installation orientation either from the ground surface or from within the excavation.

2. Furnish read-out devices in numbers sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

3. Furnish with mechanical or electrical read out systems, as indicated.

B. Characteristics:

1. Range of each anchor: Within plus or minus 2 to 6 inches and extensible by resetting.

2. Sensitivity: Able to measure movements of anchors relative to reference head to a sensitivity of 0.001 inch over a range of 2 inches.

3. Repeatability: 0.005 inch maximum variation from the mean of repeated successions of readings.

C. Reference heads:

1. Provide reference heads which permit easy cleaning of the measuring surfaces.

2. Provide a removable cover to protect the reference head from damage during construction operations.

D. Drill hole: Anchors and reference head to fit entirely within a drill hole sized in accordance with the instrument manufacturer’s recommendations.

E. Anchors:

1. Rear anchors, center anchors, and reference head anchors to be of mechanical rock bolt or expansion shell type, able to grip the sides of the hole securely without detrimental effects from vibrations.

2. Rear anchors shall be adjustable at the time of installation for locations from 8 feet to 30 feet from the hole collar. Center anchors shall be adjustable at the time of installation for locations from 2 feet to 8 feet from the
hole collar. Adjustment of rear and center anchors made by using extension rods and couplings.

3. Subsurface anchor points and the entire subsurface assembly to be grouted with a weak sand-cement grout.

F. Rods:

1. Exposed ends of extension rods to have stainless steel tips.

2. Measurement rods to be encapsulated in oil or grease filled, flexible tubing.

G. Telltale:

1. To extend from the bottom anchor position of the extensometer to a point 5 feet inside the line of the opening.

2. Telltale set so that the position of the bottom anchor, relative to the opening, can be determined after the opening is excavated.

H. Readouts:

1. Capable of reading by either mechanical depth micrometer or remote reading electronic readout head.

2. Stainless steel reference points.

3. Protect remote readout lead wires from damage. Terminate lead wires in enclosure sealed against the intrusion of dirt, grout, and water.

2.13 STRAIN GAUGES

A. Provide strain gauges that are weather-resistant, suitable for either permanent encasement in concrete, or installation on bracing, or installation on tunneling steel ribs. Furnish latest model developed specifically for applications anticipated within this Contract.

B. Characteristics:

1. Insensitive to traffic and anticipated construction activity vibrations and able to function under water.

2. Capable of attaining a minimum service life of 4 years.

3. Complete with mounting brackets, waterproof cable, cable connectors, terminal boxes, protective steel channel covers, and steel flex conduit for full length protection of cables.

C. Provide terminal boxes recommended by the manufacturer of the strain gages containing switching arrangement which will enable each gauge contained in a load instrumentation zone to be recorded without changing connecting electrical leads.

D. Provide connector wires as recommended by strain gauge manufacturer.

E. Provide vibrating wire indicators in quantities sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

2.14 LOAD CELLS

A. Provide load cells of bonded strain gauge transducer type, moisture-resistant model developed specifically for load measurements and conditions anticipated within this Contract. Provide load cells having a working capacity equal to at least yield load of structural member and having an accuracy to within 1 percent of the load range.

B. Provide terminal boxes containing switching arrangement which enables each load cell contained in a load instrumentation zone to be recorded without changing connecting electrical leads.

C. Provide connector wires as recommended by load cell manufacturer.

D. Furnish read-out boxes in numbers sufficient to ensure constant availability of functioning units on the site in case of loss or failure of the prime units.

2.15 PRESSURE CELLS

A. Provide pressure cells, as approved by the Contracting Officer.

2.16 PIEZOMETERS

A. Provide piezometers as specified in Section 02140, "Dewatering".

PART 3 - EXECUTION

3.1 MOVEMENT DETECTION INSTRUMENTS, GENERAL

A. Notify the Contracting Officer not less than 24 hours before installing any instrumentation.

B. Calibrate instruments as per manufacturer's requirements.

C. Replace or repair damaged or nonfunctional instruments within 48 hours or as directed by the Contracting Officer.
D. Take corrective measures and modify construction procedures as required by the Contracting Officer to prevent any damage to structures, facilities, and utilities, if the geotechnical instrumentation measurements of deformation or ground water levels exceed acceptable limits indicated on the Contract Drawings.

E. Tunnel Instrument Installation: Take special care during installation of instruments in ground immediately adjacent to the proposed tunneling to ensure that adequate clearance between the instrument and the tunnel is maintained.

3.2 TOLERANCES

A. Establish the elevation of cased deep benchmarks to 0.001 feet.

B. Establish the initial coordinates of each instrument installation to 0.1 foot, or less.

C. Establish the initial elevation of settlement reference points and subsurface settlement indicators to 0.005 feet.

D. Record the subsequent elevations of settlement reference points and subsurface settlement indicators to 0.005 feet. Achieve level circuit closure with an error of closure of 0.01 foot, or less.

E. Establish survey turning points so that backsight and foresight are kept approximately equal.

3.3 BOREHOLE EXTENSOMETERS INSTALLATION:

A. Drill boreholes of size and at locations indicated, to required depth and to receive borehole extensometer.

B. Prepare logs of soil and rock encountered using qualified personnel to witness and log samples during drilling.

1. In soil obtain samples with standard 2 inch O.D. split spoon or equivalent;

2. Sample at minimum 5 foot intervals and at each change in stratification;

3. In rock, log continuous NX or AX cores as applicable to the specified installation.

C. Submit the logs and samples to the Contracting Officer.

D. Verify hole is drilled such that manufacturers installation requirements will be met.

E. Install multiple-anchor rod-type extensometers at locations indicated. Individual anchor positions will be subject to approval by the Contracting Officer.

3.4 INCLINOMETER CASINGS INSTALLATION

A. Open-Cut and Cut-and-Cover Excavation: Install inclinometer casings where shown on approved working drawings at least 7 days prior to start of adjacent excavation.

B. Tunnel Excavation: Install inclinometer casings a minimum of 14 calendar days prior to either the left or right tunnel advance approaching within 100 linear feet of the proposed instrumentation location.

C. Drill minimum 6 inch diameter and maximum 8 inch diameter holes, at locations indicated, to required depths to receive inclinometer casing.

1. Prepare logs of soil and rock encountered using qualified personnel to witness and log samples during drilling.

a. In soil obtain samples with standard 2 inch O.D. split spoon or equivalent;

b. Sample at minimum 5 foot intervals and at each change in stratification;

c. In rock, log continuous NX or AX cores as applicable to the specified installation.

2. Submit the logs and samples to the Contracting Officer.

D. Cap bottom of casings and fill annular space between casings and sides of holes with inclinometer casing grout pumped through a pipe or small tube to bottom of hole.

E. Cap bottom of casings and fill annular space between casings and sides of holes with inclinometer casing grout pumped through a pipe or small tube to bottom of hole.

F. Ground Surface Protection:

1. If inclinometer casings will be within unpaved work areas, project top of inclinometer casings a minimum of 16 inches above the ground. Protect inclinometer casings with 8-inch diameter steel casings. Locate tops of inclinometer casings not further than 2 inches below tops of steel casings. Embed steel casings 4 feet into ground, project 18 inches above ground elevation, and provide with removable caps. Mark steel casings with yellow paint.

2. If inclinometer casings will be in paved areas, excavate a hole 2 feet deep by not
larger than 12 inches in diameter, through paving, and install the valve box. Make the box flush with the paved surface and fill annular space between the box and the 2 foot hole with concrete. Project inclinometer casings within 3 inches of surface and not closer than 2 inches above bottom of hole or as required to read instrument. Close hole through pavement with a removable cover.

G. Maintain inclinometer casings in operating condition from time of installation until completion of work requiring inclinometer casings. Keep inclinometer casings locked when not being read or serviced. Establish and maintain convenient access.

3.5 DEEP BENCHMARK INSTALLATION

A. Establish a system of benchmarks as indicated before starting excavation and before other instruments are installed.

B. Drill 4-1/2 inch diameter holes, to 18 feet in soil or 3 feet in rock below bottom of future excavation or the tunnel construction invert. Install the outer casings to the bottom of the hole. Install steel spiders, to center the 2 inch diameter inner casings, at a maximum spacing of 20 feet.

1. In soil, split the inner casings for 12 inches at tips (as indicated) and drive the inner casings 2 feet into undisturbed soil below bottom of outer casings.

2. In rock, drill the inner casings 2 feet into rock below bottom of outer casings and grout bottom 12 inches of inner casings in place.

3. Pump heavy non-toxic (USDA Classification H-1) into annular space between the 2 inch diameter and the 4 inch diameter steel pipes until the space is completely filled.

C. Bore Logs: Prepare logs of soil and rock encountered using qualified personnel to witness and log samples during drilling. Submit the logs and samples to the Contracting Officer.

1. In soil obtain samples with standard 2 inch O.D. split spoon or equivalent;

2. Sample at minimum 5 foot intervals and at each change in stratification;

3. In rock, log continuous NX or AX cores as applicable to the specified installation.

D. Weld stainless steel read point to top end of benchmark pipe.

3.6 HEAVE MARKER INSTALLATION

A. Install heave markers as indicated before starting excavation and dewatering.

3.7 SHALLOW SUBSURFACE SETTLEMENT REFERENCE POINT INSTALLATION

A. Establish a system of settlement reference points on or about buildings and structures as indicated before starting excavating and dewatering. Correlate system with benchmarks established as reference points.

B. Locate and construct reference points in a manner which will not create a hazard to pedestrians and vehicles. Maintain access to settlement reference points.

C. Drive pipe to required depth utilizing a coupling and nipple as a striking surface.

D. Adjust depth to site conditions to embed pipe in soil below pavement.

E. Remove coupling and nipple and install pipe cap with read point.

F. Excavate around pipe and place curb lock box. Backfill outside of box. Leave box with the cover locked.

3.8 DEEP SUBSURFACE SETTLEMENT INDICATOR INSTALLATION

A. Install each deep subsurface settlement indicator as indicated.

B. Drill holes for the outer casings to a point 2 feet above the elevations shown. Do not damage the casing or disturb the soil below the casing where the inner pipe will be anchored.

C. Install outer casing and grout in-place.

D. Install protective cast iron curb boxes and grout in-place.

E. Install inner pipe split 12 inches at tips by driving to required elevation. Where inner pipe is to rest on a subsurface structure, take care not to damage or penetrate more than necessary for attachment to the subsurface structure. Pump heavy non-toxic (USDA Classification H1) into annular space between outer casing and inner pipe until space is completely filled.

F. Set pipe cap reference surface.

G. Install cover and lock.

3.9 GROUND SURFACE SETTLEMENT POINT INSTALLATION

A. Establish reference points on and about building and structures as indicated. Locate and construct reference points in a manner which will not create a hazard to pedestrians and vehicles. Maintain access to reference points.
B. For buildings or structures within zone of influence of the proposed excavation boundaries, install reference points on the outside of the building at a convenient height above grade, on all corners and at each column, or on walls, at spacings not to exceed 20 feet. Insofar as practicable, install all points on each side of the building at the same elevation. Install before installation of the excavation support system and underpinning and before beginning of dewatering operation.

3.10 BUILDING SETTLEMENT REFERENCE POINT INSTALLATION

A. Install building settlement reference point where shown on approved working drawings.
B. Drill correct diameter and depth hole into receiving surface.
C. Blow out drilling debris from the hole.
D. Assemble expansion anchor and insert into hole.
E. Tap outer sleeve on to wedge nut to effect initial sleeve contact with wall of hole.
F. Expand outer sleeve into tight contact with wall of hole by turning bolt until anchor is rigid with the hole. Do not strip wedge nut threads by excessive turning of the bolt.

3.11 LEVEL DEVICE INSTALLATION

A. Install level device where shown on approved working drawings.
B. Install plastic tubing filled with liquid around the lower level of the structure with a T-fitting at each column and the branch tube clamped to the column with a scale marking the liquid level.
C. Change in the liquid level on the scale will be indicative of the column settlement.
D. Record change in liquid level reading at each column.
E. Protect tubes from operations and people stepping on the tubes.

3.12 TILTMETER INSTALLATION

A. Install tiltmeter where shown on approved working drawings.
B. Bond tiltplates on buildings and structures with grout or epoxy resin and as specified before starting excavating and dewatering.
C. Maintain access to tiltplates.
D. Remove and dispose of the tiltplates upon completion of the Contract. Restore disturbed or damaged surfaces to the conditions existing prior to installation of tiltplates.

3.13 TAPE EXTENSOMETER INSTALLATION

A. Install Tape Extensometer anchor points on excavation walls or tunnel rings as soon as the plan locations of anchor points indicated are exposed.
1. If tunnel equipment prevents the taking of measurements the installation of anchor points or the taking of readings use alternate methods as approved by the Contracting Officer.
2. Install tape extensometer standard on tunnel sidewall in an area free from disturbance by equipment and freely accessible for use.
B. Maintain anchor points in functional condition and remove obstructions from lines of measurement as necessary for monitoring.

3.14 INTERNAL BRACING AND ANCHOR LOAD INSTRUMENTATION SYSTEMS INSTALLATION

A. Definition: A load instrumentation zone is defined as containing:
1. Strain gauges, switch boxes, connection wires, and other auxiliary hardware installed on or for cross bracing struts, at all strut levels, in 3 consecutive strut lines at the zone locations in plan, as indicated.
2. Load cells, switch boxes, connecting wire, and other auxiliary hardware installed on or for tiebacks on both sides of the excavation within the plan limits as shown.
B. Strain Gauges:
1. Install strain gauges in pairs, on opposite sides of bracing member's cross section. The strain gauges shall be installed at the end opposite the one being jacked, at least 3 strut depths away from the strut end. Exact locations will be determined by the approved design of the system. Install strain gauges before preloading bracing members, in conformance with the strain gauge manufacturer's installation instructions. Install the first strain gauges under the supervision of a qualified representative of the strain manufacturer.
2. For each zone of strain gauges on stressed bracing members, install 1 additional temperature compensation strain gauge on an unstressed segment of strut affixed to the support wall in a position to be subject to the same temperature fluctuations as the stressed member. Install the temperature compensation gauges in the same manner as those installed on stressed members.
3. Connect strain gauges to terminal boxes in conformance with the strain gauge manufacturer’s instructions. Route wiring to prevent mechanical damage and encase in conduit. Connect and operate under the supervision of a qualified field representative of the strain gauge manufacturer for the first load instrumentation zone.

4. Install terminal boxes for each load instrumentation zone, at street level within 10 feet of the excavation, in a protected location, and with convenient access for the Contracting Officer.

5. Assign alphanumeric designations to the strain gages that are consistent with the Contractor’s chosen designations for the support ribs. Clearly label electrical leads.

C. Load Cells:

1. Install load cells between walers and earth anchor plates or soldier piles. Exact locations will be determined in accordance with the approved design. Install load cells in conformance with the load cell manufacturer’s instructions.

2. Connect load cells to terminal boxes in conformance with the load cell manufacturer’s instructions. Encase connections in waterproof conduit. Connect and operate under the supervision of a qualified field representative of load cell manufacturer for the first load instrumentation zone.

3. Install terminal boxes on both sides of each load instrumentation zone, at street level within 10 feet of excavation, in a protected location, and with convenient access for the Contracting Officer.

4. Assign alphanumeric designations to the load cells that are consistent with the Contractor’s chosen designations for the support ribs. Clearly label electrical leads.

D. Pressure Cells: Install pressure cells as shown and subject to approval by the Contracting Officer.

3.15 PIEZOMETER INSTALLATION

A. As specified in Section 02140, “Dewatering”.

3.16 MONITORING SCHEDULE

A. General:

1. At a minimum, perform monitoring of geotechnical instrumentation, and follow the minimum schedule as specified below.

2. When instrumentation detects sudden changing movement or changing ground water levels take additional readings, in number and frequency as directed by the Contracting Officer.

B. Open-Cut and Cut-and-Cover Excavation Monitoring:

1. Movement detection instruments, except heave markers, within 20 feet of the excavation: Monitor an average of once per day during excavation, and once per week thereafter, until backfilled.

2. Movement detection instruments 20 feet or more outside of the excavation: Monitor an average of once every other day during excavation, and once every other week thereafter, until backfilled.

3. Heave markers: Monitor once following installation of the markers and once upon completion of excavation.

4. Internal bracing and anchor load instrumentation: Monitor an average of once per day while excavating 50 feet on either side of strut location, and once every week thereafter.

C. Tunnel Excavation Monitoring:

1. For the purposes of monitoring, instruments considered to be affected during construction of each individual tunnel are within a zone bounded by planes at a slope of 1 horizontal to 1 vertical at right angles to the tunnel alignment and tangent to the tunnel periphery.

2. Provide the instrumentation and take 3 readings of each instrument to establish an initial value. Take each of the 3 initial readings at an interval of at least 24 hours. Take the third and the last initial reading at least 2 weeks prior to the tunnel face approaching within 100 feet of the instrument. If the initial readings show a large variance, take additional readings to establish an initial reading.

3. Except for tape extensometer, read movement detection instruments once per shift while within the affected tunneling within 100 feet either way of the tunnel face, as follows:

   a. Once per shift or once per day, whichever is more frequent while tunneling within the 100 feet distance.

   b. At least once per day for 1 week after the tunnel excavation has
passed the 100 feet limit and once every week for 1 month thereafter.

4. Read movement detection instruments installed outside the affected zone once before the start of tunnel excavation, and at least once per day during tunneling when the tunnel is within 100 feet either way of the instrumentation stationing and once per week for 1 month thereafter.

5. Read level monitoring devices installed inside buildings near the proposed tunnel route for monitoring settlements on a schedule that is coordinated with compaction grouting and as follows:
   a. At least once per day during tunneling when the tunnel is within 100 feet of the building. Unless otherwise noted, the position of the tunnel refers to the face of excavation at the leading edge of the tunnel.
   b. At the end of each shift while tunneling under or near each affected building column and once per day for 1 week thereafter.


D. Observation Well Monitoring: As specified in Section 02140, "Dewatering."

E. Monitor instrumentation more frequently, if instrumentation detects significant, anomalous, or suddenly changing deformations, loads, or hydrostatic pressures.

3.17 INSTRUMENT PROTECTION, MAINTENANCE, AND REPLACEMENT

A. Protect and maintain instruments. Drain water or flush debris from under protective covers. Keep protective covers locked.

B. Provide suitable substantial protective barriers around instruments in construction areas.

C. Repair or replace damaged or missing instrument components or entire instruments as required within 48 hours at no extra cost to the Authority.

3.18 REMOVAL OF INSTRUMENTS

A. Upon completion of the Contract, leave cased deep benchmarks in place. Set cased deep benchmark protective covers flush with pavement or finished grade.

B. Prior to final acceptance of the work and subject to approval of the Contracting Officer, remove and dispose of the settlement reference points and heave markers, together with the protective boxes and covers. Fill holes drilled in masonry or concrete surfaces for settlement reference points with Portland cement mortar.

C. Upon completion of Contract, demolish inclinometer casings, unless otherwise directed, to a depth of 2 feet minimum below ground surface. Plug remaining open portions of inclinometer casings with Portland cement concrete. Backfill casing excavations with suitable material. Construct new pavement patches in paved areas of the same material and to the same thickness as existing adjacent pavement. Restore disturbed or damaged surfaces to the conditions existing prior to installation of instruments.

D. Terminate monitoring of observation wells when directed by the Contracting Officer. Leave observation well covers in place at the same elevation as of surrounding ground or pavement.

E. Remove painted instrument identification numbers from building and other surfaces. Remove wooden markers and protective barriers.

F. Restore and replace insulation, protective wrappings, and covers on utilities.

G. Backfill excavations made over and around utilities.

3.19 CONTRACTING OFFICER’S MONITORING

A. Access to Instruments: Provide and facilitate safe access to each instrument for the Contracting Officer at all times. Access includes, ladders, working platforms, and other necessary facilities, and the removal thereof.

B. The Contracting Officer may perform supplemental monitoring of instruments at any time. Cooperate with such instrumentation monitoring activities as follows:
   1. Make probes, sensors, and read-out devices available as required.
   2. Coordinate activities to minimize interference.
   3. Remove obstruction from lines of sight when requested by the Contracting Officer.
   4. Regulate traffic during instrument surveying operations.
   5. Temporarily cease activities which create hazards to instrument monitoring or surveying personnel.
PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. The work of this section, geotechnical instrumentation, including design of geotechnical instrumentation program and its implementation, interpretation, and maintenance (including removal of instruments and casings when specified) will be measured and paid for under the unit prices specified below.

B. Inclinometers will be measured by and paid for at the unit price for “Inclinometers” per linear foot based on the total number of linear feet of casing per installation to the nearest whole foot.

C. Deep benchmarks will be measured by and paid for at the unit price for “Deep Benchmarks” per linear foot based on the total number of linear feet of outer casing per installation to the nearest whole foot.

D. Heave markers will be measured by and paid for at the unit price for “Heave Markers” per each.

E. Settlement Reference Points: Settlement reference points shall be considered incidental to construction. No separate payment for settlement reference points will be made.

F. Deep subsurface settlement indicators will be measured by and paid for at the unit price for “Deep Subsurface Settlement Indicators” per linear foot based on the total number of linear feet of drilling to the nearest whole foot.

G. Level monitoring devices will be measured by and paid for at the unit price for “Level Monitoring Devices” per each.

H. Tiltmeters will be measured by and paid for at the unit price for “Tiltmeters” per each based on the total number of tiltmeters installed.

I. Tape extensometer will be measured by and paid for at the unit price for “Tape Extensometers” per each.

J. Borehole extensometer will be measured by and paid for at the unit price for “Borehole Extensometer” per linear foot based on the total number of linear feet of drilling to the nearest whole foot.

K. Strain gauges will be measured by and paid for at the unit price for “Strain Gauges” per each.

L. Load cells will be measured by and paid for at the unit price for “Load Cells” per each.

M. Pressure cells will be measured by and paid for at the unit price for “Pressure Cells” per each.

N. Piezometers, for the work related to this section only, will be measured by and paid for at the unit price for “Piezometers” per linear foot based on the total number of linear feet of drilling to the nearest whole foot.

END OF SECTION 02316
SECTION 02360
DRIVEN PILES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specifications for designing, furnishing, and driving steel H-piles, prestressed concrete piles, and steel sheet piles as indicated, and performing any required pile load tests.

B. Pile Types:
   1. Type A: Steel H-piles, driven.
   2. Type B: Prestressed concrete piles, driven.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO/AWS D1.5M/D1.5 - Bridge Welding Code

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A252 - Standard Specification for Welded and Seamless Steel Pipe Piles
   2. ASTM D1143 - Standard Test Method for Piles under Static Axial Compressive Load
   3. ASTM D4945 - Standard Test Method for High-Strain Dynamic Testing of Piles

C. Texas Department of Transportation (TxDOT): Standard Specifications for Construction of Highways, Streets and Bridges.

1.3 DEFINITIONS

A. Geotechnical Engineer: For the purpose of this specification section, a Professional Engineer licensed in the State of Texas, whose qualifications include 5 years of documented experience in geotechnical testing, construction and inspection of piling foundations.

B. Structural Engineer: For the purpose of this specification section, a Professional Engineer licensed in the State of Texas, whose qualifications include 5 years of documented experience in the design of structures and structural foundations.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Where load tests are shown or specified, show load test arrangements.
   2. For precast concrete piles, show procedures for fabrication including arrangement of reinforcing, as well as pick up and handling methods.
   3. For prestressed piles, show prestressing methods, tendon arrangement, working stresses, concrete mix design to be used, curing procedures, and methods for pick-up and handling, and minimum required strength prior to handling.

B. Documentation:
   1. Provide mill certificates for Type A piles and steel sheet piles.
   2. Provide certified concrete test reports in conformance with requirements of Section 03305, "Portland Cement Concrete".
   3. Pile order list:
      a. List of piles to be installed in the work showing size, type, number, location, and length needed to ensure penetration necessary to attain design capacity.
      b. Submit list prior to ordering piles.
   4. Submit details of the proposed pile driving job progress schedule, pile driving plan and termination blows per foot.
   5. Prior to commencement of pile installation operation, Contractor shall submit to the Contracting Officer for approval, details of all equipment for installation of piles. This shall include details of the pile hammer, power plant, leads, cushion material and helmet.
   6. Pile driving record: Maintain record throughout pile driving operations and submit upon completion of such operations. Include the following:
      a. Pile location.
      b. Ultimate pile load.
DRIVEN PILES

c. Date and time of beginning and ending of pile driving.
d. Sequence in which piles are driven.
e. Pile type, length, and diameter.
f. Equipment: Type and rating.
g. Blow counts throughout driving in blows per foot.
h. Splice locations.
i. Number of blows per inch of penetration for last 12 inches.
j. Vertical pile plumbness and batter.
k. Unusual conditions encountered during driving operations.
l. Final tip and cut-off elevations.

7. Submit evidence of experience of installer with names of projects, type of project, total linear feet of pile installed.

1.5 QUALITY ASSURANCE

A. Codes and regulations of the jurisdictional authorities.

B. The installer shall be a company specializing in performing the work of this section and have a minimum of 10 years experience in the installation of driven pile foundations.

C. The Contractor shall employ Geotechnical Engineer, or alternately retain a geotechnical consultant firm acceptable to the Contracting Officer to supervise the installation and driving of piling. The Geotechnical Engineer shall be required to certify the pile driving reports as described herein.

D. Pile Splices:

1. Welded splices shall conform to the design in the Drawings, or as approved by the Geotechnical Engineer and that are in conformance with AASHTO/AWS D1.5M/D1.5, latest revisions.

2. Submit qualifications of welding and testing personnel in accordance with Section 05120, “Structural Steel - Bridges”.

3. Remanufactured splices are not acceptable.

4. Splices shall provide at least equal stress strain behavior in bending, tension, compression and torsion as unspliced segment of pile.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. When handling and delivering precast concrete piles, provide equipment to avoid undue bending stresses and breaking or chipping edges of pile. Do not use chain slings.

B. Support all piles, both steel and concrete, above ground and properly supported to prevent deflection and undue stress.

C. Storing and handling of steel piles shall be in ways that protect them from damage. The Contracting Officer will reject bent or kinked piles that the Contracting Officer believes cannot be straightened without damaging the metal.

D. The Contractor shall be responsible for all damage to the piles until they are incorporated into the structure and the structure is accepted, except specified otherwise in these specifications.

1.7 JOB CONDITIONS

A. Locate and protect underground facilities and structures as specified in Section 02220, “Grading, Excavating and Backfilling”.

PART 2 - PRODUCTS

2.1 CONCRETE PILES

A. Construct precast concrete piles, either conventionally reinforced or prestressed in accordance with Sections 03100, 03200, 03300, 03430, and 03365, as applicable, and the following:

1. For precast piling, concrete shall be Mix S-3.

2. For prestressed piling, concrete shall be of class shown on the plans.

3. All corners of square piling shall have a chamfer or radius.

4. The maximum sweep (curvature along axis of pile) not to exceed 1/8 inch per 10 feet of length.

2.2 STEEL H-PILE AND MISCELLANEOUS STEEL ACCESSORIES

A. In accordance with Section 05120, “Structural Steel - Bridges”; sizes as shown on the plans and AASHTO/AWS D1.5M/D1.5.
2.3 MISCELLANEOUS DRIVING ACCESSORIES

A. Driving heads, collars, bands, shoes, mandrels, and other driving devices in accordance with manufacturer's recommendations.

PART 3 - EXECUTION

3.1 DRIVING EQUIPMENT

A. Impact Hammer:

1. Adequacy of driving equipment, accessories, and methods is the general responsibility of the Contractor.

2. Foundation steel H-piles shall be driven with diesel, steam or air hammers.

3. The pile hammer used shall have a delivered energy suitable for the total weight of the pile, the character of the subsurface material to be encountered and the pile capacity to be developed as specified on the Drawings. If, in the opinion of the Contracting Officer, the driving equipment is inadequate or deficient, the Contracting Officer will direct it be removed from the job site. All costs for remobilizing, removing or replacing such equipment shall be at the Contractor's expense.

4. Driving criteria for piles shall be established by a Wave Equation Analysis of Pile Driving (WEAP). The Contractor shall furnish the manufacturer's specifications and catalog for the proposed hammer at least seven days in advance of pile driving in order to complete the WEAP.

5. Piles shall be driven to the ultimate pile capacity and to a driving resistance as determined by WEAP and as modified by test pile results, load test results, and pile driving analyzer (PDA) analysis.

6. If a diesel hammer is selected, the Saximeter, developed by Pile Dynamics, Inc., or equivalent, shall be used to provide an estimate of the driving energy of the hammer. If the driving energy of the hammer is different to the driving energy used to establish the pile driving criteria, the analysis to determine the pile driving criteria shall be reperformed using the measured hammer driving energy.

7. Driving equipment shall conform with the general criteria as specified in the Item 404 of the TxDOT Standard Specifications.

8. Should the driving equipment, accessories, or methods used or employed by the Contractor prove to be damaging to the piles or inadequate in attaining or maintaining the job progress schedule, the Contracting Officer may require the Contractor to replace some or all of the driving equipment, utilize different types of accessories, or use additional equipment.

9. Unless the use of gravity hammers are permitted by the Contracting Officer, all pile driving shall be done by impact hammer.

10. If the plans specify that test piles are required, the test piling shall be driven with the same size hammer as used for production piles.

B. Use a vibrohammer only with permission of the Contracting Officer.

C. Leads:

1. Piles shall be driven with fixed-lead drivers. The Contractor shall not use hanging or swinging leads unless they can be fixed in position during driving.

2. Provide leads of sufficient length to accommodate the combined length of pile and hammer.

3.2 DRIVING

A. General:

1. Drive piles only after completion of excavation or construction of an embankment, unless otherwise approved.

2. For piles installed in embankments, predrill through fill or embankment to natural ground or bottom of embankment, unless otherwise approved.

3. Pile jetting is not allowed without prior approval of Contracting Officer.

4. Drive each pile in a continuous operation until required penetration and bearing value have been obtained. If driving is stopped before required blow count is reached, drive 1 foot upon resumption of driving before resuming blow count.

5. Redrive each pile which is lifted by ground heave during driving of adjacent piles to at least original tip elevation or as directed.
6. Contractor shall ensure that ground conditions at the pile locations are adequate to support pile driving operations. Make provision for access and support of piling equipment during performance of work.

7. Piles shall not be driven until the excavation in the area which the piles are to occupy has been complete.

8. A driving helmet or cap shall be used between the top of the pile and the ram to prevent impact damage to the pile. The driving helmet or cap shall be capable of protecting the head of the pile, minimizing energy absorption and dissipation and cap shall have appropriate tapered grooves to fit the pile head and to prevent its distortion.

9. Use a driving helmet to protect the pile head.

10. Do not use any loose inserts in the helmet. The Contracting Officer is sole judge of the acceptability of the helmet.

11. Hold pile securely and accurately in position while driving.

12. Deliver hammer impacts concentrically and in direct alignment with pile taking care to avoid forcing pile laterally or bending pile. If in the Contracting Officer’s opinion, lateral or bending forces unduly affect the pile, the Contractor shall stop and rectify the situation at his own expense and to the satisfaction of the Contracting Officer.

13. Piling shall be driven to within five feet of plan length and to such greater depths necessary to obtain the required bearing resistance shown on the plans unless other penetration requirements or bearing evaluation methods as stated herein governed.

14. Restrike piles which have settled or heaved during driving of adjacent piles. No additional compensation will be made for pile restructured due to such settlement or heave.

15. Restrike piles as required by the Contracting Officer.

16. Remove loose and displaced material from around the piles after completion of driving, and leave clean, solid surfaces to receive foundation concrete.

B. Steel and Concrete Piles:

1. Hold pile heads in position with steel driving block or anvil.

2. Protect heads of concrete piles from direct impact of hammer by cushion driving block. Maintain cushion in good condition during entire driving operation. Arrange cushion driving block so that reinforcing bars projecting above piles will not be displaced or damaged in driving.

3. Use steel combination driving heads and pilots when driving steel H-beam piles. Closely fit driving heads to top of steel pile or shell and extend down sides of pile at least 4 inches.

4. Do not drive precast or prestressed concrete piles until 14 calendar days after casting.

3.3 SPlicing

A. Make splicing to produce a straight pile.

B. Prior to installing the splice, square the ends of the two sections of the pile to produce a straight splice with uniform bearing. In no case shall the ends of the pile sections be out of square by more than 1/16 inch.

C. Perform all splicing in the presence of the Contracting Officer.

D. In the event that a pile splice becomes damaged so as to impair the pile from its intended use, replace the pile. All costs associated with replacement, including any necessary changes to the pile cap, shall be borne by the Contractor.

3.4 Welding and Nondestructive Testing

A. Perform welding in accordance with AASHTO/AWS D1.5M/D1.5.

B. Welded splices shall be full penetration butt joints using qualified welding procedures and welders as indicated herein.

C. Provide a full-time, onsite Certified Welding Inspector (CWI) whenever any welding is being done.

D. Ultrasonically examine 10 percent of all pile splices. Contractor and Contracting Officer shall agree on splices to be examined.

E. Acceptance criteria for welding examination shall be AASHTO/AWS D1.5M/D1.5.
3.5 **PREDRILLED HOLES**

A. Where shown, drill holes to diameter not exceeding greatest cross sectional dimension of pile.

B. Set pile in predrilled hole and drive to necessary penetration and bearing value but in all cases to a minimum depth of 5 feet below bottom of predrilled hole.

C. Fill voids in hole with clean dry sand or lean concrete as approved.

D. Dispose of material resulting from drilling holes in accordance with the requirements of Section 02220, "Grading, Excavating, and Backfilling".

3.6 **DETERMINATION OF PILE LENGTH**

A. Furnish bearing piles of length necessary to develop a specified bearing value or to obtain a specific or a minimum penetration as specified in the plans.

B. If specified in the plans, furnish and install test piles to establish bearing resistance and subsequent pile lengths.

C. The Contractor may install additional test piles, make borings, or make such other investigations as he deems necessary at no additional cost to the Authority.

D. Cut-off piles neatly and squarely at the elevations shown on the Drawings. All cut-off lengths of piling shall remain the property of the Contractor and shall be properly disposed of.

3.7 **INSTALLATION OF TEST PILES**

A. Provide test piles, where shown, to determine lengths of piles to be furnished. Locate piles so that they can be cut off and become a part of the completed structure provided they conform to specified requirements for piling.

B. Based on result, adjust required penetration of permanent piling.

C. Install test piles with same type of equipment to be used to install foundation piles. Perform work in the presence of the Contracting Officer.

D. Dynamic tests shall be performed on all test piles during driving in accordance with ASTM D4945.

E. Remove piles which are not incorporated into completed structure or which do not satisfy test requirements to at least three feet below finished grade and backfill resulting hole as directed.

3.8 **PENETRATION RESISTANCE AND VERIFICATION**

A. All H-piles shall be driven to the bearing capacity shown on the Drawings as verified by the Dynamic Test (ASTM D4945) of one H-pile per substructure (pier or abutment).

B. Attain bearing value of not less than design loading shown or specified. Penetrate at least 12 feet into natural ground and, when pile tip elevation is specified, penetrate at least to specified tip elevation, unless otherwise approved.

C. Installation of each pile will be subject to approval of the Contracting Officer, who will be the sole judge of acceptability of pile with respect to penetration resistance at end-of-initial-driving as well as at restriking, to depth of penetration, or to other penetration criteria. Contracting Officer to approve final penetration resistance of piles prior to removal of pile driving equipment from the site.

3.9 **BEARING EVALUATION**

A. The ultimate pile capacity shall be determined by the Geotechnical Engineer based upon wave equation analysis (WEAP).

B. The WEAP shall be based upon the results of dynamic measurements during driving of piles designated as dynamic test piles.

C. Dynamic testing shall be performed in accordance with ASTM D4945.

D. Dynamic testing shall be performed on a minimum of one pile per bridge bent. The number of dynamic tests required may be reduced by the Contracting Officer.

E. The Geotechnical Engineer shall confirm adequate bearing or load capacity of driven piles to ensure the load capacities are in compliance with the project drawings. Evaluation shall be included in the pile driving record.

3.10 **LOAD TESTS**

A. Perform load test when required by the plans.

B. Load test equipment and testing procedures: In accordance with ASTM D1143.

C. Provide equipment with capacity equal to 200 percent of design working load and having means of determining applied load within plus or minus five percent and measuring settlement to nearest 0.001 inch.
D. Install test piles for load test at location shown in the presence of Contracting Officer after approval of test arrangement has been received. Assist the Contracting Officer in recording measurements necessary for determination of performance of piles.

E. Pile driving records shall be maintained for each pile type.

F. Dynamic tests shall be performed on all load test piles in accordance with ASTM D4945.

G. Commence loading test piles not sooner than 72 hours after installation. Unless failure occurs first, load pile in increments of 25 percent of individual pile or group design load as follows:

1. Individual piles: To 200 percent of pile design load.
2. Pile groups: To 150 percent of group design load.

H. Maintain each load increment until rate of settlement is not greater than 0.01 inch per hour, but not to exceed two hours.

I. Unless pile or pile group fails and if settlement is not greater than 0.01 inch per hour for one-hour period, remove total test load.

J. If settlement for one-hour period exceeds 0.01 inch, allow total load to remain for 24 hours, after which remove test load in decrements of 25 percent of total test load, allowing one hour between decrements.

K. Cut off test pile at elevation shown, if it is to be incorporated into structure.

L. Pile heads, at cut-off elevation, shall be within 3 inches of locations shown on the Contract Drawings as measured immediately after termination of initial driving, and 6 inches as measured after piles have been driven.

M. If tested to failure or not incorporated into structure, pull test pile or cut off so that top of pile is a minimum of 3 feet below finished grade or not less than 3 feet below bottom of structures.

N. Safe allowable load of test pile: Fifty percent of test load producing net settlement measured at top of pile equal to 0.0025 inch per ton of applied test load or 50 percent of test load which produces maximum net settlement of 1/4 inch after continuous application for 48 hours.

3.11 DEFECTIVE PILES

A. Contracting Officer will reject any pile found to be damaged or defective.

B. Contractor shall remove and replace rejected piles as directed by the Contracting Officer.

C. No extra compensation shall be made for removing and replacing or other work made necessary through rejection of a defective pile.

D. Replace piles which do not conform to specified tolerances or are split, broken or otherwise damaged to such a degree as to compromise design load. Perform repairs on such piles if approved. Have a Professional Engineer, licensed in the State of Texas, prepare a new design for pile cap or replacement piles or approved out-of-tolerance piles and submit the new design for approval. Do not begin remedial work without approval.

E. Fill rejected predrilled holes with lean concrete and redrill at approved location.

3.12 CUT OFF AND EXTENSION

A. Concrete Piles:

1. Cut off concrete piles at such elevation that they will extend into cap or footing as shown and in such manner as to avoid spalling or damaging pile below cut off.

2. Piles may be cast full length of reinforcing bars extending into the cap or footing, provided that after piles have been driven concrete is removed to expose steel as shown.

3. When reinforcing steel dowels are shown, dowels may be anchored in cast or drilled holes in concrete pile. If holes are drilled, drill by methods that will not damage concrete, reinforcing steel or prestressing steel. Drill minimum diameter consistent with placing approved epoxy adhesive and dowel. Leave holes free of dust, moisture, and other deleterious material. Place sufficient epoxy in holes before inserting dowels leaving no voids afterwards. Leave dowels undisturbed until epoxy has developed 100 percent of its strength capacity.

4. When concrete piles are driven or cut off below elevation of bottom of cap, extend pile section to elevation of bottom of cap by means of reinforced concrete extension.
constructed in accordance with approved details.

5. Replace or repair piles damaged when cut off.

B. Steel Piles:

1. Cut off steel piles at designated elevations and install anchor bars as shown.

2. Splice steel piles by use of approved prefabricated pile splices.

3. Welding shall be in accordance with AASHTO/AWS D1.5M/D1.5.

C. Only one splice per steel or concrete pile will be permitted.

D. Remove and dispose of cut off lengths of piling.

3.13 FIELD QUALITY CONTROL

A. Allowable Tolerances: Install piles at location shown in the plans to required vertical or batter alignment, within the following tolerances:

1. Axis of pile within 3 inches of design location at cut off elevation.

2. Axis of pile not out of plumb or batter by more than one percent of its driven length.

B. Pull and replace piles as directed by the Contracting Officer if out of alignment, or if approved by the Contracting Officer, redesign foundation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work under this Section will not be measured for payment, and shall be considered incidental to other work specified, unless a quantity is provided in the Bid Schedule. If a quantity is provided, measurement will be per linear foot, from the tip to the head of the pile remaining in place in the completed structure.

B. If a Bid Item is provided, the unit price per linear foot shall include furnishing piles, driving piles, splices, obtaining safe bearing capacity, tip elevation performing Wave Equation Analysis and disposing of pile cut-offs, for each type and size or diameter.

END OF SECTION 02360
SECTION 02375
DRILLED SHAFT FOUNDATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section covers the construction of drilled shaft foundations in accordance with this specification and in conformance with the details shown on the plans.

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):
   1. ACI 301 - Standard Specifications for Structural Concrete
   2. ACI 336.1 - Specification for the Construction of Drilled Piers

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code Steel
   2. AWS D1.4 - Structural Welding Code - Reinforcing Steel

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field
   2. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
   3. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete
   4. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
   5. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete

1.3 DEFINITIONS

A. Drilled Shaft Foundation: A machine or hand excavated shaft cast-in-place and designed and constructed for structural support. It is an open excavation, circular in cross section with or without an enlarged or belled end bearing area.

B. Dry Construction Method: A method of shaft installation that allows the sides and bottom of the bearing stratum to be visually inspected prior to concrete placement. Temporary casing may be required to support caving soils and to control groundwater to allow dry construction in the bearing stratum.

C. Bearing Stratum: Bearing stratum is the soil or rock layer that carries the load transferred to it from the drilled shaft as designated on the plans.

D. Geotechnical Engineer: For the purpose of this section, Contractor-hired Professional Engineer licensed in the State of Texas, whose qualifications include 5 years of documented experience in geotechnical testing, design, construction and inspection of drilled shaft foundations. Geotechnical Engineer shall be present during the first day of drilled shaft installation or for the installation of the first 2 drilled shafts, whichever is greater. An experienced technician under the supervision of the Geotechnical Engineer shall be present during the drilled shaft installation.

1.4 MINIMUM DRILLED SHAFT INSTALLER QUALIFICATIONS

A. Three years experience in constructing shaft foundations.

B. Two years experience of on-site supervisors and 1 year of experience of drilling equipment operators.

C. Successful completion of 3 projects in the past 5 years with the installation of drilled shafts of similar diameters, lengths, and subsurface conditions as shown in the Contract Documents.

1.5 SUBMITTALS

A. Installer Qualifications: Submit 1 month prior to shaft construction written documentation of the installer’s qualifications in compliance with Article 1.4 herein. Supporting documentation shall include brief description of at least 3 projects on which the installer had been previously engaged in shaft construction with satisfactory results including project, names and current telephone numbers of owner’s representatives who can verify participation of cited projects.

B. Submit 1 month prior to construction of the work of this section the following items:
   1. Shop drawings showing placement of reinforcing steel.
   2. Concrete mix designs in accordance with the requirements of Section 03305, “Portland Cement Concrete”: Submit trial batches if Contracting Officer rejects the proposed mix proportions evidence.
   3. Submit certified mill test reports for reinforcing steel, including bar markings.
D. Concrete batch-plant tickets containing the information required by Section 03305, “Portland Cement Concrete”.

E. Submit Final Shaft Report prepared and sealed by the Geotechnical Engineer: Include at a minimum:

1. Top of rock elevation.
2. Penetration into bearing stratum.
3. Final axis of shaft and its variation from the design location.
4. Shaft diameter.
5. Variation of shaft from plumb and variations in shaft diameter.
6. Water inflow rate and method of control, if any, at time of concrete placement.
7. Reinforcement. Include elevation and length of any splices required by the plans or by additional length of shaft as required under Article 3.4. Record the total length of reinforcing cage installed and total length of reinforcing placed in pier.
8. Elevations, both top and bottom of any casing left in place.
9. Elevations of top and bottom of pier.
11. Other documentation as may be dictated by construction conditions.
12. Specific identification of drilled shaft installations that do not conform to the Contract Documents.

1.6 QUALITY ASSURANCE

A. Codes and regulations of the jurisdictional authorities shall be followed.

B. Contractor shall employ a Geotechnical Engineer as defined in Paragraph 1.3.D, acceptable to the Contracting Officer, to verify that the excavation, steel placement, and concrete placement for drilled shaft foundations conform to Contract Documents.

PART 2 - PRODUCTS

2.1 TEMPORARY CASING

A. When required by site conditions or directed in order to prevent caving or as necessary to exclude ground water, furnish a temporary casing with the following properties:

1. For size of casing and of the shaft below casing, see Article 3.6, herein.
2. Fabricated of sufficient strength to withstand handling stresses, concrete pressure, and surrounding earth or fluid pressures. Weld casing in accordance with AWS D1.1/D1.1M.
3. Smooth, watertight, clean, and free of accumulations of rust, grease, and hardened concrete. Corrugated casing is not allowed.

2.2 CONCRETE

A. As specified in Section 03300, “Cast-In-Place Concrete”, and Section 03305, “Portland Cement Concrete”.

B. Concrete mix design shall be S-1 or S-2 as specified in Section 03305, “Portland Cement Concrete”, and shall conform to the additional requirements specified herein.

C. Concrete shall be flowable, non-segregating concrete.

D. Concrete shall maintain a slump workability of nominal 6 inches. Minimum slump requirement shall be maintained until concrete placement is complete.

E. Concrete mix designs shall take into account the following additional requirements:

1. One additional sack of cement per cubic yard shall be added to design mix if concrete is to be placed in water.
2. Retarder or water reducing agent shall be included in concrete when casing is used or when drilled shafts are placed underwater.

2.3 REINFORCEMENT

A. ASTM A615/A615M, as shown and in accordance with Section 03200, “Concrete Reinforcement”.

B. Splice bars in conformance with Contract Documents. Submit any splice requirements for acceptance by Contracting Officer.

C. Protect reinforcing steel from contamination and corrosion that will preclude concrete bonding to reinforcing steel.

PART 3 - EXECUTION

3.1 GENERAL

A. Control operations to prevent damage to existing structures and utilities. Preventative measures shall include selecting construction methods and procedures that will prevent caving of shaft excavations and monitoring and controlling
DRILLED SHAFT FOUNDATIONS

vibrations from casing installation and removal and shaft drilling.

B. Comply with the requirements of Section 02220, “Grading, Excavating and Backfilling”.

C. Notify the Contracting Officer in time to permit inspection of the completed excavation prior to placement of reinforcing steel and prior to placement of concrete.

D. Construction Sequence: Comply with the following sequencing requirements unless otherwise shown in the Contract Documents or approved by the Contracting Officer:

1. Complete excavation to drilled shaft cap or footing elevation before shaft construction begins. Repair any disturbance to cap or footing area caused by drilled shaft installation prior to the cap or footing pour.

2. When drilled shafts are installed in conjunction with embankment placement, construct the drilled shafts after the placement of the fills. In areas where MSE retaining wall reinforced zone will cover drilled shafts, the drilled shafts shall be installed prior to wall construction.

3. Drilled shafts, constructed prior to the completion of embankment fills, shall not be capped until the fills have been placed as near to final grade as possible, leaving only the necessary workroom for construction of the caps.

E. Install drilled shafts in reasonable dry excavation, less than 2 inches of standing water, where the sides and bottom of the bearing stratum can be visually inspected prior to placing concrete unless shown otherwise in the Contract Documents or approved by the Contracting Officer.

F. Use temporary casing where caving soils are present and to control groundwater unless shown otherwise in the Contract Documents or approved by the Contracting Officer.

G. Complete drilled shafts within 8 hours of penetrating the bearing stratum. If delays prevent concrete placement within 8 hours of exposing the bearing stratum, increase the drilled shaft length or diameter as approved by the Contracting Officer to compensate for the deterioration of the bearing surfaces.

H. Remove subsurface obstructions at drilled shaft locations. Such obstructions may include hard rock layers, hard concretions, or boulders. Employ special procedures and tools if the hole cannot be advanced using augers, drilling buckets and underreaming tools that are appropriate to penetrate the formation above and below the hard rock obstructions. Such special procedures/tools may include chisels, boulder breakers, core barrels, air tools, and hand excavation. Blasting is prohibited.

I. Drilling tools that are lost in the excavation shall not be considered obstructions and shall be promptly removed by the Contractor.

J. Provide suitable access to Contracting Officer and lighting for inspection of the completed excavation, alignment of shafts, and placement of reinforcing bar cages.

K. Provide electric lighting, if necessary. Operate any mechanical equipment within excavation by air or electricity. Gasoline driven equipment within excavation is prohibited.

L. For all Traction Power Substation (TPSS) buildings, Communications and Signal House foundations, the top surface of drilled shaft piers shall be finished level and smooth, and have a minimum of 12 inches above grade or 2 inches above surrounding crushed stone as shown on Drawings. Pier foundations top elevation shall be to the same level for each building, within the tolerances given in Paragraph 3.6.J.

3.2 SOIL AND ROCK BEARING DETERMINATIONS

A. Excavate drilled shafts to the dimension and depths shown. Maintain sidewall integrity and stability throughout the excavation process.

B. Bearing stratum shall be confirmed in the field by the Geotechnical Engineer to ensure that the drilled shaft penetration depths are in compliance with the Contract Drawings.

C. Where requested by Geotechnical Engineer, the bearing stratum beneath the bottom of the drilled shaft excavation shall be continuously sampled where soil is present and cored where rock is present to a minimum depth equal to 2.5 diameters below the planned bearing depth. Soil samples shall be obtained with thin walled tube samplers and rock with a rock core sampler. The samples can be taken before the excavation is made or when the excavation reaches the planned tip penetration into the bearing stratum.

D. If the stratum is not capable of providing the required service load bearing resistance, stop work and notify the Contracting Officer.

E. Upon confirmation that the bearing stratum has been reached, complete the drilled shafts as shown on the Contract Drawings.

F. Excavate the bottom of drilled shaft foundations to a level plane. In the event that the shaft is founded in rock with an apparent surface slope of 2 (horizontal) to 1 (vertical) or steeper, the excavation shall be evaluated by the Geotechnical Engineer, for compliance with the geotechnical recommendations for design prior to concrete placement.
G. Remove loose material from the bottom of the drilled shafts and dewater as required to complete concrete placement in a dry excavation. Shaft cleanliness shall be determined by the Geotechnical Engineer or approved qualified staff by visual inspection and measurements and shall meet the following criteria:

1. Less than 40 percent of the shaft base may have loose material up to 0.5 inch thick at the time of placement of concrete.

2. Maximum thickness of any single piece of loose material shall not exceed 1.5 inches.

3. The maximum depth of standing water at the base of the drilled shaft shall not exceed 2 inches when concrete is poured.

H. Remove all waste material in accordance with Section 02220, “Grading, Excavating, and Backfilling”.

I. For TPSS buildings, Communication and Signal House foundations, the required soil bearing resistance shall not be less than 5000 psf.

3.3 TEMPORARY CASING

A. When required by site conditions, install temporary casing sufficient to withstand handling stresses, concrete pressure, and surrounding earth and water pressures.

B. Seat temporary casing into the top of the rock to obtain a seal to prevent fines and water from entering the excavation. Measure the tip elevation of the surface casing and the elevation of the top of the rock to confirm that the casing is seated into the rock.

C. If water is flowing into the shaft excavation at the bottom of the casing, advance the casing further into the rock to attempt to cut off the water. The rock may be excavated up to several feet to allow the casing to be set further into rock. However, the shaft excavation shall not be advanced to the design elevation until the casing is sealed in the rock.

D. Measure the penetration into the rock to confirm that the shaft has the specified embedment into the bearing strata.

E. Underwater concrete placement may be used, if after the casing is advanced into sound unweathered rock 12 inches or more, a seal cannot be obtained or if a fracture in the bearing strata is present that discharges water into the shaft excavation. Underwater concrete placement, by tremie or by pumping shall be in accordance with ACI 336.1.

F. Do not place concrete into the drilled shaft excavation with standing water until the condition of the bottom of excavation is evaluated by the following 3 criteria:

1. Clean out bucket should only discharge rock chips or fragments. If clay balls, sand, or mud are present, the clean out operations shall be continued until only rock chips or gravel are discharged from the clean out bucket. The continued removal of clay balls, gravels, and sands may indicate that the casing is not properly seated. If these conditions are present, steps shall be taken to seal the casing to prevent clay, sand, and gravel from entering the excavation.

2. Excavation shall be "vacuumed" with a pump capable of removing particles up to 0.5 inch rock chips. The materials discharged by the pump should only consist of rock chips in a clear to gray colored water. If clay balls, sands, gravels, or mud are discharged, bottom clean up operations shall be continued.

3. Sand content in water at bottom of the shaft shall not exceed 1 percent by volume.

4. If a seal cannot be created which prevents the entry of sand, gravel or mud into the drilled shaft; notify the Contracting Officer and obtain approval before placement of drilled shaft concrete.

G. Once it is established that underwater placement will be necessary, the construction operations shall be executed in a manner to allow the shaft to be concreted within 8 hours after the design penetration is reached.

H. If vibratory or impact type methods are approved for use by the Contracting Officer for use to install or remove the temporary casing, the following limitation applies. No casing may be installed or removed after any concrete is placed within a horizontal distance of 50 feet until all such concrete has set at least 24 hours.

I. Temporary casing shall be removed only while the concrete remains workable with a slump of 4 inches or greater. Casing extraction shall be at a slow, uniform rate with the pull in line with the shaft axis. As casing is withdrawn, a 5 foot minimum head of fresh concrete in the casing shall be maintained so that all the fluid trapped behind the casing is displaced upward without contaminating the shaft concrete. The required minimum concrete head shall be increased as needed to counteract the groundwater head outside of the casing.

J. Do not withdraw casing after concrete has attained initial set as determined by the Contracting Officer.

K. Do not vibrate concrete prior to removing casing.

L. Leave temporary casing in place only as specifically approved by the Contracting Officer.
M. Where the Contract Drawings indicate that the length of the shaft includes skin friction in the design, the shaft length shall be adjusted to provide the required embedment below the bottom of the installed casing.

3.4 REINFORCEMENT

A. Place reinforcement as shown on the Contract Drawings, in accordance with Section 03200, “Concrete Reinforcement”.

B. Completely assemble the reinforcing steel cage, consisting of longitudinal bars, spiral reinforcement, and lateral ties and place as a unit immediately prior to placement of concrete, unless otherwise specified.

C. Tie spiral reinforcement to the longitudinal bars at a spacing not to exceed 12 inches.

D. Reinforcing cage shall be designed as a structural element and braced to retain its configuration throughout the placing of concrete and removal of casing from the shaft. The reinforcing cage bracing shall not interfere with the placement of concrete.

E. Conform to following if shaft length is increased as determined by Contracting Officer:

   1. Provide a minimum of 1/2 number of longitudinal bars as required in the shaft, and place on the bottom extension.
   2. Provide lateral bars.
   3. Lap splice extension bars a minimum of 30 bar diameters.

F. Support and hold down the cage by positive method to ensure against vertical displacement during placing concrete and extracting temporary casing. Permissible reinforcing steel vertical movement during casing withdrawal shall not exceed upward movements of 6 inches and downward movement of 6 inches per 20 feet of shaft length.

G. Maintain minimum lengths for reinforcing bar laps shown on the plans. Only every third vertical reinforcing bar shall be lap-spliced at the same elevation.

H. In uncased shafts, use concrete spacer blocks, or steel chairs at sufficient intervals to ensure concentric spacing for the entire length of the cage. In cased shafts, use steel chairs. Plastic centralizers and boot chairs (roller type) can be used in lieu of concrete spacer blocks or steel chairs. Use “Shaft Spacer Systems” from Low-Tech Corp. in Georgia or approved equal.

I. Use concrete spacer blocks at the bottom of the cage to prevent contact of the reinforcing steel with the bottom of the excavation. Approved plastic spacer blocks may be used in lieu of concrete spacer blocks. Use “Shaft Spacer Systems” from Low-Tech Corp. in Georgia or approved equal.

3.5 CONCRETE

A. Place concrete in accordance with Section 03300, “Cast-In-Place Concrete”.

B. Place concrete continuously for entire length of shaft. The elapsed time from beginning to end of concrete placement shall not exceed 4 hours. The Installer can request a longer placement time provided the submitted concrete mix design will maintain a slump of at least 4 inches for the extended placement time. The concrete mix design shall be based on trial mixes and slump loss tests using concrete and ambient temperatures appropriate for site conditions.

C. For free fall of concrete, maximum of 25 feet will be allowed provided Installer can demonstrate that concrete can be directed such that it does not strike reinforcing cage or sides or holes during placement and no more than 2 inches of standing water is present. Otherwise place concrete through suitable tube or tremie to prevent segregation of materials. Tube or tremie may be made in sections to provide proper discharge and permit raising it as placement progresses. The tremie shall have a minimum diameter of 8 inches and a pump tube shall have a minimum diameter of 4 inches and watertight joints. Nonjointed pipe may be used if concrete is not allowed to discharge from side openings.

D. Do not begin placing concrete until shaft has been inspected and accepted by the Contracting Officer and reinforcing cage is in place and secured.

E. Make provisions to dewater shafts with pumps or other approved method. Place concrete in water, by tremie or pumping method, only if approved by the Contracting Officer.

F. Protect tops of drilled shafts against damage and cure and protect to prevent moisture loss and temperature extremes in accordance with ACI 301.

3.6 ALLOWABLE TOLERANCES

A. Axis of the shaft at the cut-off elevation within 3 inches of the design location.

B. Axis of the shaft shall not be out of plumb more than 1 percent of its excavated depth.

C. Center of the drilled shaft shall be within 3 inches of the plan position in the horizontal plane at the plan elevation for the top of the shaft.

D. After concrete is placed, the top of the reinforcing steel cage shall be no more than 6 inches above and no more than 3 inches below plan position.
E. Top elevation of the shaft shall have a tolerance within plus or minus 1 inch to 3 inches from the plan top-of-shaft elevation.

F. Final bottom elevation: As shown and determined by the Geotechnical Engineer and approved by the Contracting Officer. Cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of 3/8 inch per foot of diameter.

G. Bells shall be excavated to the plan bearing area as a minimum. The actual diameter of the bells shall not exceed 3 times the specified shaft diameter.

H. When casing is required, inside diameter of casing shall not be less than specified diameter of the shaft. That portion of the shaft below the casing may not be smaller than the specified diameter of the shaft.

I. Drilled shafts located in the area of the station platforms may have stricter requirements than those stipulated in Paragraph 3.6.A and 3.6.B, herein. Refer to Contract Drawings for additional or more stringent requirements.

J. The following requirements only applied only to the TPSS buildings, Communication and Signal House foundations:
   1. Center of the drilled shaft pier foundations shall be within 1/2 inch of the design position as shown on the Drawings.
   2. Top elevation of drilled shaft pier foundations for each building shall be level to a tolerance of plus or minus 1/8 inch.

3.7 FIELD QUALITY CONTROL

A. One set of 3 cylinders per 100 cubic yards or fraction thereof. Make concrete cylinders in accordance with ASTM C31/C31M and test in accordance with ASTM C39/39M.

B. Measure concrete slump in accordance with ASTM C143 for each set of compressive strength test specimens.

C. Measure concrete temperature in accordance with ASTM C1064 for each set of compressive strength test specimens.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Accepted drilled shaft foundations will be measured for payment by the linear foot for each respective diameter. Measurement will be from existing ground elevation at center of shaft, unless footing elevations shown on the Contract Drawings determine exact top of shaft elevation.

B. The quantities to be paid for removal of hard rock layer, concretion, and boulder obstructions shall be measured on the basis of the number of hours of work, or fraction thereof, after designation as an obstruction by the Contracting Officer, required to remove the obstruction and resume excavation.

4.2 PAYMENT

A. Drilled shafts will be paid for at the unit price per linear foot of each respective diameter of shaft complete-in-place. The unit price shall be full compensation for excavating, drilling test holes, pumping as required; temporary casings, concrete, reinforcing steel, disposal of excavated materials, and all other work of this section.

B. No payment will be made for extra reinforcement or shaft length if, due to Contractor’s fault, final bottom shaft elevation is placed below plan elevation in soil, or required penetration depth in rock.

C. No payment will be made for casings left in place, as they are incidental to the work described in this section.

D. No extra compensation will be made for additional concrete used in filling oversize casing or excavation.

E. No extra compensation will be made for lost tool removal including costs associated with the repair of hole degradation due to removal operations or an excessive time that the hole remains open.

F. Payment for the removal of hard rock layers, concretion, or boulder obstructions shall be paid at the unit price per hour for obstruction removal.

END OF SECTION 02375
PART 1 - GENERAL

1.1 DESCRIPTION

A. The work specified in this section consists of furnishing and construction of Overhead Catenary System (OCS) pole foundations and guy anchor piers including embedded items as shown on the Catenary Pole and Guy Anchor Pier Foundation Details and OCS Foundation Schedule Drawings.

1.2 REFERENCES

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   3. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
   5. ASTM A194/A194M – Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service, or Both
   7. ASTM F436 – Standard Specifications for Hardened Steel Washers

1.3 SUBMITTALS

A. Shop Drawings: Submit shop drawings showing anchor bolts, reinforcing steel, guy anchor rods, and grounding rods.
B. Materials List: Submit a written description of materials and sources of materials to be furnished for piers.
C. Installation Methods: Submit methods for securing the anchor bolts, anchor rods and ground rod in place and how the anchor bolts will be prevented from moving during concrete placement.

D. Certifications: Submit material certifications.

PART 2 - PRODUCTS

2.1 CONCRETE

A. Concrete: Mix S-1 or S-2, as specified in Section 03305, "Portland Cement Concrete".

2.2 REINFORCEMENT

A. Reinforcing: As specified in Section 03200, "Concrete Reinforcement".

2.3 ANCHOR BOLTS AND ANCHOR RODS

A. Anchor bolts and rods shall conform to ASTM F1554, Grade 55 and anchor bolt nuts shall conform to ASTM A194 or A563, Grade A, heavy hex. Washers shall be hardened steel, conforming to ASTM F436.
B. Galvanizing of anchor bolts, nuts, and washers shall conform to ASTM A153/A153M.
C. Guy anchor rods shall be galvanized according to ASTM A153/A153M and as indicated.
D. Guy anchor rods shall be attached to pier reinforcement with tie wire.

2.4 CONCRETE FORMWORK

A. Refer to Section 03100, "Concrete Formwork" and as specified below.
B. Forms used in constructing the pier above grade shall be of sufficient strength to withstand the pressure of the concrete and shall provide a concrete finish subject to the approval of the Contracting Officer.

2.5 EXPANSION JOINTS

A. Preformed expansion joint filler strips, conforming to ASTM D1751, shall be provided at common joint surfaces between drilled piers and other concrete work.

2.6 STEEL CASINGS

A. Steel Casings, where required, shall be sized within 2 inches of the diameter of the pier and shall be of sufficient strength to withstand surrounding soil and water pressure, and twist and handling from the machinery.
PART 3 - EXECUTION

3.1 GENERAL

A. Refer to Section 03100, "Concrete Formwork", Section 03200, "Concrete Reinforcement", and Section 03300, "Cast-In-Place Concrete", for general concrete related requirements.

3.2 EARTHWORK AND DRILLING

A. After the Contractor has established the locations of the pier foundations and guy anchors, prior to starting excavation, conduct a walkout inspection with representatives of the Contracting Officer, Contractor, and any other parties affected by the foundation locations, to resolve any problems resulting from the pole locations, soils conditions or alignment.

B. Drill the pier holes at the locations and to the diameters and depth indicated on the Catenary Pole and Guy Anchor Pier Foundation Details and OCS Foundation Schedule drawings, and within specified tolerances. If gray limestone is encountered during drilling of foundations, the hole need only penetrate the gray limestone the depth of two pier diameters or be bored the indicated depth, which ever is shallower.

C. Excavated materials satisfying the requirements of Section 02220, “Grading, Excavating and Backfilling” may be used for fill. Remove excavated materials that are surplus or unsatisfactory for fill from the work site and dispose of in a legal manner.

D. Use steel casing where approved by the Contracting Officer.

E. Remove boulders, concrete, debris, or other obstructions that will effect the drilling of the pier.

F. Remove loose dirt and water from the pier hole for proper inspection by the Contracting Officer.

G. No open pier holes shall be left overnight. Complete piers the same day as the excavation.

H. Bring utility lines or piping which block the pier drilling to the attention of the Contracting Officer and document them in writing.

I. Notify the Contracting Officer after the completion of each pier hole that it is ready for inspection.

J. Concrete placement in the pier hole shall not proceed until the hole has been approved by the Contracting Officer.

K. If it is determined by the Contracting Officer that an unfavorable soil condition exists, the shaft shall be rebored to a larger diameter or drilled deeper to satisfy structural requirements.

3.3 CONSTRUCTION

A. Concrete: smooth with float finish, per Section 03300, “Cast-In-Place Concrete” and Section 03350, “Concrete Finishing”. Foundation tops shall be sloped or level, as shown on the Catenary Pole and Guy Anchor Pier Foundation Detail Drawings.

B. Install reinforcing steel, rods, and anchor bolts embedded in the foundations as follows:

1. Place the reinforcement and install the anchor bolts in the pier shafts. The guy anchoring rods shall be located and oriented as indicated and within the tolerances specified in this section.

2. Electrical grounding, of the foundation, shall be provided as shown on the Contract Drawings.

3. Place reinforcing cages symmetrical about the axis of the foundations, and securely fasten to maintain the concrete cover as indicated.

4. Locate and orient anchor bolt assemblies as indicated, within the tolerances specified in this section.

5. Use prefabricated metal templates to hold the projecting lengths of the anchor bolts in their proper position.

C. Notify the Contracting Officer, after installation of the reinforcement, anchoring rods, or anchor bolts that the installation is ready for inspection. Adjust the reinforcement and anchor bolts or rods as required by the Contracting Officer.

D. Verify that the grounding rod is in place.

E. Immediately after inspection and approval by the Contracting Officer, begin placement of the concrete. Placement of concrete, in each pier, shall be one continuous pour.

F. Remove water and debris from the pier hole prior to and during concrete placement. In the event of contamination with earth or water, the Contractor shall remove the contamination from the shaft.

G. Protect anchor bolts, rods, grounding rod and reinforcement from movement during placement of concrete.
H. Whenever steel casings are used, they shall be withdrawn as the concrete is placed. Maintain an adequate head of concrete above the bottom of the casing to resist the soil and water pressures.

I. Vibration of the top five feet of concrete in the pier shall not be done until after the casing has been withdrawn.

J. The vibrator shall not make contact with the rebars or anchor bolts and shall not be used to position the concrete.

K. The anchor bolt template may be removed and reused elsewhere two days after the concrete has been placed. After removal of the template, clean the projecting anchor bolts and protect them from damage by moving vehicles and equipment.

L. Adjust the spacing of the ties to avoid interference with other embedded items. A two inch clearance between ties and other material is required for the passing of concrete.

M. Measure, record, and report the resistance developed by the ground rod in accordance with Section 16450, "Grounding and Bonding". Correct as required by the Contracting Officer.

3.4 TOLERANCES

A. Piers:

1. Locate each pier within 2 inches of its offset dimension as indicated on the OCS Foundation Schedule or as approved by the Contracting Officer.

2. To avoid local obstructions, the piers may be moved up to five feet parallel with the track. Adjacent to special track work, the along track positions of the foundation may only be modified by up to two feet six inches. Obtain approval in writing from the Contracting Officer prior to making such modifications.

3. Drill each pier within 5 degrees of the true vertical.

4. Drill pier not less than the diameter and length as indicated on the OCS Foundation Schedule or as required by the Contracting Officer.

5. The top of each pier shall be within 1/4 inch of the designated elevation, as indicated on the OCS Foundation Schedule.

B. Anchor Bolts and Guy Anchor Rods:

1. Locate each anchor bolt within 1/8 inch of its correct horizontal and vertical position in its anchor bolt assembly, as indicated on the OCS Foundation Schedule Drawings, and within 1/2 degree of its true vertical.

2. Locate each anchor bolt assembly within 1-1/2 inches of its correct offset and vertical position, as indicated on the OCS Foundation Schedule Drawings. Determine anchor bolt positions by the set out dimensions from the vertical and horizontal reference lines.

3. Locate each guy anchor rod within two inches of its correct horizontal and vertical set out dimension, within the pier.

4. Each anchor bolt assembly shall be within two degrees of its designated orientation, as indicated on the OCS Foundation Schedule Drawings.

5. Foundation anchor bolts or rods, which are bent or damaged after installation and prior to acceptance by the Contracting Officer, shall be repaired by an approved method at no additional cost to the Authority. If two or more anchor bolts in a foundation are bent greater than 20 degrees or are broken, the foundation shall be completely removed and replaced at the Contractor's expense.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Accepted quantities of work described in this section will be paid for at the unit price per each for the type of drilled pier foundations and guy anchors listed, including both the portion above grade and the portion below grade for each type.

B. The unit prices shall be full compensation for excavating, drilling test holes, pumping as required; temporary casings, concrete, reinforcing steel, disposal of excavated materials, and all other work of this section.

C. No payment will be made for casings left in place, as they are incidental to the work described in this section.

D. No extra compensation will be made for additional concrete used in filling oversize casing or excavation.

E. No extra compensation will be made for the removal of hard rock layers, concretion, or boulder obstructions.
END OF SECTION 02376
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies general track construction which consists of the mainline and yard trackwork indicated on the plans including installing direct fixation track, ballasted track, embedded/paved track, special trackwork, and track appurtenances.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)
   2. AREMA - "Portfolio of Trackwork Plans"

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D3786 - Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
   3. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity
   4. ASTM D4533- - Standard Test Method for Trapezoid Tearing Strength of Geotextiles
   5. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

C. American Public Transportation Association (APTA):
   1. APTA - "Guidelines For Design of Rapid Transit Facilities" (APTA Guidelines

1.3 DEFINITIONS

A. Approach Slab: A reinforced concrete slab located at the interface of ballasted track with direct fixation track or paved track to provide a transition between ballasted track construction and the types of track with significantly higher track modulus.

B. Ballast: An integral part of the track structure, generally composed of crushed stone in which ties are embedded. Track ballast includes ballast compacted beneath the ties, in the cribs between the ties, and in the ballast shoulders at the ends of the ties.

C. Bumping Post: A device placed at the end of stub-end tracks to prevent a moving rail vehicle from inadvertently rolling off the end of the track.

D. Closure Rails: The rails between the parts of any special trackwork layout, such as the rails between the switch and the frog in a turnout; also the rails connecting the frogs of a crossing or of adjacent crossings, but not forming parts thereof.

E. Continuous Welded Rail (CWR): A number of rails welded together into a single length.

F. Crossing, Road: The intersection of one or more tracks and a street, road, or highway, at grade.

G. Crossing, Railroad: The intersection of two tracks, at grade, consisting of four frogs, also known as a "diamond".

H. Crosslevel: The difference in elevation of the tops of heads of opposite rails measured at right angles to the track alignment.

I. Crossover, Single: Two turnouts with the track between the frogs arranged to form a continuous passage between two nearby and generally parallel tracks.

J. Crossover, Double: Two crossovers which intersect between the connected tracks.

K. Crossover, Universal: Two single crossovers, one being right hand and the other left hand, joining two nearby parallel tracks. The two single crossovers are located in close proximity to one another and typically are operated by the same signal interlocking.
L. Dutchman: A short piece of running rail temporarily placed between the ends of two rails. A Dutchman is placed at the zero thermal stress length before the two rail ends are welded into CWR, to reduce the damage which would occur to the rail ends as a result of rail mounted track equipment passing over those ends.

M. Frog: A device used at the intersection of two running rails to provide support for wheel treads and passageways for their flanges, thus permitting wheels traversing either rail to cross the other.

N. Frog Number: The number used to designate the size of a frog, and being equal to one-half the cotangent of one-half the frog angle.

O. Grade Line: The line on the profile representing the top of the roadbed ready to receive the sub-ballast at the intersection of the roadbed with a vertical plane through the track center line.

P. Guard Rail: A rail or other device laid parallel with the running rails of a track to prevent wheels from being derailed; or to hold wheels in correct alignment to prevent their flanges from striking the points of frogs. A rail or other device laid parallel with the running rails of a track to keep derailed wheels adjacent to running rails.

Q. Inside Rail: On curved track, the rail closest to the curve center, the rail with the shorter radius. Sometimes referred to as the "low rail".

R. Joint Bar: A steel member, embodying beam-strength and stiffness in its structural shape and material; commonly used in pairs for the purpose of joining rail ends together, and holding them accurately, evenly, and firmly in position with reference to surface and gauge-side alignment.

S. Outside Rail: On curved track, the rail farthest from the curve center; the rail with the longer radius. Sometimes referred to as the "high rail".

T. Pocket Track: A track located between the two mainline tracks on which an out-of-service train may lay over or reverse direction.

U. Profile Grade Line (PGL): The datum line which defines the vertical alignment of the track, applied at the top of the low rail.

V. Rail Fastening - Ballasted Track: A resilient device used to secure the running rail to the concrete tie at the proper track gauge to provide proper vertical, lateral, and longitudinal restraint of the rail. Also known as direct fixation fasteners or DF fasteners.

X. Rail Joints: A fastening designed to unite the abutting ends of contiguous rails.

Y. Rail Joint, Insulated: A rail joint designed to arrest the flow of electric current from rail to rail by means of insulation so placed as to separate the rail ends and other metal parts connecting them. Commonly called insulated joints or "IJ's".

Z. Restraining Rail: A guard rail installed parallel to, concentric with, and on the gauge side of the inside running rail of curved track with a flangeway of approximately 2-1/8 inches. It extends into the tangent track on each end of the curve, bears against the back side of the wheels, and steers the inside wheels of each truck around the curve, thereby reducing the degree of contact of the leading outside wheel flange with the outside rail. It also reduces gauge wear on the outside running rail.

AA. Roadbed: The foundation (prepared subgrade) on which the track structure consisting typically of sub-ballast and ballast is placed.

BB. Special Trackwork: A generic term referring to turnouts, single and double crossovers, track crossings, and other such items.

CC. Standard Rail: A synonymous term to 115 RE rail.

DD. Stock Rail: A running rail against which a switch rail bears in a turnout.

EE. Stub-up: A conduit temporarily terminated in the roadbed for later use by signal, communication, or traction power installers.

FF. Sub-Ballast: A material which provides a semi-impervious layer between the finished subgrade of the roadbed and the ballast, to provide better drainage, prevent upheaval by frost, and better distribute the load over the roadbed.

GG. Subgrade: The finished surface of the roadbed below the level of sub-ballast or track slab.

HH. Superelevation: The vertical distance of the outer rail of a curve above the inner rail. It is provided to overcome or partially overcome the effects of curvature and speed.

II. Switch, Point of: The tip of the tapered end of a switch rail; the end of a switch rail farthest from the frog or heel block.
JJ. Switch Point, Undercut: A switch point planed to mate with a stock rail having a planed undercut, in order to provide an effective point width of zero.

KK. Switch Rail (Switch Point): A planed, tapered, movable rail which mates with a stock rail to enable movement of a train from one track to another.

LL. Switch, Split: The common type of track switch consisting essentially of two planed, movable switch rails.

MM. Top of Rail (T/R): The top surface of the head of the running rail.

NN. Track, Ballasted: Track constructed of rails, cross ties, and ballast. It is the predominant form of track constructed at-grade, but it is also used on short bridges.

OO. Track, Direct Fixation: Track constructed of rail and rail fasteners attached by means of anchor bolts to concrete, located in tunnels, cut and cover structures, aerial structures, and slab track.

PP. Track, Embedded (Paved): Track constructed on a track slab and, except for the flangeways, embedded in asphalt, concrete, paving blocks, rubber epoxy, or other such material to the elevation of the top of rail.

QQ. Track, Gauge: The distance between the inside faces of running rails at right angles measured at a point 5/8 inch below the top of rail. Standard gauge: 4 feet 8-1/2 inches.

RR. Track, Mainline: A track designated by route name and direction, and which is for the purpose of carrying revenue passengers.

SS. Track, Secondary and Yard: Track constructed for the purpose of switching, storing, or maintaining rail vehicles or connecting such tracks to mainline tracks.

TT. Trackway: The foundation on which the track is constructed. It usually consists of an earthen roadbed, but it may also be one of the following: a concrete roadbed for support of direct fixation track or paved track; a ballasted bridge deck (designed to receive ballast); or an aerial structure.

UU. Turnout: An arrangement of a switch and a frog with stock rails and closure rails, enabling rail vehicles to be diverted from one track to another.

VV. Turnout Number: The number corresponding to the number of the frog used in the turnout.

WW. Zero Thermal Stress: The state of uniform stress in CWR, while the rail is unrestrained and free to move longitudinally.

XX. For additional definitions, refer to AREMA Manual and Portfolio of Trackwork Plans.

1.4 SUBMITTALS

A. Shop Drawings, include the following:

1. Complete details for distributing CWR, including a rail schedule showing:
   a. Designation of line and profile rails.
   b. Layout of CWR strings by lengths.
   c. Location of proposed field cuts and field welds in CWR on the rail schedule. Include locations of factory insulated joint plugs and any insulated joints fabricated in the field.

2. Complete details of the proposed methods, including equipment, of laying and fastening CWR. Include method and equipment proposed for achieving zero thermal stress.

3. Description of temperature adjustment and final anchoring procedures for CWR, including charts, tables, and field instructions on heating, cooling and stretching.

4. Charts shall be provided that indicate gaps for varying lengths of rail and varying rail temperatures.

B. Procedures: Provide complete details of the end-hardening procedures, including identification of personnel to perform the procedure, the equipment, and the test results required no less than 30 days prior to initiating any end-hardening.

C. Equipment to be used on Roadbed: Submit weights and dimensions of equipment proposed for use on roadbed prior to employing it on roadbed.

D. Rail Mounted or Hi-Rail Construction Equipment: Submit a complete list of equipment for use during trackwork construction, within 30 days after receipt of the Notice to Proceed. Include rail-mounted geometry inspection vehicle.

1. Equipment to be utilized shall not exceed design clearance envelope and loading criteria for the Light Rail System.
2. Submit a complete description of all proposed modified equipment, including calculations verifying that loading criteria for the light rail system will not be exceeded.

3. Certify that the equipment modifications will clear all structures and other facilities at the areas where the equipment will be used.

4. Certify rail wheels are in good condition, without excessive wear. Damage to frogs, crossing panels, etc. shall be repaired or replaced as determined by the Contracting Officer.

E. Product Data: Submit manufacturer’s data for Contractor-furnished material including non-woven filter fabric and adhesive for bonding tags to concrete. Submit installation information and sufficient description to verify that materials comply with the specifications. Include specification data and manufacturer’s installation instructions for non-woven filter fabric.

F. Samples: Submit sample for non-woven filter fabric.

G. Test Reports: Submit summaries of test results each week for field weld tests, Brinnell Hardness Tests, insulated joint continuity tests, track geometry vehicle measurements, and any other periodic testing required by Contract. If there was no activity during the week, submit each summary noting no activity.

H. Rail Laying Record: Submit records in accordance with Article 3.10D. herein.

1.5 QUALITY ASSURANCE

A. Comply with:

1. Codes and regulations of the jurisdictional authority.

2. APTA Guidelines.


1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Contractor-Furnished Material: Supply track construction material indicated in the Contract Documents.

B. Authority-Furnished Material:

1. In accordance with Section 01640, “Authority-Furnished Materials and Equipment”.

2. Load, store, and distribute continuous welded rail, crossties, and other Authority-furnished track material in a manner and with equipment which will prevent bumping and striking of the rail. Notify the Contracting Officer immediately, and in writing, of any damage discovered at the time of loading. Damage discovered after the materials are transported to the work site shall be repaired by the Contractor at no cost to the Authority.

3. Authority-furnished material shall not be used for temporary fixtures, jigs, templates or any other purpose other than their intended application in the final trackwork product.

1.7 MONUMENTATION AND SURVEYING

A. Monuments will be provided by the Authority to establish the centerlines of tracks as specified in Section 01722, “Field Engineering - Surveying”.

B. The Contractor shall set monuments at all points as shown on the Contract Drawings.

C. The Contracting Officer will furnish the Contractor with identifications and elevations to 1/1000 of a foot for all existing baseline monuments in accordance with Section 01722, “Field Engineering - Surveying”.

D. Do not use controls for surveys other than the monumentation described above unless otherwise approved by the Contracting Officer.

E. Perform surveying required herein in accordance with Section 01722, “Field Engineering - Surveying”. Assume full responsibility for all dimensions and elevations taken and the setting of lines and grades relating thereto.

1.8 CONSTRUCTION EQUIPMENT

A. No excess load is permissible for ballast cars, tie cars, or the rail train, and all equipment loads shall conform to the loading requirements as specified in the “DART Design Criteria Manual, Volume I, Facilities Design” on Figure 9.2.

B. Oversize Equipment: Operate equipment only on parts of the system where clearances have been checked for the equipment, with the following restrictions:

1. Past station platforms: Stop clear of platforms, check clearances, then proceed at 10 mph or less prepared to stop.
2. Under overpasses: Stop clear of structure, check clearance, then proceed at 10 mph or less prepared to stop.

3. Tangents: Speed restricted to avoid excessive rocking.

4. Curves:
   a. Track not at final alignment and superelevation: Proceed at speed of 10 mph or less prepared to stop.
   b. Track at final alignment and superelevation: Speed controlled to avoid excessive lean or rocking.

C. Equipment Condition:
   1. Operate only equipment on the roadbed which is in good state of repair and with all safety appliances and protective devices in place and functioning.
   2. Brakes shall be capable of stopping and holding equipment on 6 percent grades. The Contracting Officer may require braking demonstrations at any time, in any weather condition, and with any allowable load, to verify the safe operation of the equipment.
   3. Rail-mounted equipment shall be provided with brakes, including trailers and push carts. Semi-permanently coupled units may be treated as a single braking system.
   4. Rail-mounted equipment shall be provided with mechanical devices to permit the equipment to be securely anchored to the rails while unattended.
   5. Rail wheels with flat spots whose length exceeds 8 percent of the wheel diameter are prohibited. Equipment with a wheel having a flat spot exceeding 5 percent of the wheel diameter is restricted to a maximum speed of 10 mph on aerial structures and ballasted deck bridges. Remove equipment with a wheel which develops a flat spot whose length exceeds 8 percent of the wheel diameter.

1.9 STRUCTURAL WEIGHT LIMITS AND CLEARANCES

A. For the purposes of this Article, structure shall be understood to mean any constructed element within the completed roadbed which may interfere with or obstruct the track construction, including bridges or aerial structures, station platforms or foundations, road crossing headers, manholes, foundations, and conduit terminations (stub-ups).

B. Roadbed Structural Capacity:
   1. Aerial structures, ballasted deck bridges, culverts, and other structures under the roadbed are designed to support train loads applied through the track structure only, unless otherwise shown.
   2. If any construction vehicles are to be moved across bridge structures, the Contractor shall submit calculations signed and sealed by a registered Professional Engineer in the State of Texas to indicate the developed stresses do not exceed those of the equivalent train load.

PART 2 - PRODUCTS

2.1 METAL TAGS

   A. Provide aluminum or brass identification tags stamped in 1/4 inch increments from zero superelevation to maximum superelevation to mark the superelevation on curved track. These tags shall be 1-1/4 inches wide by 2 inches long by 0.050 inch thick, and stamped with numerals 1/2 inch high.

   B. Adhesive for Bonding Tags to Concrete: As proposed by the Contractor and approved by the Contracting Officer.

2.2 RAIL

   A. Tee-rail: 115 RE section either standard or premium rail in accordance with the requirements of AREMA "Specifications for Steel Rails" and as specified.

2.3 TIES

   A. Main line, special trackwork, yard track and pocket track construction shall consist of concrete crossties, unless otherwise shown on plans or in the Special Provisions.

   B. Concrete crossties: 8 feet 3 inches in length unless specified elsewhere conforming to AREMA “Specifications for Concrete Ties”. Concrete ties shall be prestressed monoblock concrete. Type to be used shall be shown on the Contract Drawings.

   C. Concrete switch ties of varying lengths conforming to AREMA “Specifications for Concrete”. Concrete ties shall be prestressed monoblock concrete. Type used shall be as shown on Contract Drawings.

   D. Concrete ties for at-grade road crossings shall be 10 feet in length conforming to AREMA “Specifications for Concrete".
2.4 NON-WOVEN FILTER FABRIC (GEOTEXTILE)

A. Shall adhere to the following requirements:

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<th>TEST PROCEDURES</th>
<th>MINIMUM ALLOWABLE VALUES</th>
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<td>Elongation, percent</td>
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<td>Trapezoidal Tear, lbs.</td>
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<tr>
<td>Thickness, mils</td>
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</table>

3.3 ALIGNMENT

A. Alignment consists of a series of straight lengths of track referred to as tangents, connected by simple, compound or reverse curves, with or without spirals.

B. The track shall be constructed to the alignment and profile indicated on the plans, within the tolerances specified in Table 02450-1.

C. Use outer rails of curves as the line rail. Either rail may be used as the line rail in tangent; however, use that same rail for the full length of that tangential segment of track.

D. The ends of the chord to be at points on the gauge side of the line rail 5/8 inch below the top of the rail head.

E. In addition to the requirements specified:

1. Place the track in good alignment before the finishing lift is made.

2. Follow immediately behind the finishing lift with a mechanical means of lining the track and line to accurate alignment. Typically line and surface in the same operation, but the finishing lift may include adjustments to “accurate alignment”.

PART 3 - EXECUTION

3.1 NON-WOVEN FILTER FABRIC

A. Use non-woven material for subgrade stabilization at locations indicted on the Contract Drawings.

B. Install fabric in accordance with manufacturer’s installation instructions.

3.2 GAUGE

A. Measure the track gauge between points 5/8 inch below the top, perpendicular to and from inside face to inside face of the running rails.

B. Tangent and curved track gauge: 4 feet 8-1/2 inches.

C. Special trackwork track gauge: 4 feet 8-1/2 inches.

D. Allowable gauge variation:

1. Ballasted mainline track: plus or minus 1/8 inch.

2. Direct fixation mainline track: plus or minus 1/8 inch.

3. Paved mainline track: plus or minus 1/8 inch.

3.3 ALIGNMENT

A. Alignment consists of a series of straight lengths of track referred to as tangents, connected by simple, compound or reverse curves, with or without spirals.

B. The track shall be constructed to the alignment and profile indicated on the plans, within the tolerances specified in Table 02450-1.

C. Use outer rails of curves as the line rail. Either rail may be used as the line rail in tangent; however, use that same rail for the full length of that tangential segment of track.

D. The ends of the chord to be at points on the gauge side of the line rail 5/8 inch below the top of the rail head.

E. In addition to the requirements specified:

1. Place the track in good alignment before the finishing lift is made.

2. Follow immediately behind the finishing lift with a mechanical means of lining the track and line to accurate alignment. Typically line and surface in the same operation, but the finishing lift may include adjustments to “accurate alignment”.

3.4 SURVEYING REQUIREMENTS

A. Refer to Section 01722, “Field Engineering - Surveying”.

B. Verify layout information shown in relation to the existing Authority-provided monuments and existing structures before proceeding with layout of the actual work. As the work proceeds, check every major element of work for line. Bring discrepancies in location of structures to the attention of the Contracting Officer before starting trackwork. Maintain an accurate surveyor’s field book of such checks; make available for the Contracting Officer’s reference. Record deviations which are accepted by the Contracting Officer on the Record Drawings.

C. Verify the actual grade line and the profile of the top of the sub-ballast. Variations from the design grade line and profile of less than plus or minus 1 inch shall be compensated for by the quantity of ballast or the thickness of concrete slab. Variations more than plus or minus 1 inch shall be reported to the Contracting Officer for direction. If no variations greater than plus or minus 1 inch are discovered, report the acceptance of the grade to the Contracting Officer, in writing.
D. Furnish and place markers for the control points and reference points of the track centerlines, as indicated. Stake centerlines at station platforms, grade crossings, and bridge structures for inspection by the Contracting Officer.

E. As required under Section 01722, furnish the Contracting Officer with a plan sheet showing the horizontal distance, azimuth, and angle from the control points indicated to the references indicated.

F. Maintain control points and reference points for the duration of the project.

3.5 SUPERELEVATION, SPIRALS, AND CURVATURE

A. Superelevation:

1. Superelevate mainline track curves as indicated.

2. Maintain superelevation uniformly over the length of curve or as otherwise shown.

3. Superelevate the outer rail above the inner rail; install the inner rail at the required profile indicated.

B. Spirals: Establish the superelevation at the point of tangency at zero and increase the superelevation uniformly through the length of the spiral to full elevation of the outer rail at the spiral-to-curve point. Install the spiral at the ends of simple curves and segments of compound curves as indicated.

C. Curvature: Curve information shall be as shown. Shop fabricated rail shall be marked by the manufacturer for installation.

3.6 TRACK SURFACE

A. Track surface is the relationship of opposite rails to each other in profile and crosstree:

1. Track profile is the running surface along the top of the grade rail.

2. The ideal surface is a uniform profile consisting of straight gradients connected by vertical curves, with zero crosstree on tangents, and predetermined crosstree on curves.

3. Do not raise the profile of track being surfaced above established grades.

4. When surfacing or raising track, select one rail, usually the lower rail on curves and the line rail on tangents, as the grade rail. Bring the other rail to surface by adjusting the crosstree as needed.

3.7 RAIL

A. Follow track charts in determining exact location and lengths of premium and standard rail.

3.8 CUTTING AND DRILLING RAIL

A. Use only the following tools for cutting rail:

1. Rail saw.

2. Abrasive cutting wheels.

B. Drill holes:

1. When necessary, drill new holes; do not punch, slot, or burn with a torch.

2. Drill holes 1-1/8 inch in diameter; locate as indicated.

3. Drill with the joint bars removed or before their application. Mark the location of the center of the hole, or drill through an approved template. Do not drill bolt holes using the joint bars as a template.

4. When bolt holes are drilled with a power track drill, maintain a uniform feeding pressure. Reduce pressure as the bit point breaks through the opposite side of the web. Do not force the drill.

5. Remove all rough edges from drilled rail holes.

6. Do not leave bolt holes in the ends of rail to be welded.

7. Reaming or enlarging incorrectly drilled holes to allow joint bar bolts to be installed will not be permitted. Rejected holes shall be sawcut from the rail.

8. Torch cuts or blown holes will not be acceptable.

9. Rail strings have handling holes. These holes shall be cropped before welding.

3.9 RAIL JOINTS

A. Either weld or bond rail joints as indicated.

B. Field weld rails in accordance with Section 02458, "Field Rail Welding".
C. Install bonded joints where indicated in accordance with the requirements of this section and Section 02457, "Bonded Joints".

D. Install joints in track that is in final horizontal and vertical alignment with ballast tamping completed.

3.10 LAYING CONTINUOUS WELDED RAIL

A. Unload and lay CWR in a place and in a manner that prevents damage to the ties, rails, and structures.

B. Lay opposite CWR strings in a manner which results in a 10 foot minimum stagger of welds.

C. Make every effort to minimize or eliminate field cuts and field welds in CWR. Designate location in finished track by route name, stations of ends of rail string, and right or left rail as determined by facing in the direction of increasing stationing. Place all rail numbers on the same side of the CWR string.

D. Record the following information at the time of laying the rails on the crossties or DF plinth and again at the time of anchoring CWR. Furnish copies of this documentation to the Contracting Officer.

1. Location by station, track designation, and rail.
2. Date and time.
3. Rail weight and section, mill brand, year rolled, and the heat number of the end rails in each CWR string.
4. Length of CWR string in feet.
5. The following temperatures, at the beginning of the activity and again at the end of the activity:
   a. Ambient temperature.
   b. Rail temperature.
6. Approximate weather conditions.
7. Adjustment applied (type and rail end movement).

E. Between the time of laying the rail (placement on the ties) and anchoring the rail, the Contractor shall monitor rail temperatures and adjust each Dutchman as required to avoid rail buckling or rail end batter

3.11 RAIL TEMPERATURE


1. Place rail thermometers on the shaded side of the rail base next to the web and leave in place until no change in its reading is detected, but not less than five minutes.
2. Take rail temperature at the time of adjusting the gap between rail ends.

3.12 RAIL GAP

A. During rail laying below the indicated zero thermal stress temperature, determine the required gap between CWR strings and between CWR and bolted rail by using the equation:

$$ G = (t - T) L K + Q $$

Where:

G = Required rail gap (inches).

[t] = Specified anchoring temperature in degrees F for type of track construction.

T = Actual rail temperature at time of laying in degrees F.

L = Length of rail in feet (one-half of the sum of lengths of the CWR string being laid and the preceding CWR string).

K = Coefficient of thermal expansion for rail steel (0.000078 inch per foot per deg. F).

Q = Rail gap as required by manufacturers of field weld kit in inches. For bolted standard joints, Q equals 0.125 inch, and for bonded insulated joints, Q equals the end post thickness.

3.13 DUTCHMAN

A. Insert a Dutchman after the rail has been laid, equal in length to G minus 1/2 inch where G is determined by the formula above, to prevent damage to the rail ends during rail laying, ballasting, and other operations requiring passage of on-track equipment over the rail joints.

B. Do not insert a Dutchman if the calculated rail gap G is less than 1-1/2 inches.

C. Remove the Dutchman prior to anchoring or when an increase of temperature results in a calculated closure of the rail gap.
D. Rail end batter in excess of 1/16" shall be removed by cutting out at least 19 feet of rail at the joint, replacing the joint with a plug rail, and field welding both ends. End batter repair by welding is not acceptable.

3.14 TEMPORARY FASTENING

A. Temporarily fasten track for use of on-track equipment.

B. Prior to equipment being placed on newly laid rail, secure the rail in a manner that will prevent damage to the CWR, rail fasteners, and other track materials.

C. Move equipment over newly laid rail in such a manner as to prevent damage to trackwork materials.

D. Temporarily fasten newly laid rail on ballasted track at not less than:
   1. Every third tie on tangents and on curves having a radius greater than 1,900 feet.
   2. Every other tie on curves having a radius of 1,900 feet or less.

E. Do not field weld or bond between contiguous CWR strings and between CWR strings and special trackwork units before the rail has been brought to final vertical and horizontal alignment, before the rail has been adjusted to the indicated zero thermal stress range, and before the rail has been fully fastened.

3.15 PERMANENT RAIL FASTENING

A. Adjust the CWR string lengths for the specified zero thermal stress temperature:
   1. Adjust rail on DF bridges before adjusting ballasted track approaches. Anchor 300 track feet on each side at the temperature specified for DF track. When adjusting the approaches, unclip the 300 ballasted track feet up to the structure and adjust the ballasted track string to the appropriate temperature for ballasted track.
   2. When closing on a fully anchored string, remove 300 feet of existing rail clips, readjust the existing string for temperature and refasten before executing the field weld.
   3. Fasten the CWR strings in a manner which ensures that there is no unfastened portion of rail greater than 100 feet in length between fastened portions of the same string.

B. Vibrate the rail to relieve internal rail stresses and fully fasten the string. Record movement at quarter points and submit to the Contracting Officer daily.
   1. Use vibrators, approved by the Contracting Officer, to relieve internal rail stresses.
   2. Do not strike CWR with objects which might damage the rail surface.

C. Temperature of a rail, when being fastened opposite a previously fastened rail, shall be within 5 degrees F of the previously fastened rail's temperature at the time of its fastening.

D. Once the rail has been adjusted to achieve zero thermal stress at the specified temperature, maintain the correct rail gap until the rail is fully fastened.

3.16 ZERO THERMAL STRESS

A. Zero thermal stress at the specified temperature in CWR may be achieved by heating, cooling, or pulling the rails, or a combination thereof. When zero thermal stress at the specified temperature is obtained, begin fastening immediately.

B. Maintain the stress within the rail to achieve the specified zero thermal stress range during installation of joints.

3.17 FIELD WELDING

A. Perform field welds in accordance with the requirements of Section 02458, "Field Rail Welding".

B. Join CWR strings in the field by the field welding process unless otherwise indicated to be joined in the field by bonded standard joints. The location of bonded standard joints is shown on the Contract Drawings.
C. Do not locate a field weld within the following locations:

1. Within 10 feet of any weld in the opposite rail.
2. Within 19 feet of a field weld in the same rail.
3. Within 19 feet from the center of a bonded standard joint.
4. Within 8 feet of a shop weld in the same rail.
5. Within 6 inches of a tie.
6. Within 8 feet of each end of a road crossing.

D. Weld Gap:

1. At the time of field welding, providing the proper rail temperature as indicated is present, establish the rail gap recommended by the manufacturer of the weld kit.
2. Should the rail gap on fastened CWR be larger than the weld manufacturer's recommended gap after the CWR strings have been readjusted for zero thermal stress, saw a length of rail from one end of one of the fastened CWR and insert a rail not less than 19 feet long to provide the recommended gaps for field welding.
3. At a location where the rail gap is smaller than the manufacturer's recommended gap, obtain the recommended gap by sawing a piece from one rail.

E. Repair of field welds will not be permitted. Excessive grinding, dipped or peaked welds, and shear tears shall be cut out and replaced with a plug rail not less than 19 feet long. The replacement of the rail and the two additional field welds shall be at no expense to the Authority.

3.18 RAIL END-HARDENING

A. End-harden standard rail ends in the field at all bonded joints. Remove joint bars from rail ends during the end-hardening process.

3.19 END-HARDENING TESTS

A. Personnel to perform end-hardening shall prepare two sample rails in accordance with the AREMA Manual.

1. Test the two samples through an independent laboratory approved by the Authority and submit the test results to the Contracting Officer.
2. Acceptance of the end-hardening procedure and personnel will depend on the samples passing the tests specified below.

B. Two samples of end-hardened rail shall be tested for Brinell hardness in accordance with ASTM E10 in a grid pattern of 1/4-inch increments for a distance of 6 inches from the end of the rail.

C. Record the Brinell hardness numbers and locations.

D. After the hardness test has been performed, section one sample longitudinally for 1 foot along the centerline of rail. The other sample shall be sectioned transversely 1/2 inch from the end of the rail. Etch both cross sections to facilitate the observation of the hardness pattern.

E. Attain a Brinell hardness number not less than 341 nor more than 401 when measured at a point on the centerline of rail 1/2" from the rail end. The decrease in hardness shall occur uniformly over a distance not less than two inches. The hardness pattern shall be uniform across the top surface of the rail head. Examine the etched cross sections of the rail to ensure that a uniformly distributed hardness pattern is evident. End hardening shall be performed only by personnel and with procedures which have been accepted in accordance with the above procedure.

3.20 RAIL BEVEL

A. Bevel rail ends at bonded joints in accordance with AREMA Standard Plan Basic Number 1005.

3.21 RAIL GRINDING

A. Upon completion of the track by the Contractor to the specified tolerances and after acceptance, rail grinding will be done by the Authority.

3.22 FINAL ALIGNMENT AND TRACK INSPECTION

A. Survey the track in accordance with Section 01722, "Field Engineering - Surveying", to determine if the horizontal and vertical alignment, gauge, crosslevel, and superelevation are within the tolerances specified for each type of track construction.

B. Make a complete inspection of the track using a rail-mounted geometry inspection vehicle approved by the Authority. Geometry test shall meet FRA Class 4 Standards.

C. Correct track deviations which exceed tolerances.
D. The track geometry vehicle shall record the following measurements in a single pass.
   1. Track gauge.
   2. Right rail surface (profile).
   3. Left rail surface (profile).
   4. Right rail alignment.
   5. Left rail alignment.

E. Track Geometry Vehicle Measured Results.
   1. All measurements shall be displayed on the same chart, in a linear format, for a length of track, 5000 feet to 6000 feet per page. Charts shall be calibrated to read in construction survey stationing.
   2. Each measure shall be shown on a separate line with graduations at 0.25 in/div for all measurements except gauge, which shall be shown at 0.12 in/div.

3.23 ELECTRICAL TESTS

A. Track-to-earth resistance tests will be performed by the Authority’s corrosion engineer.

   1. Testing will be conducted by the Authority’s corrosion engineer as track construction progresses to ensure proper rail isolation is being achieved during construction.

   2. The Contractor shall notify the Contracting Officer when corrosion testing can be conducted in order to avoid construction conflicts. A minimum of three days notice is required. Testing time required is to be estimated at one day per 1000 feet of track.

   3. Testing will also be required after trackwork installation is completed (final acceptance for trackwork construction prior to signal and traction power rail connections) and after all signaling and traction power components/wiring are installed (final acceptance for signaling and traction power installations).

B. Contractor shall correct Contractor installations that fail the track-to-earth resistance tests, during construction testing or final acceptance testing. Following completion of these corrective measures, Contractor shall notify the Contracting Officer as specified herein for testing and the installations will be re-tested. All corrective measures shall be completed at the expense of the Contractor.

C. Final acceptance testing of track to earth resistance will be performed by DART Corrosion Engineer.

D. Acceptance criteria: Track-to-earth resistance shall not be less than:
   2. Grade Crossings: 300 ohms per 1000 linear feet after installation of panels.
   3. Embedded track: 150 ohms per 1000 linear feet.

E. Typical track construction will normally yield resistance values from 10 to 100 times greater than the acceptance criteria. Ballast dust, sandblasting residue, welding debris, grinding particles, and other debris may significantly reduce the resistance.

3.24 PRECURVED RAIL

A. Install fabricated precurved rail as shown and in accordance with the approved manufacturer’s fabrication drawings.

B. Mark precurved radius and installation location.

3.25 RESTRAINING RAIL

A. Install fabricated restraining rail as shown and in accordance with the approved manufacturer’s fabrication drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will not be measured separately for payment, but all costs in connection therewith will be considered incidental to track construction measured elsewhere.

4.2 PAYMENT

A. The work specified in this section will not be measured or paid for directly, but the cost shall be allowed for in the cost of track construction and other related items of the Work.
### TABLE 02450-1

**TRACK CONSTRUCTION TOLERANCES**

<table>
<thead>
<tr>
<th>Class and Type of Track</th>
<th>Gauge Variation</th>
<th>Cross Level and Superelevation Variation</th>
<th>Vertical Track Alignment</th>
<th>Horizontal Track Alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total Deviation</td>
<td>Middle Ordinate In 62' Chord</td>
</tr>
<tr>
<td>Direct Fixation and Paved Track</td>
<td>+1/8&quot; - 1/16&quot;</td>
<td>± 1/8&quot;</td>
<td>± 1/4&quot;</td>
<td>± 1/8&quot;</td>
</tr>
<tr>
<td>Mainline Ballasted Track</td>
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<td>± 1/8&quot;</td>
<td>± 1/2&quot;</td>
<td>± 1/8&quot;</td>
</tr>
<tr>
<td>Yard Ballasted Track</td>
<td>+3/16&quot; - 1/8&quot;</td>
<td>± 3/16&quot;</td>
<td>± 3/8&quot;</td>
<td>± 1/4&quot;</td>
</tr>
<tr>
<td>Shop Track</td>
<td>± 1/8&quot;</td>
<td>± 1/8&quot;</td>
<td>± 1/4&quot;</td>
<td>± 1/8&quot;</td>
</tr>
</tbody>
</table>

**Notes:**

1. Total deviation is measured between the theoretical and actual alignment centerline at any point in the track.
2. Total horizontal and vertical deviation in road crossings ± 1/4".
3. In the Station Platform areas: Total Horizontal deviation shall be 0° towards Platform and 1/8" away from platform; Total Vertical deviation shall be 0° above Platform and 1/8" below platform.

END OF SECTION 02450
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing, placing, and compacting sub-ballast on prepared subgrade ("roadbed"). Work to be performed in accordance with Texas DOT Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges, Item 247 unless otherwise noted.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate


3. ASTM C127 - Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate


B. Texas Department of Transportation (TxDOT):

1. TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges (TxDOT Standard Specifications)
   a. Item 247 – Flexible Base

2. TxDOT Manual of Testing Procedures (TEX)
   a. TEX-113-E - Laboratory Compaction Characteristics and Moisture-Density Relationship of Base Materials
   b. TEX-115-E - Field Method of Determining In-Place Density of Soils and Base Materials

c. TEX-140-E - Measuring Thickness of Pavement Layer

1.3 SUBMITTALS

A. Qualification: Submit source of supply sufficiently in advance to obtain approval not less than 30 days prior to anticipated date of commencing installation.

B. Certification:

1. Prior to installation, provide the Contracting Officer with certified test results of sub-ballast quality and grading as conducted by an approved testing laboratory.

2. Provide additional certified test results if, during ballast installation, and with approval, the supplier changes the source of sub-ballast.

3. In any case the test results shall not be older than 6 months from the certification date.

1.4 QUALITY ASSURANCE

A. Source of Materials:

1. Obtain approval of sub-ballast and the source of supply and production prior to commencing installation.

2. Do not change material or source of supply without approval.

B. Inspection:

1. Visually inspect material delivered to the worksite. Stop delivery of material which does not appear to meet the specification pending sampling and testing.

2. If material loaded, being loaded, or installed, does not conform to specified requirements, the Contractor shall reject the material and no further delivery shall be accepted until the deficiency is corrected.

3. The Contracting Officer may reject material at the Worksite based on visual inspection. Rejected materials will be stockpiled and not used in the work pending sampling and testing.
PART 2 - PRODUCTS

2.1 SUB-BALLAST

A. Provide crushed stone, with the following requirements:

1. Gradation: ASTM C136 and C117 or in accordance with TxDOT Standard Specifications, Item 247, Type A, Grade 1 with the following additional requirements and exceptions:

   a. Sieve Size Retained By Weight
      1-3/4 inches 0
      7/8 inch 10 to 35
      3/8 inch 30 to 50
      No. 4 45 to 65
      No. 40 70 to 85

   b. Maximum liquid limit: 35.


2. Clay lumps and friable particles: ASTM C142, 0.5 percent maximum.

3. Wear: ASTM C131, 40 percent maximum.

4. Absorption: ASTM C127, 0.5 percent maximum.

5. Soundness: ASTM C88, weighted average loss 15 percent maximum after five cycles of sodium sulfate tests.

6. Use of limestone, slag or crushed concrete is not allowed.

PART 3 - EXECUTION

3.1 PLACING MATERIAL

A. Do not place material on subgrade that is muddy, rutted, or frozen or has standing water.

B. Prior to placing materials, prepare subgrade in accordance with Section 02220, "Grading, Excavating, and Backfilling".

C. Place material to provide uniformity of grading throughout work.

D. If subgrade is dusty, sprinkle with water prior to placing sub-ballast.

E. Install, shape, and compact sub-ballast to the depth shown.

1. Where compacted thickness is 6 inches or less, place sub-ballast in one layer.

2. Where compacted thickness is more than 6 inches, place material in two or more layers of equal thickness of not more than 6 inches each.

3.2 COMPACTION

A. During placing and compacting, maintain moisture content within specified tolerance, in this section.

B. Compact material for its full depth to 97 percent of maximum dry density within two percent of optimum moisture content, per TEX-115-E and TEX-113-E.

3.3 FIELD QUALITY CONTROL

A. Allowable Tolerances:

   1. Construct sub-ballast to the following tolerances:

      a. Vertical: Within plus or minus 1/2 inch of elevation shown. Deviation not to exceed 1/4 inch in 16 feet.

      b. Horizontal: Within plus 3 inch minus 1 inch of the limits shown.

      c. Thickness: Minus 1/2 inch (TEX-140-E).

   2. During compaction, maintain moisture content within two percent of optimum moisture content.

B. Test Methods:

   1. Determine optimum moisture content and maximum dry density in accordance with TEX-113-E.

   2. Perform a minimum of one density test for every 200 linear feet of route on the sub-ballast in accordance with TEX-115-E, Part 2.

   3. Perform depth check for every 4,000 SY of the sub-ballast in accordance with TxDOT Item 247.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be not be measured, but will be paid for at the lump price for "sub-ballast", complete-in-place.

END OF SECTION 02451
SECTION 02453
TRACK BALLAST

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing ballast to be installed under the work of other sections.

1.2 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
   3. ASTM C127 - Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate

1.3 SUBMITTALS
A. Qualification: Submit source of supply sufficiently in advance to obtain approval not less than 30 calendar days prior to anticipated date of commencing installation.

B. Certification:
   1. Prior to installation, provide the Contracting Officer with certified test results of ballast quality and grading as conducted by an approved testing laboratory.

   2. Provide additional certified test results if, during ballast installation, and with approval, the supplier changes the source of ballast.

   C. Gradation Results: Provide certified copies of gradation belt samples results taken each day the ballast is produced. Submit a tabulation of gradation results each month, including the average percent passing for each gradation for the period.

1.4 QUALITY ASSURANCE
A. Comply with:
   1. Codes and regulations of the jurisdictional authority.
   2. AREMA Manual.

B. Source of Materials:
   1. Obtain approval of ballast prior to commencing installation.
   2. Do not change material or source of supply without approval.
   3. Take samples at the locations designated by the Contracting Officer.

PART 2 - PRODUCTS

2.1 BALLAST
A. Furnish crushed stone composed of hard, strong, durable particles free from injurious amounts of deleterious substance and with the following additional requirements:
   1. Use of limestone, slag, or any material containing metallic ore or metallic residues is prohibited.

   2. Gradation: ASTM C136 and C117 with the following additional requirements:
      a. Mainline track: AREMA Size 4A.
      c. Gradation shall comply with the following:

      Percent Passing by Weight
### Sieve Size

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>AREMA Size 4 A</th>
<th>AREMA Size 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1/2 inches</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>2 inches</td>
<td>90-100</td>
<td>-</td>
</tr>
<tr>
<td>1-1/2 inches</td>
<td>60-90</td>
<td>100</td>
</tr>
<tr>
<td>1 inch</td>
<td>10-35</td>
<td>90-100</td>
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<td>3/4 inch</td>
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<tr>
<td>3/8 inch</td>
<td>0-3</td>
<td>0-15</td>
</tr>
<tr>
<td>No. 4</td>
<td>-</td>
<td>0-5</td>
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</tbody>
</table>

### PART 3 - EXECUTION

#### 3.1 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Handle ballast during all stages of manufacture and supply in a manner that ensures a uniform product.

B. Handle and transport ballast at all times in a manner and with equipment that prevents segregation and contamination by mud or any other deleterious material.

C. Do not allow ballast to fall from a height in a manner that the larger particles are thrown beyond the smaller particles. When placing ballast in a bin, drop the material vertically over the center of the bin.

#### 3.2 STOCKPILING

A. Stockpile ballast on level, well-drained sites free of all foreign materials and of adequate bearing capacity to support the weight of the materials to be placed thereon.

B. Except where stockpiled on concrete or asphaltic concrete foundations or on otherwise acceptably stabilized areas, provide a stockpile base approved by the Authority.

C. Build stockpiles in layers not to exceed three feet in depth, for each layer, completing each layer over the entire area of the stockpile before beginning the next layer. Uniformly spot-dump aggregates delivered to the stockpile in trucks. Coning of the piles or spilling of material over the edges of the pile is prohibited.

#### 3.3 DEFECTIVE MATERIALS

A. Unless otherwise permitted by the Contracting Officer, remove rejected materials from the Worksite within 48 hours of rejection.

#### 3.4 FIELD QUALITY CONTROL

A. Inspection:

1. The Contracting Officer has the right to stop delivery of material to the Worksite based upon visual inspection pending sampling and testing, in accordance with the General Provisions, "SUSPENSION OF WORK".

2. The Contractor shall reject any ballast which arrives at the Worksite for unloading that does not conform to the specified requirements.
3. Take two samples of the delivered ballast product from each 4000 tons of delivered ballast. Each sample shall be representative and weigh not less than 100 pounds. Test for conformance with the specifications.

4. If material delivered does not conform to specified requirements, the Contracting Officer may reject the material and no further delivery will be accepted until the deficiency is corrected. Non-conforming material will be removed and replaced.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will not be measured or paid for separately, but costs in connection therewith will be considered incidental to Section 02459, “Special Trackwork” and Section 02460, “Ballasted Track Construction” and related items of work.

END OF SECTION 02453
SECTION 02455
TRACK APPURTENANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing, fabricating, and installing track appurtenances as shown on Contract Drawings.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A490 - Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength
   3. ASTM D257 - Standard Test Methods for DC Resistance or Conductance of Insulating Materials

C. National Electric Manufacturing Association (NEMA):
   1. NEMA LI1 - Industrial Laminating Thermosetting Products

1.3 SUBMITTALS

A. Shop Drawings.
B. Product Data: Ballast mats.
C. Installation Procedures.
D. Certification:
   1. Tests certified by an approved testing laboratory.
   2. Manufacturer's certification.

1.4 QUALITY ASSURANCE

A. Comply with:
   1. Codes and regulations of the jurisdictional authority.
   2. AREMA Manual.

PART 2 - PRODUCTS

2.1 AUTHORITY-FURNISHED MATERIALS

A. In accordance with Exhibit D, "SPECIAL PROVISIONS".

B. In accordance with Section 01640, "Authority-Furnished Materials and Equipment".

C. Restraining rails furnished by the Authority under this Contract will include the following materials.
   1. Fabricated wear bar holder assembly.
   2. Wear bar.
   3. Elastomeric pad 1/4 inch by 7-1/2 inch by 13-1/2 inch with identical hole location as holder assembly.

2.2 CONTRACTOR FURNISHED MATERIALS

A. Furnish insulated joints and rail plugs meeting the following requirements:
   2. Each insulated joint shall bond together two lengths of new fully heat treated or head hardened rail in accordance with Section 02450, "General Track Construction". Overall length of the insulated joint plug shall be 39 feet minimum with joint located 16 feet from one end.
   3. The insulated joint assembly shall be suitable for installation in CWR without altering the structural integrity or mechanical performance of the rail.
   4. The rails forming the insulated joint shall have a Brinell Hardness of 341 to 388, in accordance with AREMA, "Specification for Steel Rails".
   5. Electrical resistance of the insulated joint in service shall be not less than 100 megohms.
   6. Insulated joints shall be of a type that have been successfully installed (twenty or more units) in at least three North American transit systems similar to the Authority's light rail transit system. Further, these installations shall have been in service for at least the last five continuous years.
7. Furnish insulated joint with six pin bolts consisting of one inch diameter structural steel, collars, and hardened steel washer in accordance with ASTM A490.

B. Insulating sleeves and washers (bushing): Grade G-10 phenolic in accordance with NEMA LI 1 with a minimum resistivity of $10^{14}$ ohm-centimeters measured in accordance with ASTM D257. Furnish test results to Contracting Officer for review and approval.

1. Insulating bushing shall incorporate a steel flat washer integral with the top surface. The washer shall be pre-coated with 100 percent dry powder epoxy resin, 3M Corporation Scotch Kote No. 213, or approved equal.

2. Insulating bushing shall be used with a silicone-based caulk/sealant, General Electric RTV-12, or an approved equal.

3. Insulating bushing shall be fabricated using a suitable adhesive to secure sleeve and washer. Cut edges and surfaces shall be sealed with the resin used in the sleeve manufacture.

C. Bonded Standard and Insulated Joints: As specified in Section 02457, "Bonded Joints". Bonded standard joints required in special trackwork will be furnished by the Authority.

D. Special Clips and Insulators:

1. Special insulators ("shaved") to provide clearance for insulated joints.

2. Special insulators for use with the grade crossing panels provided by the Contractor to accommodate the rubber boot.

3. Special right-hand clips for use around insulated joints furnished by the Contractor.

4. Special left-hand clips for use around insulated joints furnished by the Contractor.

E. Timber Spacers:

1. New sawed mixed hardwoods, except white oak.

2. 12 feet long by 6 inches wide by 5 inches deep. Sawn to 5 inches x 6 inches or nominal.

3. Pressure Treat Timbers:

   a. In accordance with requirements of AREMA, "Specifications for Ties and Wood Preservation".

   b. With seven pounds of creosote-petroleum solution retained per cubic foot or to refusal.

F. Standard Bumping Posts:

1. General Requirements:

   a. The standard bumping post shall be as shown on the Contract Drawings, and shall consist of a steel bumping post equipped with shock-absorbent head of multiple-spring and shock bed design.

   b. Bumping posts shall be designed to be bolted to the running rails and not to require anchoring to crossties or concrete track bed. No part of the bumping post assembly shall extend more than 1-3/4 inches below the rail base.

2. Material: Tension bars and compression beams to be ASTM A36 steel.

G. Ballast Mats:

1. Provide ballast mats at specific locations indicated on Track Charts. The ballast mats, type and size shall be as shown on the Contract Drawings.

2. Material:

   a. Made of polyurethane or natural rubber base or blend of one of these materials.

   b. Minimum 1 inch thickness.

   c. Static stiffness in the range of 0.01 to 0.02 N/mm$^3$ (Newtons per cubic millimeter).

   d. Maximum dynamic to static stiffness ratio of 1.75.

   e. Trade name of material: Sylomer, Sylodyn, Escoa/Phoenix, Clouth or approved equal.
PART 3 - EXECUTION

3.1 RESTRAINING RAIL
   A. Install an Authority-furnished restraining rail assembly with an adjustable and replaceable wear bar where shown and as specified.
   B. Install restraining rail to guard the running rail as follows: Mainline ballasted and direct fixation track with a centerline radius less than or equal to 500 feet.
   C. Install restraining rail to an elevation one inch above the top of the low rail.
   D. Electrically isolate restraining rails from the running rail and track concrete.
   E. Electrical resistance of the restraining rail assembly in service shall not be less than 400 ohms/1000 linear feet of restraining rail.

3.2 TIMBER SPACERS
   A. Install timber spacers as shown on the Contract Drawings the entire length of the station platform.
   B. Timber spacer shall be attached to the concrete platform as shown on the Contract Drawings.
   C. The Contractor will drill the appropriate holes in the concrete platform at the specified locations and install female bolt inserts accordingly.
   D. The timber spacer holes shall be field drilled in accordance to the Contract Drawings and actual female insert locations.

3.3 STANDARD BUMPING POSTS
   A. Install bumping post in accordance with Contract Drawings and the approved manufacturer's instructions.
   B. Rail insulated joints shall be installed prior to the bumping post to electrically isolate the post from the remainder of the rail system. Location of the insulated joints shall allow sufficient distance to ensure that the wheels of a parked vehicle do not crossover the insulated joints.

3.4 BALLASTMAT
   A. Install ballast mats in accordance with manufacturer's recommendations.
   B. Install ballast mats on top of concrete slab surface that is clean and free of sharp projections or recesses.

C. Joints between ballast mat sections shall be overlapped such that there are no gaps between sections.

D. Ballast mats shall extend minimum of 5 feet 6 inches on both sides of track centerline.

E. Remove foreign material from ballast mat surface before proceeding with placement of ballast.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. With the exception of restraining rail, insulated joints and rail plugs, bumping posts, and ballast mats, the work specified in this section will not be measured or paid for separately, but costs in connection therewith will be considered incidental to the trackwork (measured elsewhere) to which these track appurtenances belong.
   B. Installation of Authority Furnished restraining rail will be measured and paid for at the unit price per lineal foot complete-in-place, including restraining rail, transition rails, brackets, hold down assemblies, elastomeric pads and restraining rail joints.
   C. "Insulated joints and rail plug" will be measured and paid for at the unit price per each for insulated joints complete-in-place, which price shall include fabricating the bonded insulated joint; field welding the complete assembly into the running rail; and fastening the rail to the track at the correct alignment and profile.
   D. Standard bumping post will be measured and paid for at the unit price per each for bumping post complete-in-place.
   E. Ballast mat will be measured and paid for at the unit price per square yard for each type of ballast mat.

END OF SECTION 02455
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for furnishing, fabricating, delivering, and installing bonded joints.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A194 - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
   2. ASTM A490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
   3. ASTM F436 - Standard Specification for Hardened Steel Washers

1.3 SUBMITTALS

A. Submit shop drawings.

B. Submit proposed procedures, including the following:
   1. Installation procedures.
   2. Recommended bolt tensioning.
   3. Proposed procedure for maintaining the specified gap in the CWR during installation of bonded joints.
   4. Proposed procedure for installing joints at direct fixation fasteners.
   5. Proposed alternate methods of dynamically testing bonded joints, if applicable.

C. Test Reports: Submit test results of bonded joints certified by an approved testing laboratory.

D. Adhesive Manufacturer's Quality Control Program: Submit detailed description of the manufacturer's proposed quality control program for the manufacture of the bonding adhesive used in the bonded standard joints, including how it is regulated, maintained, and monitored.

PART 2 - PRODUCTS

2.1 BONDED STANDARD JOINTS

A. Joint Bars:
   1. Furnish smooth, straight bars providing full face contact, conforming to the configuration of 115 RE rail and the girder rail, and fabricated from quenched carbon-steel as specified in AREMA Manual, “Specifications for Quenched Carbon Steel Joint Bars”. Joint bars shall be 36 inches in length.

   2. Provide joint bars with the following tolerances:
      a. Fishing height: Plus or minus 1/64 inch of the dimension shown on the approved shop drawings.
      b. Length: Within plus or minus 1/8 inch of the dimensions shown on the approved shop drawings.
      c. Straightness: That portion of the bar adjacent to the rail: within plus or minus 1/32 inch, when using a 36 inch straight edge.

   B. Pin Bolts: Furnish 6 pin bolts consisting of 1 inch diameter structural steel, collars, and hardened steel washer in accordance with ASTM A490.

   C. Joint components: Furnish bonded standard joints complete with bars, washers, bolts, nuts, and manufacturer recommended adhesives.

   D. Provide materials necessary for testing as specified herein.

   E. Bonded Standard Joints shall be manufactured by Allegheny Rail Products, Inc. of Pittsburgh, PA or approved equal.

2.2 BONDED INSULATED JOINTS

A. Furnish bonded insulated joints that meet the following requirements:

   2. Insulated joint assembly shall be suitable for installation in CWR without altering the structural integrity or mechanical performance of the rail.

   3. Electrical resistance of the insulated joint in service shall be not less than 100 megohms.
4. Insulated joints shall be of a type that have been successfully installed (twenty or more units) in at least 3 North American transit systems similar to the Authority LRT system. Further, these installations shall have been in service for at least the last 5 continuous years.

5. Furnish insulated joint with 6 pin bolts per bonded joint.
   a. Provide pin bolts of 1 inch diameter structural steel, A325 or Grade 8.
   b. Provide collar for 1 inch pin bolt.
   c. Provide flat circular hardened steel washers in accordance with ASTM F436.
   d. Locate the bolt holes as specified in the AREMA Manual.
   e. Bolt hole size in accordance with the manufacturer's recommendation.

6. Joint components: Furnish bonded insulated joints complete with bars, washers, bolts and collars.

B. Bonded insulated joints for paved track shall meet the same requirements as specified in Paragraph 2.2.A, except the insulated joint assembly shall be suitable for installation in continuously welded girder rail.

2.3 BONDED TWO RAIL STANDARD JOINTS

A. Joint Bars: As specified for Bonded Standard Joints.

B. Flangeway Filler: Rolled steel; for 1-7/8 inch wide flangeway, 36 inches long, with tolerances as specified in Article 2.1 herein.

C. Bolts: Same as in Article 2.1, herein, except 11 inches long.

2.4 ADHESIVES

A. Furnish adhesive with a minimum shelf life of 1 calendar year from the time of purchase when stored in accordance with the manufacturer's recommendations where the room temperature may vary from 40 degrees F to 90 degrees F.

2.5 FABRICATION TESTING

A. Test a minimum of 3 bonded joints for standard rail and a minimum of 3 bonded joints for girder rail, testing at least 2 joints of each type rail for longitudinal compression and one for stroke rolling load, as specified herein. Do not commence testing until shop drawings and installation procedures have been approved. Complete the tests as specified.

B. Longitudinal Compression Test:

1. Assemble 2 bonded joints on 2 pieces of standard rail, each 2 feet long and in accordance with the manufacturer's requirements. Saw the assembly in half where the rails are butted together. Execute sawing in a manner which will prevent overheating and damage to the epoxy bond. Make sawcuts perpendicular to the centerline of the top of the rail with a tolerance of plus or minus 1 degree. Fabricate a device so that the reaction of the sawed end occurs only at the face of the joint bars when a load is applied at the centroid of the rail at the opposite end.

2. Apply loads longitudinally in increments of 25,000 pounds. Maintain the load increment constant until the longitudinal deflection of the rail ceases before increasing the load to the next increment. Increase the load incrementally until a successful load of 650,000 pounds is achieved, or failure occurs. At each increment of loading, record the load and differential movement of the rail and the joint bars, measured to the nearest 0.001 inch.

3. Acceptable Tolerances:
   a. Slippage: No slippage before a compressive load of 650,000 pounds is applied to the joint.
   b. Differential Movement: Magnitude for the differential movement not to exceed 1/8 inch in any direction.
   c. At the completion of the test, after the load on the rail has been released, the relative position of the rail joint bar shall be within 1/32 inch of its original value.

C. Stroke Rolling Load Test:

1. Mount the joint on a 33-inch stroke rolling load test machine. Support the joint on 36-inch centers and center the joint. Apply the 44,400-pound rolling load on the rail for 2,000,000 cycles. Measure and record to the nearest 0.001 inch, for every 500,000 cycles, the deflection of the rail at the centerline of the rail joint when the wheel load is over both point A and point B.

2. Acceptable Tolerances, after 2,000,000 cycles:
   a. Show no evidence of joint failure by bending.
b. Do not exceed 0.065 inch of joint deflection during the test.

3. Alternate: Submit for approval other methods of testing the bonded joint for review, if desired. Submit manufacturer’s certification of tests of a similar joint.

D. Repeat Tests: After the Stroke Rolling Load Test, repeat the Longitudinal Compression Test.

E. The Contracting Officer may reject joints which fail to meet these requirements.

F. Fabrication testing of bonded joints may be waived by the Contracting Officer if the Contractor’s bonded joint crews have been qualified by either a Class 1 railroad or other Transit Agency with similar testing requirements. Qualifications of bonded joint crews may be submitted for review by the Contracting Officer provided the qualification testing was conducted within 12 months of the first bonded joints being placed on the project.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Bonded Standard and Two Rail Joints:

1. Install at non-insulated joint locations, as shown.

2. Install bonded standard joints, in accordance with the manufacturer’s written instructions except as modified by these specifications.

B. Bonded Insulated Joints: Install per manufacturer’s written instructions, except as modified by these specifications.

C. Bonded Insulated Joints for Paved/Embedded Track: Install per manufacturer’s written instructions, except as modified by these specifications.

D. End Hardening in the Field: End harden rail ends at joints that are not fully heat treated, as specified in Section 02450, “General Track Construction”.

3.2 FIELD QUALITY CONTROL

A. Crew and Foreman Qualifications: Prior to installation of bonded standard joints have each crew and its respective foreman prepare 2 sample bonded standard joints.

1. Prepare each sample joint in accordance with the approved procedures and the requirements of this section.

2. Perform thorough grinding to remove the rail brands from the rail for the entire length of the joint.

3. Test each sample for compliance with the Longitudinal Compression Test as specified.

a. Should a sample joint fail to meet the specified requirements of this test, the qualification of the foreman involved will be deemed unacceptable.

b. If the foreman of a joint bonding crew is changed at any time during the Contract, the new foreman shall be qualified as specified, unless he has already been accepted as qualified.

4. Test insulated joints for electrical resistance. Joint shall have 100 megohms or greater resistance.

B. Bolts: Prior to installing bolts in bonded joints, calibrate the installation tool that is to be used for tightening the bolts by testing at least 3 typical bolts in a device capable of indicating actual bolt tension. Use a torque multiplier for the bolts which is capable of producing the minimum installed fastener tension recommended by the joint manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section will not be measured separately for payment, and costs in connection therewith, including qualifying the procedure and crews, and the removal, reinstallation, and retesting of rejected joints, will be considered as included in the Contract lump sum price or the Contract unit prices per linear foot of track of the different types as specified in applicable trackwork sections.

END OF SECTION 02457
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section shall include providing materials, equipment, laboratory and quality control testing of rail welds, and labor necessary to weld together the abutting ends of rail, and qualification of welding and welders. Rail welds shall be one of the two types indicated below:

1. Pressure (Electric Flash-Butt) Welds: Tee rail for ballasted mainline track, embedded/paved tracks, direct fixation (DF) tracks, and yard body tracks outside the limits of special trackwork shall be welded into continuous strings using the electric flash-butt pressure welding process.

2. Thermite Welds: Thermite welds shall be used only where it is impractical to perform Pressure Welds. Thermite welds shall be used in rail for use in embedded (paved) yard track and within the limits of grade crossings. Shop pre-curved rail shall be welded in place in the track.

B. Pressure welding shall be performed using mobile electric flash-butt welding machine designed for rail welding.

C. Contractor shall make his own assessment as to the number of rails to be welded under this Contract, and the number of welds to be made by any one welding process, based on the information contained in these Specifications and the Contract Drawings.

1.2 REFERENCED STANDARDS

A. Association of American Railroads (AAR):


B. American Railway Engineering and Maintenance-of-Way-Association (AREMA):

1. AREMA Manual for Railway Engineering (AREMA Manual)

C. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code Steel

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM E10 - Standard Test Method for Brinell Hardness of Metallic Materials

2. ASTM E94 - Standard Guide for Radiographic Examination

3. ASTM E164 - Standard Practice for Ultrasonic Contact Examination of Weldments

4. ASTM E709 - Standard Guide for Magnetic Particle Examination

1.3 SUBMITTALS

A. Certification: Submit manufacturer’s certification for foreman and crew.

B. Pressure (Electric Flash-Butt) Welds: Submit the following:

1. A written description of the welding procedure, including facilities, personnel and list of similar completed projects.

2. A list of equipment and calibration methods, method of rail end alignment, method of rail straightening.

3. Welding Machines Performance: Submit pressure welding machine performance standards as provided by the manufacturer. During welding production, a recorder shall be attached to each welding machine to record platen movement and current impulses on the form "Record Of Field Welds". A record of machine performance for each weld shall be submitted to the Contracting Officer. If the record indicates performance which is not in conformance with the approved standards, the weld will be considered defective and shall be rejected.

4. Shop Drawings: Submit Shop Drawings for the pressure welding machine and Shop Drawings of the proposed method and equipment for handling and laying CWR. This submittal shall include reference data relating to where the proposed equipment and laying method were previously successfully used.

5. Details of the equipment and procedure proposed for straightening welds if required. The submittal shall include reference data relating to where the proposed straightening equipment and method were previously successfully used.

6. The manufacturer’s recommended procedure for welding high strength rail if different from requirements for standard rail.
7. Pressure Weld Samples: Prior to beginning of production welding, 6 test welds shall be made using the welding machine and the procedures proposed in the Manufacturer’s instructions. Two of the welds shall be standard rail to standard rail; two shall be high strength rail to high strength rail; two welds shall be standard treated rail to high strength rail. The welds shall be tested by the testing service. Certified test reports shall be submitted to the Contracting Officer.

8. Proposed location for flash-butt welding plant including methods of transporting materials and equipment to the site, types and locations of environmental controls and duration of welding operations.

C. Thermite Welds: Submit the following:

1. Prepare a detailed description covering the step-by-step procedures to be employed in making the welds. Include a complete description of each of the following applicable items as well as any other characteristics essential to the welding procedures.
   a. Manufacturer’s trade name for the welding process.
   b. Method used for cutting and cleaning of the rail ends. Flame cutting of rail ends will not be allowed.
   c. Minimum and maximum spacing between rail ends.
   d. Method used for maintaining the rails in alignment during welding.
   e. Method used for preheating, including time and temperature.
   f. Tapping procedure, including the minimum time required to cool the weld under the mold insulation.
   g. Method used, including a description of special tools and equipment, for removing the upset metal and finishing the weld to the final contour.
   h. Manufacturers recommended procedure for welding high strength rail if different from requirements for standard rail.
   i. Method for controlling smoke and fumes from field welding within indicated requirements.
   j. Quality control procedures.

2. Documentation: Prepare, maintain, and make available to the Contracting Officer a complete welding record indicating kit manufacturer, welding foreman, rail temperature, weather conditions, and station location.

D. Calibrations: Submit description of calibration equipment and calibration methods.

E. Testing Programs for Field Quality Control: Submit testing programs prepared by the radiographic, ultrasonic, and magnetic particle weld testing services for approval by the Contracting Officer. Each program shall include a description of the proposed procedures, materials, equipment, safety requirements, and report.

1.4 QUALITY ASSURANCE

A. Welding Supervision:

1. Perform welding under the direct supervision of an experienced rail welding supervisor or foreman.

2. Qualify each field welding foreman and crew through a representative of the field rail welding process manufacturer.

3. Have each welding crew perform 3 sample welds to be subjected to rolling load, bending, and hardness tests.

4. Have the field rail welding process manufacturer witness the first satisfactory 5 welds made by each crew. Field welding crews which produce more than 10 percent defective welds will be barred from further work until re-qualified by the manufacturer.

B. Fabrication of Sample Pressure Welds and Thermite Welds.

1. Produce 3 sample welds of each combination of metallurgy standard to standard, standard to high strength, high strength to high strength to be pressure or thermite welded for testing.

2. Prepare samples by the welding crews in accordance with the Contractor’s submitted, reviewed, and accepted methods and procedures for rail welding. The supervisor of each welding crew shall be trained and certified by the manufacturer supplying the weld kits and/or pressure welder to perform rail welding. Each welding crew shall perform at least one of each type of the sample welds. Prior to performing welds in the specified work, the welds and each welding crew shall be qualified as specified below.

3. When the weld machine is returned to production after a period of malfunctioning
FIELD RAIL WELDING

or major repair, or when the welding crew is replaced, additional sample welds, as stated above, will be required. Acceptance of the welding machine or the new crew will only be after acceptable welds as above have been produced.

4. Sample pressure and thermite welds shall be tested by an independent laboratory and the certified test results shall be submitted to the Contracting Officer. Approval of the pressure welder, weld kit, weld specification, and welding crews will be dependent upon the sample welds satisfying the test requirements in this specification. Qualification testing of sample welds shall be as stated herein.

5. Fabrication and testing of sample welds may be waived by the Contracting Officer if the Contractor’s welding crews have been qualified by either a Class 1 railroad or other Transit Agency with similar testing requirements. Qualifications for welding crews may be submitted for review by the Contracting Officer provided the tests have been conducted within 12 months of the first welds taking place on the project.

PART 2 - PRODUCTS

2.1 RAIL WELDING

A. Perform field rail welds utilizing one of the following brands of rail welding or an approved equal. All field welds shall only be preheated type.

1. Field Flash Butt Welding: Process by Holland or approved equal.


B. Unless otherwise shown or specified, conform to the rail welding kit manufacturer’s recommended standards when welding high strength rail.

2.2 RAIL

A. Rail for welding shall be as specified in Section 02450, "General Track Construction".

PART 3 - EXECUTION

3.1 RAIL END PREPARATION

A. Clean the rails to be free of grease, oil, dirt, loose scale, and moisture to a minimum of 6 inches back from the rail ends, including the rail end surfaces, by use of a wire brush.

B. Align the faces of the rail ends.

C. Clean for 2 inches on each side of the weld, to remove scale and rust, using a power actuated grinder with abrasive wheel.

D. Rail ends shall show no steel defects, dents, or porosity before welding.

E. If rail is required to be cut to length for any reason, cut it square and clean by means of rail saws or abrasive cutting wheels in accordance with AREMA Manual Chapter 4, Section 2.1.

3.2 RAIL

A. Straighten rail not meeting the requirements of AREMA Manual Chapter 4, Section 3.11, to within the specified tolerance.

B. If any rail cannot be straightened, cut it back a sufficient distance to achieve the required alignment.

C. Perform all straightening or cutting prior to welding.

3.3 RAIL GAP

A. Align and properly gap the ends of the rails to be welded to produce a weld which conforms to the alignment tolerances specified.

B. Hold the rail gap and alignment during field welding without change during the complete welding cycle.

1. Align rail on the head of the rail:

   a. Vertical alignment: To provide for a flat running surface. Any difference of height of the rails shall be in the base.

   b. Horizontal alignment: In such a manner that any difference in the width of heads of rails occurs on the field side.

2. Horizontal offsets: Not to exceed 0.040 inch in the head and 0.125 inch in the base.

3. Surface misalignment tolerance:

   a. Combined vertical offset and crown camber: Not to exceed 0.040 inch per foot.

   b. Combined vertical offset and dip camber: Not to exceed 0.010 inch per foot.

4. Gauge misalignment tolerance: Combined horizontal offset and horizontal kink camber not to exceed 0.040 inch per foot.
3.4 BOLT HOLES
A. One handling hole may be made in each end of a CWR string. Cut off rail ends containing such holes prior to welding.

3.5 SAMPLE WELDS
A. In accordance with the approved methods and procedures, prepare at least 3 sample welds on standard rail, and 3 sample welds on high strength rail or alloy rail.
B. In addition, each welding crew to prepare a minimum of one sample weld.
C. Each sample weld shall join two pieces of rail each a minimum of 30 inch in length.
D. All sample welds shall be tested by the testing laboratory (approved by the Authority) as follows:
   1. Radiographically inspect each weld in accordance with ASTM E94.
   2. Use radiographic tests to establish the acceptable procedures for performing field inspection of welds.
   3. For each type of rail, and after passing the radiographic test, subject at least one sample weld to each of the following tests:
      a. Slow Bend Test for Sample Welds: Sample weld shall be subjected to the Slow Bend Test described in the Proceedings of the AREMA, Volume 68, pages 384 and 385. Test acceptance criteria minimum of 1 inch deflection and 100,000 pounds per square inch modulus of rupture.
      b. Hardness test: In accordance with ASTM E10 longitudinally section the rail for a distance of 12 inches on each side of the weld and test for Brinell Hardness. Test the rail head portion for hardness on the sectioned face at points on a grid pattern of 3/8 inch increments for 1 inch on each side of the centerline of the weld and on a grid pattern of 1/2 inch increments beyond the weld until the hardness is that of the parent metal. The Brinell Hardness throughout to be as follows:
         1) For standard rail: Minimum 285 and maximum of 331.
         2) For high strength rail: Minimum 341 and maximum of 401.
E. Submit the test results for the sample welds to the Contracting Officer for approval of the welding process and the crew. Should any sample weld fail to meet the specified requirements, the welding process, the welding crew, or both may be disapproved.
F. Should the supervisor of an approved crew be replaced, the entire welding crew shall be re-qualified under the direction of the new supervisor.
G. Welding crews that have been qualified by either a Class 1 railroad or other Transit Agency with similar testing requirements may be submitted for review by the Contracting Officer provided the tests have been conducted within 12 months of the first welds taking place on the project.

3.6 FIELD WELD POSTHEATING
A. Leave the molds in place after tapping for the time required to permit complete solidification of the molten metal and proper slow cooling to prevent cracking and provide a complete weld with proper hardness and ductility.

3.7 PRESSURE (ELECTRIC FLASH-BUTT) WELDING
A. Pressure welding shall be in accordance with the AREMA Manual Chapter 4, Section 3.11, except as modified hereinafter.
B. Mismatched or jagged rail ends shall be either sawed or cut with an abrasive rail cutter. Mating rail ends by flashing shall not be accepted.
C. Rails shall have the scale removed down to bright metal in areas where the welding current-carrying electrodes contact the rail. Grind down raised rail brands in electrode areas. Grind down raised rail brands in electrode areas. The weld and adjacent rail for a distance clearing the electrodes shall be rejected if in the areas of electrode contact there is not more than 95 percent of the mill scale removed. Electrode contact areas shall be examined for evidence of electrode burn. Where metal is displaced or where the oxidized areas exhibit checks or small cracks the weld shall be rejected and the rail cut back clear of the electrode burn.
D. Welds shall be forged to point of refusal to further plastic deformation and shall have a minimum upset of 1/2 inch, with 5/8 inch as standard.
E. If flashing on electric pressure (flash butt) welds is interrupted, because of malfunction or external reason, with less than 1/2 inch of flashing distance remaining before upsetting, rails shall be reclamped in the machine and flashing initiated again.
F. Whenever possible, grinding shall be accomplished immediately following welding at an elevated temperature. When grinding must be done at ambient temperature, avoid grinding burns and metallurgical damage.
G. Alignment of rail in the welding machine shall be at the head of the rail.

1. Vertical alignment shall provide for a flat running surface. Any difference of height of the rail shall be in the base.

2. Horizontal alignment shall be accomplished in such a manner that any difference in the width of heads of rails shall be divided equally on both sides of the head. Where the difference, when divided, exceeds 0.040 inches, 0.020 inches of the difference shall be placed on the gauge side and the remaining differences in the width of heads shall be on the field side.

3. In any case horizontal offsets shall not exceed 0.040 inch at the head and/or 0.125 inch at the base.

H. Surface and Gauge Misalignment Tolerances: Shall meet the alignment tolerances given in the AREMA Manual, Chapter 4, Part 2, “Tolerances for Inspection of Welded Rail New and Mainline Relay Rail”.

I. If, at any time, 7 or more of a series of 12 consecutive welds made on one machine exceed 75 percent of the stated surface misalignment tolerances that machine shall be shut down and adjusted before work continues.

J. Re-welds shall be cut out beyond the heat affected zone of the previous weld.

3.8 WELD FINISHING AND TOLERANCES

A. Bring rails and joints in the finished track to a true surface and alignment by means of an approved grinding machine.

B. Finish the completed weld by grinding to conform with the following requirements:

1. Finishing deviation shall not be more than plus 0.010 inch to minus 0.0 inch of the parent section of the rail head surface.

2. Finish the sides of the rail head to plus or minus 0.010 inch of the parent section.

3. Finish the bottom and sides of the rail base to a finishing deviation of not more than plus 0.010 inch of the parent section.

4. Finish the web zone to within 1/8 inch of the parent contour but not deeper than the parent section. Finishing shall eliminate all cracks.

5. Alignment tolerances to be as specified in AREMA Manual, Chapter 4, Section 3.11.

6. Notches created by minor offset conditions, twisted or misshaped rails shall be eliminated by minimum grinding to blend the variations.

7. Fins on the weld due to grinding or shear drag shall be removed prior to final inspection.

3.9 WELD QUALITY

A. Inspect each test weld using the dry powder magnetic particle method in accordance with ASTM E709.

B. Inspect each weld using a 3 foot straightedge along the centerline of the rail and 0.625 inch below top of rail on the gauge side of the rail head. Center the straightedge over the weld. The gap between the straightedge and the rail shall comply with the requirements of AREMA, Chapter 4.

C. Ensure that each completed weld has full penetration and complete fusion and is entirely free of cracks or fissures.

D. Porosity and slag-type defects will be acceptable provided that testing indicates that the largest defect does not exceed more than 3/16 inch in its largest dimension; the total area of the defect does not exceed 0.010 square inches, and the sum of the greatest dimension of defects in a line does not exceed 1/2 inch.

E. Weld Hardness: As specified for the sample welds herein.

3.10 WELD NUMBERING

A. Mark a sequential weld number on the rail immediately adjacent to the weld using a quality lead paint marker at the time the weld is made.

B. Number welds sequentially in the order in which they are made.

C. The Contracting Officer will provide the Contractor with the initial weld number.

D. When defective welds are replaced assign a new sequential number to the new weld by adding a letter to the defective weld number.

3.11 FIELD QUALITY CONTROL

A. General:

1. Test all welds at the time of welding and ultrasonically test both the welds and the rail once the rails have been laid in final position

2. Use equipment which has a distance amplitude correction feature.
FIELD RAIL WELDING

3. Calibrate the equipment daily using an 11W calibration block, also made of rail steel.

4. Inspection Personnel: Qualify all inspection personnel in accordance with AWS D1.1/D1.1M.

5. Cut out and re-weld all welds giving fault indication in ultrasonic inspection using a minimum 19 foot piece of rail.

B. Radiographic Weld Testing:

1. Contracting Officer will select welds to be radiographically tested in accordance with ASTM E94. Radiographic film shall be Type 1 or Type 2 and the exposed film density shall be within the range of 1.5 to 3.8. At least 4 exposures are required, one through the head, one through the web, and one each through the two base flanges.

2. Testing Procedures: In accordance with the approved submittal.

3. Testing Rate: Radiographic tests shall be performed on:
   a. 100 percent of the first 10 mainline welds.
   b. 20 percent of the next 50 mainline welds.
   c. 10 percent of the remaining mainline welds.
   d. 4 yard welds shall be radiographically tested.

4. Defective Welds: Upon detection of a defective weld, the test rate shall be increased to ensure that all defective welding is disclosed. The Contracting Officer will select additional welds to be radiographed.

5. Penatrameters shall be shimmed to compensate for excess weld metal on the web and base.

6. Acceptance Criteria: The weld quality shall meet the requirements of Paragraph 3.8.

C. Ultrasonic Weld Testing:

1. Mainline and yard field welds not subject to radiographic testing shall be ultrasonically tested (UT) over the entire cross section of head, web, and base. The UT equipment shall meet the requirements of AWS D1.1/D1.1M, Paragraph 6.17. The procedure shall meet the requirements of ASTM E164. Prior to performing production UT of welds, UT technicians shall demonstrate to the satisfaction of the Contracting Officer that they can discern and identify indication produced by slag, porosity, lack of fusion, and cracks.

   a. Use ultrasonic test equipment capable of detecting a 3/64 inch discontinuity, 6-1/2 inches below the top of rail. At a minimum, scan the weld from the top and both sides of the rail head and the base. Scan the weld from both sides on the face for longitudinal and transverse discontinuities using the applicable scanning pattern or patterns.

2. Testing Procedures: In accordance with the approved submittal.

3. Acceptance criteria shall be as follows:
   a. Welds showing a response at any level that is identified as a crack or lack of fusion will not be acceptable.
   b. Welds showing a response that is less than 50 percent of the primary reference level will be acceptable.
   c. Welds showing a response greater than 50 percent but that do not exceed the primary reference level are acceptable, providing that all of the following apply:
      1) Defects are evaluated as slag or porosity.
      2) Largest defect does not exceed 0.180 inch in its largest dimension.
      3) Total area of the defects do not exceed 0.09 square inch.
      4) Sum of the greatest dimension of defects in a line does not exceed 3/8 inch.
   d. Welds showing a response that exceeds the primary reference level will not be acceptable.

D. Magnetic Particle Testing:

1. Main line and yard field test welds shall be magnetic particle tested (MT). The procedures used shall meet the requirements of ASTM E709. Welds surfaces shall be tested except the underside of the rail base. The magnetizing equipment shall be an electro-magnetic yoke meeting the following requirements:
FIELD RAIL WELDING

a. DC lift capacity of 40 pounds, and/or
b. AC lift capacity of 10 pounds at the maximum pole spacing.

2. Testing Procedures: In accordance with the approved submittal.

3. Acceptance Criteria: The weld quality shall meet the requirements of Paragraph 3.8.

3.12 DEFICIENT WELDS

A. Replacement of Defective Welds:

1. When the Contracting Officer determines a weld is unacceptable, cut out the weld and replace it with a 19 foot (minimum) rail plug.
   a. Make saw cuts at least 6 inches from the centerline of the faulty weld.
   b. Renumber replacement welds as indicated.
   c. Ultrasonically test replacement welds made in rail as specified herein.

2. If one or both of the rails may be moved, cut out the weld, pull rails together to the indicated rail gap and reweld.

3. If neither rail may be moved, cut the weld out of the rail and replace with a section of new rail and with 2 new welds. Use a 19 foot minimum length of the new rail.

3.13 PROTECTION OF RAIL INSULATORS

A. Rail insulators (pads, clips, insulators, and bushings) shall be covered/protected by a non-flammable material to prevent hot grinding fines from fusing into the rail insulating components.

3.14 WELD SLAG

A. Welding fines and slag shall be removed from around the rails, insulating components, and the entire track area.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will not be measured separately for payment, but all costs in connection therewith will be considered incidental to track construction measured elsewhere.

END OF SECTION 02458
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing special trackwork comprising of turnouts, crossovers, crossings, and similar work as shown on the Contract Drawings.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Portfolio of Trackwork Plans"

1.3 SUBMITTALS

A. Installation Procedures: Prepare and obtain approval of a description of the procedures to be employed in the execution of the special trackwork installation at least 30 calendar days before beginning the work. Place particular emphasis upon alignment, clearances, and methods of checking both.

B. Product Data: Submit manufacturer's description of the proposed lubricants for use on the riser plates.

C. Submit qualifications of welders qualified as specified in Section 02458, "Field Rail Welding".

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Contractor shall arrange, at the expense of the Contractor, for the delivery of materials to the Worksite.

B. Handle special trackwork materials in a manner which will prevent damage during loading, unloading, storing, transporting, and installing.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Materials required for special trackwork, in accordance with the Standard and Directive Drawings and AREMA Trackwork Plans.

   1. The Authority will be providing 80 foot rail sections.

2.2 CONTRACTOR FURNISHED MATERIALS

A. Provide materials, including ballast necessary for ballasted special trackwork installation.

B. Provide concrete materials, bonding agent, insert anchor grout, and shims required for Direct Fixation special trackwork construction as specified in Section 02462, "Direct Fixation Track Construction".

C. Insulated joints and rail plugs within special trackwork will be furnished by the Authority. Refer to track charts for Contractor furnished insulated joints and rail plugs.

D. Turnouts, crossovers, and track crossings as indicated, including rails, switches, frogs, special plates, resilient clips, hand throw switch stands, spring connecting rod, and guard rail assemblies as shown on the drawings.

E. Concrete switch ties and crossties for ballasted special trackwork.

F. Direct fixation (DF) fastener assemblies required for DF special trackwork.

2.3 LUBRICANTS

A. Provide Glidex as manufactured by Midwest Industrial Supply or approved equal for application to the riser plates. The lubricant shall have low electrical conducting properties.

2.4 RELATED MATERIAL NOT IN CONTRACT

A. Switch machines, operating rods, and switch machine mountings furnished and installed by others.

PART 3 - EXECUTION

3.1 BALLASTED SPECIAL TRACKWORK INSTALLATION

A. Install ballasted special trackwork as specified herein and in accordance with Section 02460, "Ballasted Track Construction". If work involves operating tracks, track outages shall be arranged through the Contractor.

B. On the initial layer of ballast, space and align ties within the limits of special trackwork, as indicated. Place switch ties within a tolerance of plus or minus 1/2 inch of the location shown, except that ties adjacent to switch rods are to be placed within plus or minus 1/4 inch of the location shown.

C. Special care is required for railroad crossings, since similar frogs may not be identical. Review shop drawings and locations of insulated joints.

D. Clean ties and rail pads prior to installing rails to ensure full bearing of the pads on the ties.

E. Frog Gauge Plate Stops: Field welded to gauge plates.
F. Surfacing and Aligning:

1. Surface, tamp, and align special trackwork as specified herein and in Section 02460, “Ballasted Track Construction”.

2. Uniformly tamp ballast under both sides of each tie directly under each running rail for a distance of 15 inches on both sides of the rail.

3. In general, bring the top of the ballast section to within 1 inch below the base of the rail throughout the special trackwork units. Ballast shall not be in contact with any rail or metallic rail appurtenances.

4. Provide 4 inch clearance below the rail base at operating and switch rods.

5. Conform the width and slope of the shoulders to the sections indicated.

G. Final Alignment:

1. The final surface and alignment of the special trackwork to be within the tolerances specified for ballasted mainline track in Section 02450, “General Track Construction”.

2. After final surfacing and aligning, dress the ballast to conform to the ballast sections indicated.

3. In the event that sub-ballast outside the toe of the slope is fouled or disturbed as a result of the Contractor’s operations, re-slope those portions of the sub-ballast and ballast.

3.2 DIRECT FIXATION SPECIAL TRACKWORK INSTALLATION

A. Install direct fixation special trackwork as specified herein and in accordance with Section 02462, “Direct Fixation Track Construction”. If work involves any live tracks, track outages shall be arranged through Contracting Officer.

B. Follow manufacturer’s instructions in the installation of special trackwork components.

C. Install direct fixation fastener assemblies and conduct insert pullout tests as specified under Section 02462, “Direct Fixation Track Construction”.

3.3 JOINTS

A. Locate special trackwork joints as indicated.

B. Install joints as specified in Section 02457, “Bonded Joints”.

3.4 LUBRICATION

A. Lubricate sliding surfaces on special trackwork assemblies.

B. Clean surfaces free of foreign material before applying the lubricant in accordance with the manufacturer’s recommendations.

3.5 FIELD MAINTENANCE

A. Adjust rods for 4-3/4 inches throw at the number one rod.

B. Adjust switch rods, clips, and bearings to permit free movement of the switch points. Install shims and shim keeper plates and lubricate bearings as required for free movement.

C. Maintain and protect special trackwork materials installed prior to final acceptance.

D. Do not operate Contractor work trains or other rail-mounted equipment over special trackwork until fasteners and rails have been fully fastened and switch points have been secured.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Materials furnished by the Authority will not be measured for payment.

B. Special trackwork will be measured and paid by the Contract unit price per each, complete-in-place. Such unit price shall be considered as full compensation for work described in this section and related other sections including the materials furnished by the Contractor; transportation, storage and handling of the Authority's furnished material; and installation.

C. The “unit” length of turn outs and the “overall” length of crossovers as defined in the Contract Documents, will not be measured or paid for under the pay items for ballasted track or direct fixation track but will be paid for as part of in the Contract unit prices for special trackwork.

END OF SECTION 02459
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies constructing ballasted track on constructed trackbed to lines and grades shown. Ballasted track construction includes the following: placing ballast; distributing and lining ties; installing and field welding running rail; raising and lining track; and other incidentals as specified herein. Track on approach slabs and ballasted deck bridges is included.

B. Unless otherwise shown or specified, trackwork within the limits of ballasted special trackwork units is included in this section.

C. Timber spacers installed in stations along platform walls shall be considered incidental to ballasted track construction.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):

1. AREMA - “Manual for Railway Engineering” (AREMA Manual)

1.3 SUBMITTALS

A. Submit descriptions of the proposed dynamic track stabilizers, liners, and other track laying equipment. Subject the track laying equipment to inspection and acceptance by the Contracting Officer prior to and during its use.

1.4 QUALITY ASSURANCE

A. Comply with:

1. Codes and regulations of the jurisdictional authority.

2. AREMA Manual.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. In accordance with Exhibit D, “SPECIAL PROVISIONS”.

B. In accordance with Section 01640, “Authority-Furnished Materials and Equipment”.

2.2 CONTRACTOR FURNISHED MATERIALS

A. Furnish ballast and filter fabric.

B. Furnish all other materials and equipment required for ballasted track construction.

2.3 BALLAST

A. Provide ballast in accordance with Section 02453, “Track Ballast”.

2.4 RAIL FASTENINGS

A. Provide Pandrol Fastclip rail fasteners or approved equal for concrete ties for ballasted track and install per manufacturer’s installation instructions. Fastclip rail fasteners shall include toe insulators, 4 side post insulators, 2 rail seat pads, and 4 cast-in-place shoulders.

2.5 BONDED JOINTS

A. Provide bonded rail joints as specified in Section 02450, “General Track Construction” and Section 02457, “Bonded Joints”.

PART 3 - EXECUTION

3.1 INITIAL LAYER OF TRACK BALLAST

A. Uniformly distribute and compact an initial layer of track ballast over the finished sub-ballast before tie distribution.

B. Uniformly spread and compact each lift of ballast within the initial layer with not less than four passes of either a self-propelled, pneumatic-tired roller or vibratory compactor capable of applying a dynamic load of not less than 18,000 pounds.

C. Do not distribute track ballast over sub-ballast which has not yet been approved by the Contracting Officer.

D. Place ballast to the cross-section shown.

E. Haul and place ballast material in such a way that damage to the adjacent track areas is avoided.

F. Ballast Depth:

1. Place ballast in lifts not to exceed 4 inches in depth.

2. Bring the initial layer of compacted ballast to an elevation that will establish the track surface no higher than 4 inches below final grade.

3. Minimum depth of ballast from the bottom of tie to the top of sub-ballast: 12 inches for mainline track and 8 inches for yard track and bridges.
3.2 TIE DISTRIBUTION

A. Distribute all ties as shown on drawings.
B. Avoid unnecessary handling, reloading, and redistribution of the ties.
C. To the extent practical, unload ties in the proper position for use without further handling. Do not drop ties. Move ties using only equipment or tools suitable for moving ties.
D. Inspect ties for damage after unloading and remove ties with excessive cracking. Crack widths greater than 0.06 inches will be cause for rejection. Exposed rebar will be cause for rejection.
E. Install ties at right angles to the centerline of the track at the following spacings, center to center, plus or minus 1/4 inch:
   1. Mainline track: Concrete ties at 30 inches on center.
   2. In Highway Grade Crossing: 10 foot concrete ties at 24 inches on center.
   3. Ballast-Deck Bridges: Concrete ties at 24 inches on center.

3.3 LAYING RAIL

A. Lay, fasten, and field weld rail as specified in Section 02450, "General Track Construction".

3.4 ZERO THERMAL STRESS TEMPERATURE

A. Determine rail temperature as specified in Section 02450, "General Track Construction".
B. Fasten rail to achieve zero thermal stress at a temperature of 105 degrees F plus or minus 5 degrees F.
C. The temperature of opposite rails to be within 5 degrees F of each other.
D. The Authority will test the zero thermal stress temperature at ½ mile intervals, unless otherwise required by the Authority, using the Vortek “Verse” machine, a non-destructive test method, accurate within plus or minus 2.5 degrees F. The Authority may also employ destructive methods of testing for the actual zero stress temperature. Ballasted track outside the specified limits and the accuracy of the Verse machine (97.5 degrees F to 112.5 degrees F) shall be adjusted to conform to the specifications at no cost to the Authority. Contractor shall provide the necessary support (including labor) to perform the test.

3.5 RAIL FASTENING

A. Prior to laying rail, clean the fastener assembly contact surface to allow full bearing of the rail on the assembly.
B. Mainline Tracks:
   1. In each rail clip application, drive in a direction perpendicular to the length of the rail.
   2. Drive the two clips per fastening assembly toward each other.

3.6 FINAL BALLAST

A. Following assembly of the track, unload the ballast in the tie cribs and on the shoulders of the track structure.
B. Unload sufficient ballast to restrain the movement or buckling of track due to temperature changes.
C. Unload sufficient ballast to continue to hold the track after the surfacing raise.

3.7 TRACK SURFACING

A. Following placement of final ballast, perform track surfacing as follows:
   1. Do not perform track surfacing unless the cribs are filled with ballast.
   2. Do not perform track surfacing when the rail temperature exceeds 115 degrees F, unless otherwise approved by the Contracting Officer.
B. Perform track surfacing by an approved method which prevents undue bending of the rail or straining of the joints.
C. Perform a minimum of two surfacing lifts of the track, each lift a minimum of 1 inch and a maximum of 2-1/2 inches.
D. Restore to full bearing any ties pulled loose during surfacing operations.

3.8 BALLAST TAMPING

A. Tamping shall be done with a squeeze-vibratory type power tamper approved by the Contracting Officer. Control of the power tamper's tamping cycle shall ensure the maximum uniform compaction of ballast along the track.
B. Thoroughly tamp ballast on both sides of the tie from a point 15 inches inside the rails to the ends of the tie.
C. Do not tamp at the center of the ties outside the limits described above.

D. Tamp inside and outside both rails on each tie simultaneously.

E. Grade crossings may be temporarily tamped with lighter tampers, but shall be retamped with the production tamper after adjacent track connections are completed. The final tamping shall be performed by mechanical means before the grade crossing panels are placed.

F. Ties damaged by Contractor in any fashion by tamping of ballast shall be replaced at no cost to the Authority. The Authority will deduct the cost of the Authority-furnished tie for replacement.

3.9 FINAL SURFACING AND ALIGNMENT

A. Complete final surfacing and alignment of the track to the specified tolerances.

B. Perform rail alignment in accordance with Section 02450, “General Track Construction”.

C. Upon completion of the raising and aligning operations, fill cribs and shoulders with ballast to one inch below the base of rail. Remove any ballast touching metallic portions of the track.

D. Unless otherwise shown, extend shoulder ballast 12 inches beyond the end of ties parallel to the plane formed by the top of rails. In at-grade sections, slope shoulder ballast at 2:1 to the sub-ballast, as indicated.

3.10 BALLAST COMPACTION

A. Compact ballast with approved equipment specifically designed to dynamically stabilize the track structure.

B. Track Stabilization Equipment: Dynamic track stabilizer capable of applying stabilizing forces into the track structure at a continuous speed of 1/2 mph. The equipment shall have a proportional measuring system to accurately measure and control stabilization.

3.11 FIELD QUALITY CONTROL

A. Refer to Section 02453, “Track Ballast”, for inspection of delivered material. If material installed does not conform to specified requirements, the Contracting Officer may reject the material and no further delivery will be accepted until the deficiency is corrected.

B. Allowable Tolerances:

1. Construct surface of initial layer ballast to the following tolerances:

   a. Vertical: Within plus or minus one inch of elevation shown, with deviation not more than 1/4 inch within five feet either side of the track centerline nor more than 1/2 inch from a 16 foot straight edge, not cumulative.

   b. Horizontal: Deviation throughout the limits of the work: plus three inches, minus one inch.

2. Remove a maximum of one percent of the ties, selected at random by the Contracting Officer, in order to inspect the ballast compaction beneath the ties. Use the information to determine the variables of each piece of tamping and compaction equipment. Restore ties and ballast to the original configuration.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Materials furnished by the Authority will not be measured for payment.

B. Ballasted track construction will be measured and paid for at the Contract unit price per linear track foot for each type, complete in place. Such unit price shall be considered as full compensation for track construction described in this section and other related sections including the materials furnished by the Contractor; transportation; storage and handling of materials furnished by the Authority; and installation of all materials.

C. In areas of ballasted special trackwork, the “unit” length of the turnouts and the “overall” length of crossovers as defined in the Contract Documents, will not be measured or paid for under the pay item for ballasted track construction, but will be paid for as part of the Contract unit prices for special trackwork as specified in Section 02459. “Special Trackwork”.

END OF SECTION 02460
SECTION 02462
DIRECT FIXATION TRACK CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the construction of direct fixation (DF) track to the lines and grades shown. The work is comprised of the installation of track concrete (second placement as shown), direct fixation rail fasteners, rail, field welding, and other incidentals, as specified.

B. Direct fixation track construction applies to grade separation structures and other construction, as indicated.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M148 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

B. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM D570 - Standard Test Method for Water Absorption of Plastics

D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC-SP 1 - Solvent Cleaning

1.3 SUBMITTALS

A. Installation Procedures: Prepare and submit a description of the procedures and methods to be employed in the execution of the installation of direct fixation trackwork. At a minimum, include the following:
   1. Method of laying out the work including track concrete pads, inserts, and fasteners, to result in finished track meeting the alignment requirements within the specified tolerances.

   2. Method of preparing concrete invert surfaces to obtain the specified bond to reinforced track concrete plinth.

   3. In accordance with the requirements of Sections 03100. "Concrete Formwork", 03200, "Concrete Reinforcement", and 03300, "Cast-In-Place Concrete", submit the track concrete construction procedures, including:
      a. Plinth sizes, and procedures for forming, mixing, placing, and curing of concrete.
      b. Proposed concrete materials; include packing, storing, handling, proportioning, additives, mixing, and placing details.
      c. Proposed method for measuring and controlling substrate temperature during concrete setting and curing.


   5. Details for securing the fastener inserts in the track concrete, including the following:
      a. Brand or manufacturer of each component.
      b. Proposed temperature range of the substrate for setting inserts and curing anchor material; supported by test data.
      c. Proposed wetness range for placing and curing anchor material.
      d. Proposed packing, storing, handling, proportioning, mixing, and placing details.
      e. Proposed insert cleaning and degreasing details.
      f. Proposed method for measuring and controlling substrate temperature during setting and curing of anchoring materials.

   6. Equipment and procedures for completing the insert pull-out tests as specified.

   7. Quality control procedures to ensure proper installation.

   8. Procedure for handling, installing, and field welding continuous welded rail on direct fixation track.
B. Product Data: Submit product data for bonding agent, insert anchor grout, and concrete bonding agent.

C. Mix Design: Submit concrete mix design as specified in Section 03305, "Portland Cement Concrete".

D. Certification: Certification of concrete mix design, reinforcement, and bonding agents.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. In accordance with Exhibit D, "SPECIAL PROVISIONS".

B. In accordance with Section 01640, "Authority-Furnished Materials and Equipment".

2.2 CONTRACTOR FURNISHED MATERIALS

A. Concrete Materials:
   1. Provide concrete formwork as specified in Section 03100, "Concrete Formwork".
   2. Provide concrete reinforcement as specified in Section 03200, "Concrete Reinforcement".
   3. Provide concrete: Mix S-3, as specified in Section 03305, "Portland Cement Concrete".

B. Bonding Agent: Provide a bonding agent free of polysulfides; resistant to acids and petroleum products; with a water absorption rate of less than one percent when tested in accordance with ASTM D570; and with a minimum tensile strength of 4000 psi when tested in accordance with ASTM D638.

C. Insert Anchor Grout: The following grouts are acceptable for use in the installation of the direct fixation insert anchorage systems. Provide one of these insert anchorage grouts, or an approved equal.
   2. FX-830 polyester resin grout: As manufactured by Fox Industries, Incorporated, Baltimore, MD 21211.
   3. Five Star ET epoxy grout or Five Star REG epoxy grout: As manufactured by U.S. Grout Corporation, Fairfield, CT 06430.

D. Shims:
   1. ASTM, A167, UNS S30400; and 1/16, 1/8, and 1/4 inch.

E. Concrete bonding agent: As proposed by Contractor and approved by Contracting Officer.

PART 3 - EXECUTION

3.1 DRAINAGE SYSTEM PROTECTION

A. Prior to the start of direct fixation track construction, proof test with a mandrel all under track drainage systems.

B. Protect track drainage systems at all times during construction. Ensure that the track drainage system is kept free of the intrusion of concrete, aggregates, grouts, oils, or other materials.

C. At the completion of direct fixation track construction, proof test all track drainage systems to demonstrate that the Contractor's operations have not plugged the drains. Clean the drainage system of all foreign materials found as a result of the post construction operations mandrel proofing.

3.2 CONCRETE FORMWORK AND REINFORCEMENT

A. Prepare concrete formwork in accordance with Section 03100, "Concrete Formwork".

B. Provide concrete reinforcement in accordance with Section 03200, "Concrete Reinforcement".

3.3 ANCHOR ASSEMBLY AND TEMPLATES

A. Install the direct fixation anchorage assembly using an approved template. Ensure that the template allows the spacing shown and that the anchorage assembly is located properly with respect to rail location, elevation, and orientation.

B. Ensure that the top of the female anchorage assembly insert is flush with, or embedded no lower than 1/32 inch below the surface of the track concrete plinth. Set the insert normal, plus or minus 1 degree, to the plane of the fastener assembly.

C. Remove oil, grease, and other foreign matter from the outside of the anchorage using a solvent, caustic degreaser, or steam cleaning in accordance with SSPC SP1.

D. Keep the anchorage clean and free of dirt, debris, and loose concrete during installation.

E. Prior to concrete placement, coat the anchorages with a bonding agent.
F. Welding or mechanically affixing anything to the anchorage or the anchorage insert is prohibited.

3.4 ALTERNATE ANCHORAGE INSTALLATION

A. Submit alternate anchorage assembly installation procedures and methods to the Contracting Officer for approval. Impact installation of anchorage assemblies on aerial structures is prohibited.

3.5 CONCRETE PLACEMENT

A. Prior to concrete placement, clean existing surfaces in accordance with the requirements of Section 03300, "Cast-In-Place Concrete".

B. Coat the surface of the existing concrete slab with concrete bonding agent in accordance with the manufacturer's recommendations.

C. Place the track plinth concrete in accordance with the requirements of Sections 03100, "Concrete Formwork", 03200, "Concrete Reinforcement", and 03300, "Cast-In-Place Concrete".

D. Utilize a stubby, 4 inch long “Shallow Slab” vibrator in placing plinths, unless otherwise approved by Contracting Officer.

3.6 CONCRETE FINISH

A. Steel trowel finish the top surface of the track plinth as described in Section 03350, "Concrete Finishing".

B. Provide form finish for other surfaces of track plinths as described in Section 03350, "Concrete Finishing".

3.7 CONCRETE TOLERANCES

A. Do not cast the plinth across any construction, expansion, or contraction joints.

B. Track Plinth (Second pour concrete) Dimensional Tolerances:
   1. Segment casting length: 54 inch long, maximum, unless approved otherwise by Contracting Officer.
   2. Spacing: 6 inches between segments, minimum.
   3. The plinth shall extend a minimum of 6 inches beyond the edge of the fasteners except where lesser space is required to provide clearance for switch rods, detector rods, and other switch machine connecting rods.
   4. Top of track plinth surface: Parallel to a plane passing through the top of both rails, and even with adjacent fastener bearing surface.

5. Cross slope variation: Not to exceed plus or minus 1/2 degrees.

6. Difference in elevation at the rail centerline at two adjacent fastener locations: Not to exceed 1/16 inch.

3.8 INSERT ASSEMBLY GROUT PLACEMENT

A. Prepare non-shrink grout in accordance with the approved manufacturer’s recommendations.

1. Clean all grout mixing equipment prior to preparing grout mix.

2. Mix only that quantity of grout which can be placed prior to initial set as determined by the manufacturer’s recommendations and existing conditions.

3. Mix grout when components achieve a temperature between 70 degrees F and 80 degrees F.

B. Grout placement temperature requirements:

1. Place grout when the surface temperature at insert assembly location is at least 50 degrees F and rising.

2. Do not place grout when the surface temperature at the insert assembly location is expected to fall below 50 degrees F within 48 hours of placement.

3. Do not place grout when insert assembly surface temperatures exceed 90 degrees F. Shade or cool insert assemblies to achieve a surface temperature at or below 90 degrees F.

C. Thoroughly clean and dry the insert assembly and the insert assembly locations using approved methods.

3.9 INSERT PULL-OUT TESTS

A. After the curing of the track concrete plinth, subject at least one anchorage assembly in every 200 installed to a restrained and an unrestrained pull-out test, as described. An indicator marker shall be installed in the field at all locations where the actual plinth pull-out tests were completed.

B. Restrained Pull-out Test:

1. Place a 6 inch by 6 inch by 1/2 inch steel plate with a 1.75 inch diameter hole in the center over the anchor bolt in an installed anchorage assembly.
2. Apply an upward vertical load of 1000 lbs. per second, against the plate, until a load of 20,000 pounds occurs; after achieving 20,000 pounds, release the load.

C. Unrestrained Pull-out Test:
1. Remove the steel plate described above.
2. Apply the upward vertical load of 1000 lbs. per second as described until a load of 10,000 pounds is achieved and release the load.
3. The test assembly shall be as described in the AREMA Fastening Uplift Test. Vol.1, Chapter 30 “Ties”, Section 2.6 Fastener

D. Record all tests, identifying each bolt location, the loads applied and the results and submit copies of the documentation to the Contracting Officer.

E. Acceptance Criteria: Restrained pull-out test: No evidence of failure by either slippage or cracking of the concrete to anchorage assembly bond before the load of 10,000 pounds is achieved.

3.10 DIRECT FIXATION FASTENER ASSEMBLY INSTALLATION

A. Ensure that the surface of the track plinth to receive the direct fixation fastener assembly is free of dirt and debris or concrete which might affect the proper setting of the assemblies.

B. Set the direct fixation fastener assemblies over the anchorage assembly insert and temporarily secure them to the track plinth.

C. Install fastener assemblies in pairs, within a tolerance of one inch, except at skewed structural joints.

D. Install fasteners at right angles to the centerline of the track, one fastener under each running rail.

E. Direct fixation fasteners shall be installed so as to permit plus or minus 1/4 inch gauge adjustment of rail at each fastener to accommodate future rail wear.

F. Install fastener assemblies spaced every 30 inches, unless otherwise shown or specified. Every 25 feet of length as measured along the rail must contain 10 fasteners.

3.11 SHIMS

A. Install shims between the direct fixation fastener assembly and the track concrete in accordance with the manufacturer’s recommendations in order to ensure proper rail line and grade.

B. Unless otherwise approved, do not chip concrete to adjust the direct fixation assembly fasteners line and grade.

3.12 LAYING CONTINUOUS WELDED RAIL (CWR)

A. Lay, fasten and field weld CWR as specified in Section 02450, "General Track Construction", and Section 02458, "Field Rail Welding".

3.13 ZERO THERMAL STRESS TEMPERATURE

A. Determine rail temperature as specified in Section 02450, "General Track Construction".

B. At-Grade and Aerial Direct Fixation Rail:
1. Install, fasten, and field weld rail in at-grade and aerial structures direct fixation track to produce zero thermal stress in rail at 85 degrees F plus 10 degrees F and minus 5 degrees F.
2. U-Wall sections are considered to be at-grade for zero thermal stress temperature if the walls are less than 30 feet high above top of rail.

C. The temperature of opposite rails to be within 5 degrees F of each other.

D. The Authority will test the zero thermal stress temperature at 1/2 mile intervals, unless otherwise required by the Authority, using the Vortek "Verse" machine, a non-destructive test method, accurate within plus or minus 2.5 degrees F. The Authority may also employ destructive methods of testing for the actual zero stress temperature. Ballasted track outside the specified limits and the accuracy of the Verse machine (97.5 degrees F to 112.5 degrees F) shall be adjusted to conform to the specifications at no cost to the Authority. Contractor shall provide the necessary support (including labor) to perform the test.

3.14 ADJUSTING RAIL

A. Bring the rail to final line with the rail bearing against the field side shoulder of the fastener.

B. Tension the anchor bolts in accordance with the approved installation procedures.

1. If power wrenches are used for tensioning, adjust them to stall or cut out at the required tension.

2. If manual torque wrenches are used, torque the bolts until the calibrated tension is achieved. Ensure that the anchor bolt is in the tightening position when the torque is measured.
3.15 FASTENING DIRECT FIXATION TRACK

A. Fully tension anchor bolts on the direct fixation fasteners prior to fastening any string of continuous welded rail.

B. Anchor CWR by applying the direct fixation rail clips in accordance with the manufacturer's recommendations and the approved installation procedures.

3.16 AERIAL DIRECT FIXATION TRACK

A. Complete the following sequence when fastening direct fixation aerial track to aerial structures:
   1. Prior to installing direct fixation track to an aerial structure, prepare for installation a minimum of 500 feet of approach track beyond each end of the aerial structure track.
   2. Install all direct fixation fasteners on the aerial structure.
   3. Place the CWR strings throughout the limits of the structure. Fasten rail on approach tracks in accordance with this section or Section 02460, "Ballasted Track Construction". Secure the resilient rail clips on every fifth fastener of the aerial structure, except on curves having radii less than 1,900 feet. Secure every third fastener on curves having radii less than 1,900 feet.
   4. Bring the track throughout the structure, including ballasted track, to the final line and surface shown or specified in accordance with the requirements of Section 02460, "Ballasted Track Construction", and as specified herein for direct fixation track.
   5. Install the remaining resilient rail clips.

3.17 FIELD WELDING IN DIRECT FIXATION TRACK

A. Perform field welding of direct fixation track in accordance with the requirements of Section 02458, "Field Rail Welding".

3.18 SPECIAL TRACKWORK

A. Install direct fixation track within the limits of special trackwork as specified in Section 02459, "Special Trackwork".

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Materials furnished by the Authority will not be measured for payment.
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SECTION 02464
CONCRETE APPROACH SLAB AND TRACK SLAB

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing reinforced Portland cement concrete approach slab and track slabs.
B. Refer to Division 3, Concrete, for concrete provisions applicable to the work of this Section.

PART 2 - PRODUCTS

2.1 CONCRETE
A. Reinforcement and Corrosion Control Bonding Materials: In accordance with Section 03200, "Concrete Reinforcement".
B. Concrete Mix Design: Mix S-3, as specified in Section 03305 "Portland Cement Concrete".

PART 3 - EXECUTION

3.1 CORROSION CONTROL BONDING
A. Provide corrosion control bonding as shown and specified in Section 03200, "Concrete Reinforcement".

3.2 PROTECTION OF CONCRETE PAVEMENT
A. Obtain approval prior to permitting use of completed pavement by construction or other traffic.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. Concrete in transition slab and track slab will be measured and paid for as specified in Section 03300, "Cast-In-Place Concrete".

END OF SECTION 02464
SECTION 02469
TRACK DEMOLITION AND SIGNAL EQUIPMENT REMOVAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. The work covered by this section includes the dismantling, salvaging, and removal from site of certain sections of existing track, associated materials, and signal equipment, the limits of which are as indicated on the Contract Drawings.

B. Material removed and not designated to be re-used in the work or salvaged shall be disposed of by the Contractor.

C. The work shall include transportation of the signal equipment and other items designated for salvage to storage facilities designated by the Contracting Officer.

D. Refer to Section 02050, “Demolition”, for general requirements for demolition.

E. Salvage: Refer to Article entitled “Definitions” in Section 02072, “Removal and Restoration of Miscellaneous Existing Facilities”.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - “Manual for Railway Engineering"
   2. AREMA - “Portfolio of Trackwork Plans"

1.3 SUBMITTALS

A. Submit the following for approval:
   1. Work plan indicating sequence of operation for dismantling, removal from site, and storage of rail, tie plates, and signal equipment.
   2. Work plan indicating sequence of operation for dismantling, removal from site, and disposal of other track materials.

1.4 QUALITY ASSURANCE

A. Comply with:
   1. Codes and regulations of the jurisdictional authority.
   2. AREMA Manual.

PART 2 - PRODUCTS

2.1 BALLAST

A. Ballast removed from line shall be disposed of in accordance with Section 02220, “Grading, Excavating, and Backfilling” except for that portion required for new ballasted freight track, as applicable.

B. Under no circumstances shall ballast removed from line be used in new light rail transit (LRT) trackwork. Ballast for new LRT trackwork shall be in accordance with Section 02453, “Track Ballast”.

PART 3 - EXECUTION

3.1 CONTRACTOR’S STORAGE YARD

A. For material and equipment removed and to be re-used in the work of the Contract, the following provisions apply in addition to those specified in Section 01500, “Temporary Facilities and Controls”, under Contractor’s Facility.

B. Provide aisle ways within the material storage yard to allow access to track material.

C. Prepare and maintain an inventory of stored material.

3.2 DISMANTLING OF TRACKWORK

A. Inspection: Coordinate removal of rail with Contracting Officer to ensure that rail lengths have been properly identified as to final disposition.

B. Dismantle trackwork on site and sort out rails and tie plates. Dismantle special trackwork only to the extent necessary for its transportation and removal from the site. Remove special trackwork completely, including throw rod, front rod, lock rod, point of detection rod, wire and cable, conduit, junction box, and mounting and fastening material. Remove bolts by hand or mechanical means unless frozen and unable to be broken loose. If frozen, bolts may be flame cut.

C. Transport designated rail and tie plates to the storage yard and place in segregated areas.

D. Stack rails on firm, level ground not more than five high. Place a minimum of four hardwood spacers, or as many as necessary to prevent bending, underneath the bottom rails and between subsequent layers of rail.

E. Carefully handle material during removal, transportation, stacking, and storage using
equipment and methods approved by the Contracting Officer. Lift rails only using antislip rail tongs which meet AREMA standards. Take precautions to prevent any damage to the rail.

3.3 DISMANTLING OF SIGNAL EQUIPMENT

A. Remove the signals completely, including supporting brackets or posts, pedestal bases, ladders, conduits, cable, and wire.

B. Remove cases completely, including mounting and fastening material, conduit, trunking, wire, and cable. At locations where track cases are to be removed, the Contractor shall remove the rail connections and track leads along with conduit. Where cases are mounted on a concrete pad by means of expansion bolts, the bolts shall be removed.

C. Remove existing messenger wire, including supporting brackets, dead-ends, insulators, brackets, hooks, clamps, bolts, and other appurtenances.

D. Remove existing junction boxes from the Worksite. The Contractor shall remove these boxes completely, including mounting and fastening materials, conduits, trunking, wire, and cable.

E. Transport signal equipment and associated materials to the storage facility designated by the Contracting Officer and place in segregated areas.

3.4 SITE CLEAN-UP

A. Remove from site and legally dispose of debris and other material resulting from the track demolition and signal equipment removal operations. Burning of any materials on site will not be permitted.

3.5 OWNERSHIP OF MATERIALS

A. Rails, standard tie plates, and material required for freight track modifications designated for salvage or re-use shall remain the property of the Authority.

B. Other rails, joint bars, spikes, bolts, associated hardware, special trackwork, grade crossing panels, other track materials, crossties, switch ties, and miscellaneous debris shall become the property of the Contractor who will be responsible for their removal from site and legal disposition.

C. Ownership of signal equipment shall be as designated on the Contract Drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section will not be measured but will be paid for under the Contract lump sum price for “Track Demolition and Signal Equipment Removal”.

END OF SECTION 02469
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the installation of highway grade crossings to the lines and grades on the Contract Drawings.

B. Concrete headers for highway grade crossings are to be constructed under another contract, unless otherwise noted.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

C. North Central Texas Council of Governments (NCTCOG)
   1. Standard Specifications for Public Works Construction

1.3 SUBMITTALS

A. Work Plan: Submit a workplan for each grade crossing for the Contracting Officer’s approval prior to starting work. The plan shall define the Contractor’s schedule, method and sequence of construction. The workplan shall include maintenance of road traffic including detour and traffic control during construction. The workplan shall include a sketch for each grade crossing locating crossing panels with respect to the concrete headers. Workplan shall be consistent with Contract milestones and Vehicular and Pedestrian Traffic Control Plan.

B. Product Data: Joint filling, preformed joint filler, rail boot, and wood shims. Include data on proposed preservative treatment, grade, and species of wood shims. Include rail boot manufacturer’s installation instructions.

1.4 QUALITY ASSURANCE

A. Comply with codes and regulations of the jurisdictional authorities including the following:

PART 2 - PRODUCTS

2.1 GRADE CROSSINGS, GENERAL

A. Materials necessary for this completion of the work described in this Section shall comply with applicable local codes and requirements of the local jurisdictional authorities.

B. Provide hardware required for installation.

C. Track Gauge: 4 feet 8-1/2 inches, measured at right angle between the inside faces of the running rail at a point 5/8 inch below the plane defined by the top of the two rails.

D. Flangeway:
   1. Flangeway width: Absolute minimum 2-1/4 inches wide, absolute maximum 2-1/2 inches wide (including tolerance).

E. Rail Boot: To ensure that the crossing system has no rail to ground connection or rail to rail connection that will cause grounding of the rail or shunting of the track signal circuit or stray currents from the traction power supply, provide a Rail Boot as shown on the Contract Drawings.

F. Ensure that the crossing system creates no electromagnetic interferences with the Authority’s train-to-wayside signal and train control system, the vehicle propulsion and control system, or the interaction between these systems.

2.2 AUTHORITY FURNISHED MATERIALS

Not Used.

2.3 CONTRACTOR FURNISHED MATERIALS

A. Provide the following items and materials:

B. Joint Filler and Preformed Joint Filler: As shown on the Contract Drawings. Where wood shims do not occur under joint sealant, provide preformed joint filler compatible with joint sealant and approved by the Contracting Officer.

C. Bond Breaker: Asphalt Felt Type II (No. 30) in accordance with ASTM D226.

D. Geotextile Fabrics (Non-Woven Filter Fabric): Provide geotextile fabric as specified in Section 02450, "General Track Construction".

E. Bituminous Pavement Materials: Where shown, furnish bituminous concrete base pavement materials for crossings in accordance with Section 02511, "Bituminous Pavement".
F. Rail Boot System:

1. Provide a rail boot system that provides encapsulation of the running rails in grade crossings so as to isolate the rail electrically and mechanically from the surrounding pavement. Rail boot at each rail shall be continuous along length of crossing, unless otherwise approved. Rail boot size and configuration shall be compatible with Authority-furnished crossing panels.

2. Provide Pip-Fast Rail Boot System as provided by the following manufacturer or approved equal:
   a. Iron Horse Engineering Co.
      4724 Schooner Blvd.
      P.O. Box 5398
      Suffolk, VA 23435

3. The rail boot system shall consist of the following component material:
   a. A rubber “rail boot” extruded profile that fits the shape of the rail section very closely, made from a medium durometer (73), high-dielectric, thermoplastic elastomer with internal shape factor to provide vibration damping, coupled with a minimum volume resistivity of 1x10^{12} ohm-centimeter when tested by soaking 7 days in a saturated NaCl solution. The elastomer shall be impervious to salts, fuels and weather extremes.
   b. Rubber “joining cuffs” shaped to fit the outside profile of the rail boot, used to make water and electrically-tight joints in the boot, usually located at field welds or where boot lengths end.
   c. Butyl sealant, as required by the rail boot manufacturer, to bond and seal the overlap joints between the boots and joining cuffs.
   d. Crumb-rubber/polyurethane resilient grout as required by the rail boot manufacturer for use to fill the void area between the ends of the rail boots, inside the joining cuffs, to prevent any intrusion of water and to prevent sharp weld projections from cutting the cuffs.
   e. Special, non-conductive “duct” tape to hold and seal the rail boot and joining cuffs to the ball of the rail, holding the rubber items tight to the rail profile and preventing the ingress during construction or use a reusable, resilient plastic profile which fits over the boot, holding and sealing it without duct tape.

G. Grade Crossing Panels: Provide grade crossing panels as specified in Section 02476, “Grade Crossing Panels”.

PART 3 - EXECUTION

3.1 GENERAL

A. In addition to the requirements specified herein, installation shall comply with the applicable local codes and requirements of the local jurisdictional authorities.

3.2 INSTALLATION

A. Construct grade crossings to the lines and grades indicated and in accordance with the requirements of AREMA Manual, Chapter 5, “Track”, Part 8 Section 8, Highway/Railway Grade Crossings, except as modified herein.

B. Install ballasted track in accordance with Section 02460, “Ballasted Track Construction”, and approved for alignment and profile by the Contracting Officer. No mechanical hand tampers will be permitted for compaction of ballast in grade crossings.

C. Install 10 foot long crossties at correct position and spacing to satisfy the requirements of the headers, grade crossing panels, and fasteners.

D. Install rail boot in conjunction with rail installation in accordance with rail boot manufacturer’s instructions.

E. Install geotextile fabric where indicated on the Contract Drawings extending to the indicated limits in accordance with the manufacturer’s instructions. Protect geotextile fabrics from puncture throughout construction.

F. Install the crossing panels in accordance with the manufacturer’s instructions and the approved installation procedure.
   1. Respace or replace ties, as necessary, to provide ties at the locations and spacing required by the crossing manufacturer.

G. Phased Construction: During phased construction of a grade crossing, construct temporary roadway consisting of 6 inch thick temporary pavement in accordance with Section 02511, “Bituminous Pavement”. Base course shall consist of compacted ballast in accordance with Section 02453, “Ballast”. Place bituminous pavement on top of two layers of bond breaker placed on top of compacted ballast. Protect concrete.

H. At the time of track installation, remove bituminous pavement and bond breaker (either temporary roadway specified herein or bituminous pavement
installed by others under previous contract). Remove and stockpile for later use sufficient ballast to install ties, rail, and fasteners 2 inches below the finished road surface. Surface and tamp to finished grade prior to installing panels.

3.3 FIELD QUALITY CONTROL
   A. Concrete Crossing Panel Installation: Arrange through the Contracting Officer for the presence of a manufacturer’s representative during installation of the crossings installed under this contract, to supervise and assist in the installation process.

3.4 SUB-BALLAST
   A. On each end of pre-ballasted cross section, check previously placed sub-ballast for grade and crown with templates and straightedges for compliance with tolerances specified Section 02451, “Sub-Ballast”.
   B. Correct deficiencies in grade, contour, and compaction.
   C. Sub-ballast may not be left high.
   D. Prior to subsequent operations, roll sub-ballast with suitable power roller.
   E. Obtain approval of sub-ballast prior to placing ballast.

3.5 PROTECTION
   A. Obtain approval prior to permitting use of completed highway grade crossing by construction or other traffic.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. Highway grade crossing will be measured and paid for at the Contract unit price for each location per track foot, complete-in-place.
   B. No separate measurement or payment will be made for joint filler, rail boot, transportation, and storage, and other work specified in this section.
   C. Removal, and disposal of temporary roadway is incidental to highway grade crossing construction and no separate measurement or payment will be made.

END OF SECTION 02470
SECTION 02471
HIGHWAY GRADE CROSSINGS - CIVIL WORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the installation of highway grade crossings to the lines and grades shown on the Contract Drawings. This section does not include installation of trackwork and crossing panels.

B. Highway grade crossing specified herein includes concrete headers, associated concrete pavement, sub-ballast, and ballast. Includes bituminous pavement roadway to accommodate use of highway crossing by public or construction traffic prior to installation of trackwork and crossing panels.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M81 - Standard Specification for Cut-Back Asphalt (Rapid-Curing Type)
   2. AASHTO M194 - Standard Specification for Chemical Admixtures for Concrete

B. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
   2. ASTM D226 - Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

D. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised

1.3 SUBMITTALS

A. Work Plan: Submit a work plan for each grade crossing for the Contracting Officer’s approval prior to starting work. The plan shall define the Contractor’s schedule, method and sequence of construction, including coordination of the installation of other elements within the crossing area, i.e., utilities, conduits, signal foundations, Workplan shall include maintenance of road traffic including detour and traffic control during construction. Workplan shall be consistent with Contract milestones and as specified in Section 01570, “Maintenance and Control of Traffic”.

B. Shop Drawings: Submit shop drawings showing layout of contraction, and expansion joints.

C. Product Data: Submit product data on joint filler and accessories.

D. Make submittals in accordance with the requirements specified in Section 03305, “Portland Cement Concrete”, including design mixes.

1.4 QUALITY ASSURANCE

A. Concrete: Conform to quality assurance requirements as specified in Section 03305, “Portland Cement Concrete”, and this section.

B. Testing: Subject concrete for slab and header to test procedures specified in Section 03305, “Portland Cement Concrete”.

C. Comply with codes and regulations of the jurisdictional authorities including the following:

PART 2 - PRODUCTS

2.1 GRADE CROSSINGS, GENERAL

A. Materials necessary for this completion of the work described in this Section shall comply with the applicable local codes and requirements of the local jurisdictional authorities.

2.2 MATERIALS

A. Concrete: Provide concrete Mix S-7 in accordance with Section 03305, “Portland Cement Concrete”.

B. Reinforcement: In accordance with Section 03200, “Concrete Reinforcement”.

C. Bituminous Paint: In accordance with AASHTO M81, Grade RC-250.

E. Underdrain Pipe: In accordance with Section 02700, "Storm Sewer Systems".

F. Bond Breaker: Asphalt Felt Type II (No. 30) in accordance with ASTM D226.

G. Base for Pavement: Where shown, furnish base material in accordance with Section 02230, "Base for Pavements".

H. Bituminous Pavement Materials: Where shown, furnish bituminous concrete base pavement materials for crossings in accordance with Section 02511, "Bituminous Pavement".

I. Sub-ballast: In accordance with Section 02451, "Sub-Ballast".

J. Ballast: In accordance with Section 02453, "Track Ballast".

K. Lime: In accordance with Section 02243, "Soil Stabilization: Lime Treatment".

L. Geotextile Fabric: In accordance with Section 02700, "Storm Sewer Systems". Application Type: Erosion Protection.

PART 3 - EXECUTION

3.1 GENERAL

A. In addition to the requirements specified herein, comply with the applicable local codes and requirements of the local jurisdictional authorities shall be used.

3.2 INSTALLATION

A. Construct grade crossings to the lines and grades indicated and in accordance with the requirements of AREMA Manual, Chapter 5, Section 8, "Highway - Railway Crossings", except as modified herein.

B. Compact subgrade and subgrade fill material as shown on Contract Drawings and in accordance with Section 02220, "Grading, Excavating, and Backfilling". Stake centerline of each track for 500 feet in each direction. Set offsets from the centerlines for the track sides of the concrete headers. Set grade stakes for each edge of pavement at each header location. Notify the Contracting Officer seven days in advance so that verification of line and grade can be confirmed before concrete is placed.

C. Perform soil stabilization where indicated on Contract Drawings.

D. Construct concrete headers and concrete slabs which form a part of highway grade crossing as shown on Contract Drawings. Apply one coat of bituminous paint to concrete contact areas of abutting structures and previously placed slabs.

E. Install sub-ballast in accordance with Section 02451, "Sub-Ballast".

F. Install underdrain to the lines and grades shown on the Contract Drawings and in accordance with Section 02700, "Storm Sewer Systems".

G. Install geotextile fabric extending to the indicated limits in accordance with manufacturer's instructions, prior to installation of ballast. Protect geotextile fabric from puncture throughout construction.

H. Install base course of compacted ballast in accordance with Section 02460, "Ballasted Track Construction". Construct 6 inch thick pavement in accordance with Section 02511, "Bituminous Pavement", on top of two layers of bond breaker material.

3.3 JOINTS

A. Joints: Construct in compliance with NCTCOG Standard Specifications for Concrete Pavements.

3.4 REINFORCEMENT

A. Place reinforcement as shown and in accordance with Section 03200, "Concrete Reinforcement".

B. Provide corrosion control bonding as shown and specified in Section 03200, "Concrete Reinforcement".

3.5 CONCRETE

A. Place, finish, and cure Portland cement concrete as specified in Section 03300, "Cast-In-Place Concrete".

3.6 FIELD QUALITY CONTROL

A. Concrete:

1. Straightedges and Templates: In accordance with Article 3.1 of this section.

2. Allowable Tolerances:

   a. Horizontal: plus or minus 1/8 inch.

   b. Vertical: plus or minus 1/8 inch.
3. Perform the following testing in addition to the testing required under Section 03305, “Portland Cement Concrete”. Test Cores:
   a. Provide test cores, four inches in diameter for testing from locations as directed.
   b. Number of cores: One core minimum per 1,000 square yards or fraction thereof of concrete surface with a minimum of two cores per discontinuous segment. Where deficient surface is discovered, take additional cores as directed.
   c. Repair core holes with specified concrete.

3.7 PROTECTION OF CONCRETE PAVEMENT

   A. Obtain approval prior to permitting use of completed pavement by construction or other traffic.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

   A. Highway grade crossing will be measured and paid for at the Contract unit price for each location by track foot, complete-in-place.

   B. No separate measurement or payment will be made for excavation, lime stabilization, subgrade compaction, concrete header, concrete slab, furnishing and installing base, sub-ballast, geotextile fabric, and ballast, transportation, storage, and handling of Authority furnished materials and other work specified in this section, but will be considered included in the Contract unit price for highway grade crossing.

   C. Installation of temporary roadway is incidental to highway grade crossing and no separate measurement will be made.

   D. Underdrain, including its geotextile fabric and filter material, will be measured and paid for in accordance with Section 02700, “Storm Sewer Systems”.

END OF SECTION 02471
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installation of concrete pedestrian crossings in stations, to the lines and grades shown on the Contract drawings.

B. The Contractor shall furnish labor, tools, materials, equipment, facilities, incidentals, and transportation to manufacture, ship, deliver, unload, and install.

C. Concrete pedestrian crossing panels shall consist of new, precast full depth modular, gauge and field panels, and associated anchoring and other hardware necessary for a complete installation without field modifications.

1.2 REFERENCE STANDARDS

A. American Concrete Institute (ACI):
   1. ACI SP-66 - ACI Detailing Manual
   2. ACI 308 - Standard Practice for Curing Concrete
   3. ACI 318 - Building Code Requirements for Structural Concrete

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
   2. ASTM D257 - Standard Test Methods for DC Resistance or Conductance of Insulating Materials

C. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA - "Manual for Railway Engineering" (AREMA Manual)
   2. AREMA - "General Specifications for Highway Grade Crossings Over Railroad Tracks"

D. Concrete Reinforcing Steel Institute (CRSI):
   1. CRSI DA4 - Manual of Standard Practice

E. Precast/Prestressed Concrete Institute (PCI):
   1. PCI/CONCRT MNL-117 - Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products
   2. PCI/CONCRT MNL-119 - Drafting Handbook - Precast and Prestressed Concrete

1.3 QUALITY ASSURANCE

A. Precast Unit Design: The precast units shall be proportioned to resist in-place service loading conditions. Analyze the units for stresses resulting from traffic, fabrication, handling, shipping, storage, erection, connection to the supporting structure, vibrations from the light rail transit (LRT) vehicle during operation, and temperature changes. Select the concrete strength, reinforcement, and lifting devices and procedures necessary to provide precast units conforming to requirements shown and specified.

B. Concrete Sampling and Testing: Fresh concrete used in the work shall be sampled and tested by the testing laboratory using technicians certified by the American Concrete Institute to determine its acceptability as required by ACI 318 and to demonstrate general conformance with specified properties as follows:
   1. Compressive Strength Test: ASTM C39; one specimen tested 7 days, two at 28 days, and one retained in reserve for later testing if required. When frequency of testing will provide less than five strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

   2. Notify the Contracting Officer prior to casting and testing cylinders. Contracting Officer's representative shall be present at the time of casting test cylinders and also shall be present during testing of the cylinders.

1.4 SUBMITTALS

A. Shop Drawings: Submit shop drawings and calculations to the Contracting Officer for approval. Include detailed information concerning installation and layout details for each crossing. Design calculations shall be certified by a registered Professional Engineer.

B. Prepare drawings in accordance with PCI/CONCRT MNL-119, ACI SP66, and CRSI DA4.
Include details of form fabrication, profiles, joints, reinforcing steel, clips, anchors, inserts, reglets, lifting devices, openings, connection to other work and placement, and erection sequence.

C. Product Data: Submit product data on elastomeric material, flangeway filler material, rail boot system, and wood. Include data on proposed preservative treatment, grade, and species.

D. Certification: Provide certification of compliance with requirements as specified herein.

E. Schedule: Submit a manufacturing, curing, testing, delivery, storage, and installation schedule for crossing panels. Arrange for the in-plant inspection of sampling, testing, and other quality control activities. Advise the Contracting Officer of any changes in the schedule as the work progresses.

F. Sample: Submit a color panel sample.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish concrete pedestrian crossing panels with associated installation hardware, including rail boot and any specialized hardware, such as rail clips or insulators, and specialized materials, such as dielectric tape, boot cuffs, sealants, cements.

B. Joint Sealant: Furnish joint sealant as shown on the Contract Drawings and in accordance with Section 07900, "Seals and Sealants".

2.2 PEDESTRIAN CROSSING PANELS

A. Provide crossing panels, elastomeric material, rail boot, and associated hardware required for installation on concrete crossties, spaced on 30 inch centers as shown on Contract Drawing. Crossing panels shall conform to the concrete tie configuration of the Authority and provide an adequate envelope for the fastening system.

B. Provide panels in 10 foot lengths. Crossing panels shall be fully clad with galvanized steel angles on the perimeter of the top surface. Angles shall be sized and anchored to the panel to prevent breakage or cracking during installation and removal of the panels, and related track.

C. Provide crossing panels which fit without field modifications and which are supported on concrete ties without modifications to the ties.

D. Provide crossing panels having been manufactured by a company who has been in production of the panels for similar use for at least two years.

E. Provide crossing panels, which will accommodate a track gauge of 4 feet 8-1/2 inches, measured horizontally between the inside faces of the running rail at a point 5/8 inch below the plane defined by the top of the two rails.

F. Provide crossing panels which will accommodate:

1. A flangeway width of 2-1/4 inches wide absolute minimum; 2-1/2 inches wide absolute maximum (including tolerance).

2. A flangeway depth of 1-3/4 inches.

G. Ensure that the crossing panels have no rail to ground connection or rail to rail connection that will cause grounding of the rail or shunting of the track signal circuit or stray currents from the traction power supply.

H. Crossing Panel Configuration:

1. Crossing panels shall be new, prefabricated modular panels without modifications to design shown on the Standard Drawings, except those approved as necessary to accommodate the Rail Boot. Fastening systems for installation of crossing panels that require either anchor bolts cast in concrete ties or u-bolts that require removal of ballast under concrete tie are not permitted.

2. The running surface of each panel, when installed, shall be 1/8 inch below the top of rail.

3. Crossing panels shall fit without field modifications.

4. Crossing panels shall be designed to allow for quick and easy removal and reinstallation without causing damage to the crossing system itself and without requiring any equipment other than hand tools.

I. Crossing Panel Components: Crossing panels shall be furnished with associated hardware necessary for complete installation including

1. The crossing panels and fasteners necessary for attaching the panels to concrete ties in accordance with manufacturer’s specifications and recommendations.

2. End plates with metal tapered ends or other approved means to close off each end of
the crossing to prevent dragging equipment from damaging the crossing material.

3. Manufactured hardware to attach end plates to the crossing system.

4. Plugs to cover each installation hook hole engineered for a tight, flush fit with the panel's exposed surface.

J. Elastomeric Material:

1. Elastomer used for pedestrian crossing panels shall have a maximum water absorption of 1 percent by weight after twenty-four hours immersion in water as measured in accordance with ASTM D570.

2. Elastomer used for pedestrian crossing panels shall have a minimum volume resistivity of $1 \times 10^{12}$ ohm-centimeters after twenty-four hours immersion in potable water measured in accordance with ASTM D257.

K. Flangeway Filler Material. The material shall have a minimum volume resistivity of $1 \times 10^2$ ohm-centimeters and water absorption of not more than 1 percent along with suitable wearing characteristics.

L. Rail Boot System:

1. Provide a rail boot system that provides encapsulation of the running rails in grade crossings so as to isolate the rail electrically and mechanically from the surrounding pavement. Rail boot at each rail shall be continuous along length of pedestrian crossing, unless otherwise approved.

2. Provide Pip-Fast Rail Boot System as provided by the following manufacturer or approved equal:
   a. Iron Horse Engineering Co.
      4724 Schooner Blvd.
      P.O. Box 5398
      Suffolk, VA 23435
   b. Rubber "joining cuffs" shaped to fit the outside profile of the rail boot, used to make water and electrically-tight joints in the boot, usually located at field welds or where boot lengths end.
   c. Butyl sealant, as required by the rail boot manufacturer, to bond and seal the overlap joints between the boots and joining cuffs.
   d. Crumb-rubber/polyurethane resilient grout as required by the rail boot manufacturer for use to fill the void area between the ends of the rail boots, inside the joining cuffs, to prevent any intrusion of water and to prevent sharp weld projections from cutting the cuffs.
   e. Special, non-conductive "duct" tape to hold and seal the rail boot and joining cuffs to the ball of the rail, holding the rubber items tight to the rail profile and preventing the ingress during construction or use of a reusable, resilient plastic profile which fits over the boot, holding and sealing it without duct tape.

2.3 TIMBER SPACER

A. Pressure preservative treated wood, treat after fabrication.

B. Preservative treatment for cut ends and drilled holes: As specified in Section 06100, "Rough Carpentry".

2.4 MANUFACTURE

A. Fabrication:

1. Formwork: Accurately construct forms, mortar-tight, and of sufficient strength to withstand pressures resulting from concrete placing operations and temperature changes. Maintain formwork to provide completed precast concrete units of shapes, lines, and dimensions indicated in Contract plans.

3. Surface Finishes: Provide exposed surface finishes for precast units as specified herein.
   a. Surface Finish: Finish shall be light sandblast as described in Section 03350 “Concrete Finishing”. Provide surfaces free of pockets, streaks, and honeycomb, with uniform color and texture to match approved control sample. Penetrating type surface sealer shall be applied to surface finish.
   b. Unexposed surfaces shall have a formed or float finish.

4. Curing: Liquid membrane curing compound shall not be applied to surfaces which will be sealed or painted. Follow recommendations in ACI 308 and PCI/CONCRTMNL-117.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not install pedestrian crossing panels until the track has been accepted by the Contracting Officer for line and surface. Verify proper horizontal and vertical dimensions between tracks and station platforms before installation. Assure that the vertical offset between crossing panels and station platform warning strips at end crossings does not exceed 1/4 inch and that the offset at the center crossing is 8 inches, plus or minus 1/4 inch.

B. Construct pedestrian crossings to the lines and grades indicated and in accordance with the requirements of AREMA, “General Specifications for Highway Grade Crossings Over Railroad Tracks”, except as modified herein.

C. Verify that ballasted track has been installed in accordance with the Specifications and approved for alignment and profile by the Contracting Officer.

D. Verify that crossties are of correct length, position, and spacing to satisfy the requirements of the pedestrian crossing panels and fasteners. Correct any deficiencies prior to proceeding with pedestrian crossing installation.

E. Install the concrete crossing panels in accordance with the approved installation procedure.

1. Install Rail Boots in accordance with the manufacturer’s instructions and the approved installation procedure.

2. Install expansion joints and flangeway filler material.

3. Install joint sealant between crossing panels and the station platforms as required and in accordance with Section 07900, “Seals and Sealants”.

4. Use fasteners and abrasion pads.

F. Install joint sealant between adjacent crossing panels as required to maintain a watertight surface.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Pedestrian crossings in stations will not be measured, but will be paid for at the Contract lump price, complete-in-place.

B. No separate measurement will be made for concrete pedestrian crossing panels, elastomeric material, joint sealant, and all other related work specified in this section and shown on the plans.

END OF SECTION 02473
PART 1 - GENERAL

1.1 DESCRIPTION

A. Contractor shall furnish all labor, tools, materials, equipment, facilities, incidentals and transportation, to manufacture, test, ship, deliver and place into storage.

B. Grade crossing panels shall be precast concrete panels.

C. Grade crossing panels shall consist of new, full depth modular gauge and field panels and all associated hardware and fastenings necessary for a complete installation without field modifications or additional materials.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):

1. AREMA - "Manual for Railway Engineering" (AREMA Manual)

B. American Association of State Highway and Transportation Officials (AASHTO)

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

2. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
10. ASTM D2000 - Classification System for Rubber Products in Automotive Applications.
12. ASTM E329 - Standard Recommended Practice for Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction.

D. American Concrete Institute (ACI):

1. ACI SP-66 - ACI Detailing Manual
2. ACI 308.1 - Standard Specification for Curing Concrete
3. ACI 318/318R - Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R)

E. Precast/Prestressed Concrete Institute (PCI):

1. PCI/CONCRT MNL-116 - Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
2. PCI/CONCRT MNL-119 - Drafting Handbook - Precast and Prestressed Concrete

F. Concrete Reinforcing Steel Institute (CRSI):

1. CRSI DA4 - Manual of Standard Practice

1.3 SUBMITTALS

A. Shop Drawings: Submit 1 reproducible and 2 legible copies of shop drawings and calculations to the Contracting Officer for approval. Include detailed information concerning installation and layout details for each crossing.

B. Certification: Provide certification of compliance with requirements as specified herein.

C. For concrete Grade Crossing Panels: Prepare shop drawings in accordance with PCI/CONCRT MNL-119, ACI SP66, and CRSI DA4. Include details of form fabrication, profiles, joints, reinforcing steel, clips, anchors, inserts, ringlets, lifting devices, openings, connection to other work and placement, and erection sequence.

D. Calculations: The precast units have been proportioned to resist in-place service loading conditions only. Using the services of a registered Professional Structural Engineer experienced in...
precast concrete design, analyze the units for stresses resulting from all grade crossing traffic, fabrication, handling, shipping, storage, erection, connection to the supporting structure, vibrations from the Authority's selected Light Rail Transit vehicle during operation, and temperature changes. Select the concrete strength, reinforcement, and lifting devices and procedures necessary to provide precast units conforming to requirements shown and specified. Maintain general design concept shown without increasing or decreasing sizes of members or altering profiles or alignment. Provide complete design calculations and drawings prepared and sealed by a Professional Structural Engineer.

E. The manufacturer of the grade crossing panels shall provide detailed installation procedures and recommendations for the contractor's use.

F. Submit Quality Assurance Program Manual as described in Article 1.4, below. The manual shall fully describe the Quality Assurance Program and provide the means for its implementation.

1.4. QUALITY ASSURANCE

A. Manufacturer's Qualifications for concrete Grade Crossing Panels: Successful experience in the fabrication of precast concrete grade crossing systems manufactured for similar applications and have been successfully used in the United States for the last 2 years by a class one railroad or transit agency in a highway or city street environment.

B. Quality Control shall be in conformance with the requirements of PCI MNL-116, current edition. The supplier shall establish, implement and maintain a Quality Assurance program according to the requirements of this standard.

C. Concrete Sampling and Testing: Fresh concrete used in the work shall be sampled and tested by the testing laboratory using technicians certified by the American Concrete Institute to determine its acceptability as required by ACI 318 and to demonstrate general conformance with specified properties as follows:

1. Compressive Strength Test: ASTM C39/C39M; one specimen tested at 7 days, two at 28 days, and one retained in reserve for later testing if required. When frequency of testing will provide less than 5 strength tests for a given class of concrete, testing shall be conducted from at least 5 selected batches or from each batch if fewer than 5 are used.

2. Contracting Officer's representative may be present at the time of casting all test cylinders and also may be present during testing of the cylinders.

D. Calculations: Design calculations shall be certified by a registered Professional Engineer.

E. Guarantees, Warranties, and Bonds: Furnish one executed original and three copies.

1.5 SHOP INSPECTION

A. Provide the Contracting Officer free entry at all times to the manufacturer's shop to inspect the processing and manufacture of the grade crossing panels and accessories while work under this Contract is being performed. Have the manufacturer, at no additional cost to the Authority, provide the Contracting Officer with all labor, machinery, material, tools, and equipment necessary to prepare test specimens to satisfy the Contracting Officer that the fabrication of the grade crossing panels is being performed and accessories are being furnished in accordance with these specifications.

B. In-Shop Inspection: Schedule in-shop inspections at a time agreeable to the Contracting Officer. Provide the inspection schedule to the Contracting Officer at least 30 days in advance of the initial in-shop inspection and 10 days in advance of subsequent in-shop inspections.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver grade crossing panels to the Worksite in such quantities and at such time to assure continuity of installation.

B. Store and handle units at the Worksite in such a manner to prevent cracking, chipping, distorting, warping, or other physical damage. Lift and support units only at designated lifting or supporting points as shown on approved shop drawings.

PART 2 - PRODUCTS

2.1 GRADE CROSSING PANELS, GENERAL

A. Provide grade crossing panel material and associated hardware required for installation on 10 feet 0 inch concrete crossties spaced on 24 inch centers unless otherwise shown on the contract drawings. Concrete grade crossing panels shall be manufactured for special trackwork areas to ensure ends of panels are positioned over the centerline of concrete ties as shown on the contract documents. Grade crossing panels shall conform to and provide an envelope for the fastening system.

B. Provide grade crossing panels that facilitate easy removal and reinstallation without causing damage to the system. Maximum grade crossing panel lengths shall be 12 feet and minimum grade
crossing panel length shall be 8 feet unless otherwise specified on the Contract Drawings.

C. Track Gauge: 4 feet 8-1/2 inches, measured horizontally between the inside faces of the running rail at a point 5/8 inch below the plane defined by the top of the two rails. Restraining Rail Gauge: 4 feet 3-3/4 inches, measured horizontally between the inside face of the running rail and restraining rail at a point 5/8 inch below the plane defined by the top of the two rails.

D. Field grade crossing panels shall conform to the spacing of the concrete headers as shown on the drawings, providing a stabilized, movement free installation. Where concrete headers are not shown on drawings, provide gauge and field panel lengths as shown on the Grade Crossing Summary drawing.

E. Flangeway:
   1. Flangeway Width: Minimum 2-1/4 inches wide; maximum 2-1/2 inches wide.

F. Grade crossing panels are to be designed to withstand the following service conditions as per ACI, AASHTO and AREMA requirements:
   1. Light rail train speeds to 65 mph.
   2. Truck and auto speeds to 55 mph.
   3. Truck loading HS-20.
   4. Service life of 25 years.
   5. Portions of individual crossings will be used for pedestrian traffic and must have a safe walking surface.
   6. Design detailing shall be similar to illustration on attached BNSF/UP Common Standard Drawing No. 200302.

G. To ensure that the grade crossing panels have no rail to ground connection or rail to rail connection that will cause grounding of the rail or shunting of the track signal circuit or stray currents from the traction power supply, a Rail Boot shall be used. Grade crossing panels shall be designed to accommodate the installation of the Rail Boots.

H. Panels shall have minimum frame cladding as shown on the Contract Drawings.

I. End cladding angles for gauge panels shall have a 3 inch gap minimum to improve shunt resistance. Non-conductive spacer is to be attached to the gauge frame.

J. Contractor shall coordinate manufacture of all grade crossing panels within special trackwork areas to conform to tie layout and special trackwork components, i.e., frogs, guardrails and restraining rails as shown on the Contract Documents.

K. Contractor shall manufacture all materials necessary for special trackwork areas to provide complete coverage of the track structure within the grade crossing limits while conforming to specifications described herein.

2.2 PRE-CAST CONCRETE GRADE CROSSING PANELS

A. Furnish grade crossing panels fabricated of a precast, full depth concrete design capable of withstand: temperatures of 20 degrees F to plus 150 degrees F; degradation from oxidation, water, alkali, petroleum products, synthetic lubricants, and sunlight without having detrimental effect on the performance of the crossing. Grade crossing panel design shall be able to withstand the rigors of installation and re-installation including the application of fasteners and accessories without breaking, cracking, or any other detrimental effect on the performance of the grade crossing panels.

B. Design of Precast Concrete Grade Crossing Panels:
   1. Concrete Materials:
      a. Portland Cement:
         1) ASTM C150, Type II or Type III, low alkali (having not more than 0.60 percent alkali content per Table 1A, “Optional Chemical Requirements).
         2) Use only one brand, type, and source of supply of cement, unless noted otherwise.
      b. Aggregates:
         1) Coarse aggregate for mixes is to conform with ASTM C33; hard, durable, selected, and graded; free of material that causes staining or reacting with cement.
         2) Fine aggregate for mixes is to conform with ASTM C33; manufactured sand of same material as coarse aggregates, unless
GRADE CROSSING PANELS

approved otherwise by the Contracting Officer.

c. Water: Potable, free from foreign materials in amounts harmful to concrete and embedded steel.

C. Proportioning and Design of Concrete Mixes:

1. Design mixes are to be certified by an independent testing facility or by qualified precast manufacturing plant personnel, at precast fabricator's option.

2. Proportion mixes by either laboratory trial batch or field experience methods, using materials to be utilized on the project for each type of concrete required, complying with ACI 318.

3. Compressive strength: 6000 psi at 28 days minimum, 2500 psi minimum before removing from forms and 4000 psi minimum before shipment.

4. Total air content: Not less than 5 percent or more than 7 percent.

5. Slump of concrete shall not exceed 3 inches unless approved by the Contracting Officer.

6. Maximum water-cement ratio shall not exceed 0.45 (by weight).

7. Minimum cement content shall be 650 pounds per cubic yard.

8. Adjustment to concrete mixes: Mix design adjustments may be requested when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Laboratory test data for revised mix designs and strength results shall be submitted to and approved by the Contracting Officer before using in the work.

9. Use air-entraining admixtures in strict compliance with manufacturer's instructions. Admixtures to increase cement dispersion or provide increased workability for low-slump concrete may be used subject to the approval of the Contracting Officer.

10. Use admixtures in conformance with manufacturer's recommendations for climatic conditions prevailing at time of placing. Adjust quantities of admixtures as required to maintain quality control.

D. Reinforcement:

1. Structural steel shall conform to ASTM A36/A36M specifications.

2. Reinforcing steel shall conform to ASTM A615 specifications and shall meet Grade 60 requirements.

3. High Strength Prestressing wire, standard in some panel systems, is acceptable.

E. Grade Crossing Panel Configuration:

1. Grade crossing panels shall be new, prefabricated modular panels without modifications to standard design, except those approved as necessary to accommodate the rail fasteners, the Rail Boots and special trackwork components. Fastening systems for installation of grade crossing panels, that require either anchor bolts cast in concrete ties or u-bolts that require removal of ballast under concrete ties are not permitted.

2. The running surface of each panel, when installed, shall be 1/8 inch below the top of rail.

3. Grade crossing panels shall fit without field modifications.

4. Grade crossing panels shall be designed to allow for quick and easy removal and re-installation without causing damage to the crossing system itself.

5. Neither removal or re-installation of the grade crossing panels shall require additional materials, other than required sealers or fillers.

6. Panels shall be field welded with a minimum 2 inch weld in accordance with Section 02458, “Field Rail Welding”, to prevent movement.

F. Grade Crossing Panel Components: Grade crossing panels shall be furnished with all associated hardware, as required, necessary for complete installation including:

1. The grade crossing panels in accordance with manufacturer's specifications and recommendations.

2. End plates with tapered ends or other approved means to close off each end of the crossing to prevent dragging equipment along the track from damaging the crossing material.
3. Manufactured hardware to attach end plates to the crossing system, as required, depending on the system provided.

4. Elastomeric shims to support grade crossing panels over concrete ties shall be provided.

5. Continuous one piece rubber boot with internal shape factor, high dielectric strength extending a minimum of 8 inches past each end of grade crossing panels.

2.4 MANUFACTURE

A. Fabrication: Grade crossing panels shall be manufactured to match the centerline track radius as required for crossings which are in spirals and curves.

B. Fabrication of Concrete Grade Crossing Panels:

1. Formwork: Accurately construct forms, mortar-tight, and of sufficient strength to withstand pressures resulting from concrete placing operations and temperature changes. Maintain formwork to provide completed precast concrete units of shapes, lines, and dimensions indicated in plans attached herewith within specified fabrication tolerances.

2. Consolidating:

a. Concrete shall be thoroughly consolidated by vibration during placement, and shall be thoroughly worked around the prestressing tendons, embedded inserts, and into corners of the forms. Consolidate concrete to the requirements of ACI 309R.

b. External form vibration, internal concrete vibration, or a combination of both shall be used to obtain uniform mix, and shall be sufficient to yield concrete with a density of not less than 143 pounds per cubic foot.

c. Forms shall not be damaged during consolidation.

3. Surface Finishes: Provide exposed surface finishes for precast units as specified herein.

a. Textured Surface Finish: Finish shall be skid resistant with broom finish perpendicular to the main traffic route. Provide surfaces free of pockets, streaks, and honeycomb, with uniform texture to match approved control sample.

b. Unexposed surfaces shall have a formed or float finish.

4. Curing: Liquid membrane curing compound shall not be applied to surfaces which will
C. Branding and Stamping: Grade crossing panels shall be marked to match approved shop drawings, with clearly identifiable markings, for ease of installation and compliance with installation requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Grade crossing panels shall be installed as per Section 02470, “Highway Grade Crossing - Trackwork”.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Grade crossing panels will be measured and paid for by the track foot of the gauge panels and will include gauge and field grade crossing panels, rail boot, end plates, transportation, site preparation, storage, and all other related work specified in this section and shown on the plans.

END OF SECTION 02476
CROSS SECTION - GAGE PANEL

5/8" DIA, x 24" LONG
DEFORMED BAR ANCHORS (18 PCS)
(SIDE FRAME)

#5 REBAR
116" LONG TOP (6 PCS)
116" LONG BTM (6 PCS)

1/2" DIA, x 2-1/2" LONG HEADED
ANCHOR STUD (18 PCS TOTAL) (SIDE FRAME)

3/8" DIA, x 4" LONG HEADED
ANCHOR STUD (8 PCS TOTAL)
(END FRAME)

CROSS SECTION - FIELD PANEL

#5 REBAR
116" LONG TOP (6 PCS)
116" LONG BTM (6 PCS)

1/2" DIA, x 2-1/2" LONG
HEADED ANCHOR STUD
(20 PCS TOTAL) (SIDE FRAME)

1/2" DIA, x 18" LONG DEFORMED
BAR ANCHORS (18 PCS) (SIDE FRAME)

3/8" DIA, x 4" LONG HEADED
ANCHOR STUD (4 PCS TOTAL)
(END FRAME)

FIELD PANEL

1/2" DIA, x 12" LONG
DEFORMED BAR ANCHOR
(12 PCS TOTAL)
(END FRAME)

1/2" DIA, x 12" LONG
DEFORMED BAR ANCHOR
(4 PCS TOTAL)
(END FRAME)

1/2" DIA, x 12" LONG
DEFORMED BAR ANCHOR
(4 PCS TOTAL)
(END FRAME)

3/8" DIA, x 4" LONG
HEADED ANCHOR
STUD (4 PCS TOTAL)
(END FRAME)

COMMON STANDARDS

FOR 10' CONCRETE TIES (10C)

NOTES:
CONCRETE COMpressive STRENGTH SHALL BE
AS FOLLOWS:
@ 28 DAYS = 5000 psi MINIMUM
@ SHIPMENT = 4000 psi MINIMUM
@ REMOVAL FROM FORMS = 2500 psi MINIMUM.
CROSSING TYPE - 10C

FOR INFORMATION ONLY
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing asphaltic surface and base courses on prepared lime treated soil subgrades or constructed flexible base course in conformance with section, lines, and grades shown.

B. For work done in the right-of-way of other jurisdictional agencies, the minimum requirements of the jurisdictional agency shall apply, unless otherwise directed on the plans.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M140 - Standard Specification for Emulsified Asphalt
   3. AASHTO M208 - Standard Specification for Cationic Emulsified Asphalt
   4. AASHTO T30 - Standard Method of Test for Mechanical Analysis of Extracted Aggregate
   5. AASHTO T164 - Standard Method of Test for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
   6. AASHTO T165 - Standard Method of Test for Effect of Water on Cohesion of Compacted Bituminous Mixtures
   7. AASHTO T168 - Standard Method of Test for Sampling Bituminous Paving Mixtures
   8. AASHTO T230 - Standard Method of Test for Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures

B. Asphalt Institute (AI):
   1. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D2950 - Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods

D. Texas Department of Transportation (TxDOT)
   2. TxDOT Manual of Testing Procedures (TEX):
      a. TEX-106-E, Calculating the Plasticity Index of Soils
      b. TEX-200-F, Sieve Analysis of Fine and Coarse Aggregates
      c. TEX-217-F, Determining Deleterious Material and Decantation Test for Coarse Aggregates
      d. TEX-410-A, Abrasion of Coarse Aggregate Using the Los Angeles Machine

1.3 SUBMITTALS

A. Mix Design: In addition to the requirements of the AI MS-2, with bulk specific gravity determined in accordance with AASHTO T165; submit the following:
   1. For each mix to be supplied submit mix design based on expected production averages.
   2. In mix design establish:
      a. Weight percent of total aggregate and of aggregate finer than each required sieve size.
      b. Weight percent of total mix of asphalt cement.
      c. Temperature of mix when batched.
   3. Maintain mix design once approved.

B. Certification: For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests. Material certifications and test results shall not be older than 6 months from proposed use dates.

C. Documentation: Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
   1. Mix type.
   2. Mix temperature.
3. Identification of the truck.
4. Tare weight of truck.
5. Loaded weight of truck.
7. Time of leaving mix plant.
8. Signature of the plant representative and date.

D. Source of Supply: Submit under Section 01450, “Quality Control”.
E. Compaction Equipment: Submit data on proposed equipment.

1.4 QUALITY ASSURANCE
A. Sources of Supply:
1. Once approved, do not change source of supply, unless approved by the Contracting Officer.
2. Do not construe approval as approval of entire location but as approved only insofar as material continues to meet specified requirements.
3. Maintain quality of material. Material may be sampled and tested by the Contracting Officer as often as deemed necessary.
4. The Contracting Officer has the right to reject material at the Worksite by visual inspection pending sampling and testing.

B. Bituminous products and solvents shall be compliant with the latest regulations of the Texas Commission on Environmental Quality (TCEQ) and other jurisdictional authorities regarding regulations governing permissible content of volatile organic compounds (VOCs).

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Delivery Trucks:
1. For transporting bituminous mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40 degrees F.

B. Weighing of Bituminous Mixtures:
1. Provide approved truck scales having both dial and automatic printer or use public scales.
2. Use scales complying with applicable laws, ordinances, and regulations governing use of scales.
3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy.
4. At least once a week, check tare weight of each truck with full load of fuel and fitted with its equipment.

1.6 JOB CONDITIONS
A. Do not place bituminous pavement on wet surfaces.
B. Do not place bituminous pavement when the ambient temperature is 50 degrees F and falling or when the temperature of the base is less than 40 degrees F. Bituminous pavement may be placed when the ambient temperature is above 40 degrees F and rising. Take the ambient temperature in the shade and away from artificial heat.

PART 2 - PRODUCTS

2.1 ASPHALT CEMENT
A. AASHTO Viscosity Grade AC-20.

2.2 CUT-BACK ASPHALT
A. Cut-Back Asphalt for Prime Coat: Equivalent to AASHTO Viscosity Grade AC-20.
B. Liquid Asphalt for Prime Coat: SC-70 or SC-250 as applicable; Slow curing type.

2.3 EMULSIFIED ASPHALT
A. Emulsified Asphalt for Tack Coat: SS-1 or SS-1h, diluted 1 part water to 1 part emulsified asphalt. Prior to dilution, emulsified asphalt to comply with AASHTO M140 or M208. Apply at rate of 0.05 to 0.15 gallons per square yard.
2.4 AGGREGATE

A. Sand:

1. General: Sand material shall constitute a part of the final aggregates for hot mix asphalt concrete (HMAC).

2. Deleterious Substances: The sand used as fine aggregates shall be free from loam, clay balls or other injurious foreign matter.

3. Tests: The plasticity index of that portion of the fine aggregates sand passing the No. 40 (425 um) sieve shall not be more than 6 when tested in accordance with TEX-106-E.

4. Gradation: Fine aggregate sand shall be that portion of the sand in the total aggregate passing the No. 10 (2.0 mm) sieve. It shall be well graded and composed of sound, durable sand particles.

B. Stone Screenings:

1. General: Stone screenings may constitute part or all of the fine aggregates for HMAC. Screenings shall be of the same or similar material for coarse aggregates.

2. Deleterious Substances: The screenings shall be free from loam, clay balls or other injurious foreign matter.

3. Tests: The plasticity index of that portion of the fine aggregates passing the No. 40 (425 um) sieve shall not be more than 6 when tested in accordance with TEX-106-E. Fine aggregates from each source shall meet plasticity requirements.

4. Gradation: The stone screening shall meet the following grading requirements unless otherwise shown on the plans:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 3/8-inch</td>
<td>100</td>
</tr>
<tr>
<td>Passing No. 10</td>
<td>70 - 100</td>
</tr>
<tr>
<td>Passing No. 200</td>
<td>0 - 15</td>
</tr>
</tbody>
</table>

5. When authorized by the Contracting Officer, stone screenings containing particles larger than 3/8 inch may be used but only that portion of the material passing the 3/8 inch sieve shall be considered as fulfilling the requirements for screening when a minimum percent of screenings is specified for a particular mixture.

6. Additional Requirements: Where limestone rock asphalt screenings are specified for use, they shall be screenings resulting from crushing operation.

7. Rejection: Sand which fails to meet the requirements of these Specifications may be rejected by the Contracting Officer. Such rejections shall incur no cost to the Authority.

8. Sand sources, from which materials not meeting these Specifications are delivered, may be rejected as further supply sources to the project by the Contracting Officer. Such rejections shall incur no cost to the Authority.

C. Coarse Aggregates:

1. General: Coarse aggregates shall consist of clean, tough, durable fragments of crushed stone, crushed gravel, or gravel as specified herein, of uniform quality throughout.

2. Deleterious Substances: The coarse aggregates shall be free from clay, organic, or other injurious matter occurring either free or as a coating on the aggregates.

3. Tests: Material removed by decantation in accordance with TEX-217-F (Part II, Decantation) shall not be more than 2 percent. The stone or gravel from which the aggregates are made shall have an abrasion of not more than 40 for all courses except the non-skid surface course, which shall have an abrasion of not more than 35. These figures may be calculated in accordance TEX-410-A.

4. Gradation: The coarse aggregates shall be that portion of the total aggregates retained on the No. 10 sieve (2.0 mm). The crushed gravel shall be so crushed that not less than 85 percent of the particles shall have more than one crushed face. The use of uncrushed gravel shall be permitted only in the coarse binder course.

5. Additional Requirements: When it is specified that the coarse aggregates be sampled from the hot bins and tested in accordance with TEX-217-F (Part II, Decantation), the amount of material removed shall not exceed 1 percent.

6. Coarse aggregates sources from which materials with properties not meeting these specifications are delivered may be rejected as further suppliers to the project by the Contracting Officer. Such rejections shall incur no cost to the Authority.

D. Mineral Filler:

1. General: Mineral filler shall consist of a thoroughly dry stone dust, Portland cement, or other mineral dust approved by the Contracting Officer.
2. Deleterious Substances: The mineral filler shall be free from foreign and other injurious matter.

3. Gradation: When tested by the method outlined in TEX-200-F (Part I or Part 3 as applicable), it shall meet the following percentages by weight:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent by Weight or Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing No. 30 sieve (600 um)</td>
<td>95 - 100</td>
</tr>
<tr>
<td>Passing No. 80 sieve (180 um)</td>
<td>Not less than 75</td>
</tr>
<tr>
<td>Passing No. 200 sieve (75 um)</td>
<td>Not less than 55</td>
</tr>
</tbody>
</table>

4. Rejection: Mineral filler which fails to meet the requirements of these Specifications may be rejected by the Contracting Officer. Such rejections shall incur no cost to the Authority.

5. Mineral filler sources, from which materials with properties not meeting these Specifications are delivered, may be rejected as further suppliers to the project by the Contracting Officer. Such rejections shall incur no cost to the Authority.

E. Seal Coat: Fog seal coat or fine seal coat, as indicated.

2.5 MIXES

A. Design of mixes shall be provided by the Contractor, and shall be obtained from a qualified independent testing laboratory or agency, properly equipped to design bituminous concrete mixes. Costs of obtaining mix designs shall be at the Contractor’s expense.

B. Design of mixes including aggregate quality and degradation, shall conform with the quality requirements of TxDOT.

C. Proportion constituents of job mixes within limits specified in Table 02511-1.

PART 3 - EXECUTION

3.1 EQUIPMENT

A. Equipment for Preparing Bituminous Material: Use bituminous paving material prepared in mixing plant conforming to AASHTO M156.

B. Equipment for Spreading and Finishing Bituminous Material:

1. Use equipment capable of placing and screeding material at widths ranging up to 12 feet by increments of 1 foot and at varying thickness.

2. Use machines which spread bituminous mixture without tearing surface. Achieve finish that is smooth, true to cross section, uniform in density and texture and free from hollows, corrugations, and other irregularities.

C. Equipment for Compacting: Provide approved equipment capable of compacting materials to specified Marshall density.

3.2 BASE PREPARATION

A. Subgrade shall be prepared as shown on the Contract Drawings. Sand or other granular leveling material shall be specifically prohibited beneath pavement areas.

B. Obtain Contracting Officer’s approval of base prior to placement of surface course.

C. Aggregate and Soil Aggregate Bases:

1. Apply cut-back asphalt primer at rate of 0.2 to 0.5 gallon per square yard when base is damp but with no standing water.

2. Allow 24 hours for base to entirely absorb primer. Blot excess primer with just enough sand to prevent pickup under traffic. Sweep loose sand from base before placing asphalt base course.

D. Portland Cement Concrete, Bituminous, and Brick Pavement Bases:

1. Apply tack coat using equipment designed for purpose.

2. Apply tack coat uniformly to clean dry base at rate of 0.05 to 0.15 gallons per square yard.

3. Ensure that surface has cured and is satisfactorily tacky before placing mix.

E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes, and similar structures.

3.3 PLACING MIX

A. Place base course mixture in one or more lifts with asphalt paver or spreader to provide nominal compacted thickness as shown. Place surface course mixture with asphalt paver to provide nominal compacted thickness as shown. Minimum lift thickness shall be at least 2 times maximum particle size. Maximum lift thickness to be that which can be demonstrated to be laid in a single lift and compacted to required uniform density and smoothness. Place material in continuous
operation. Correct irregularities before final compaction of mixture.

B. If equipment being used produces tracks, pulling, indented areas, or other permanent blemishes in material being spread, remove such equipment from Worksite and substitute other approved spreading and finishing equipment. Repair affected areas disturbed by equipment.

C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.

D. Adjacent to headers, gutters, manholes, and similar structures, place surface course so that finished surface is 1/4 inch above edge of structure.

3.4 COMPACTION

A. Compact immediately after placing. Initial rolling shall be with steel-wheel tandem roller, steel three-wheel roller, vibratory roller, or pneumatic-tire roller following paver as closely as possible, oriented with drive wheel closest to paver. If intermediate rolling is needed, use pneumatic-tire roller immediately behind initial rolling. Final rolling shall be with steel tandem roller. Use vibrating plate compactor or hand tamper to achieve thorough compaction in areas too small for roller.

3.5 COLD JOINTS

A. Longitudinal: Apply tack coat to cold material before joining new work.

B. Transverse: Place bulkhead full depth of course or cut back minimum of 3 inches from sloping surface with masonry saw. Apply tack coat to cold material.

C. Cold material is any material whose temperature is below 250 degrees F.

3.6 BULKHEADS

A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.

B. Construct cold joint as specified when work is resumed.

3.7 HANDWORK

A. When approved, perform bituminous paving work by hand.

B. Undertake handwork using equipment designed and approved for purpose.

C. Perform handwork so that resulting paving meets specified requirements.

3.8 FIELD QUALITY CONTROL

A. Allowable Tolerances:

1. Place bituminous pavement to within tolerance of plus or minus 1/8 inch of thickness shown.

2. Construct surfaces to the following tolerances:
   a. Base courses to within plus or minus 3/8 inch of elevation shown.
   b. Surface courses to within plus or minus 3/16 inch of elevation shown.
   c. Surfaces to deviate no more than 1/4 inch in the length of 10 foot steel straightedge, not cumulative.

3. For base courses, attain 94 percent of Marshall density.

4. For surface courses, attain 96 percent of Marshall density.

B. Testing:

1. Mixes: During course of the work, submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and T164 on random samples selected in accordance with AASHTO T168.

2. Determine density of base and surface courses by one of the following methods:
   a. Take samples of base and surface courses from locations designated by the Contracting Officer and test against the job mix formula in accordance with AASHTO T230.
   b. Test base and surface courses for density and thickness with a nuclear density meter in accordance with ASTM D2950.

   1) Number of cores/tests not exceeding 1 core/test per 500 square yards of bituminous pavements or 2 cores per shift, whichever is greater.

   2) Wherever deficient pavement is discovered take such additional cores/tests as directed.

   3) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course
simultaneously, use surface course mix for repair work.

C. After completion of paving work, paving shall be flooded with water, and any resulting ‘ponds’ shall be ringed with chalk. Such hollows shall be corrected with addition of bituminous materials and rerolling until paving is completely level and free from hollows and high spots.

3.9 PROTECTION OF BITUMINOUS PAVEMENT

A. Obtain approval for use of pavement by public and construction traffic.

B. Do not permit traffic to cross uncompleted longitudinal joints.

3.10 DEFICIENT PAVEMENT

A. Where directed, replace new material or repair bituminous pavement that does not meet specified requirements at no cost to Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Prime coat and tack coat will not be measured separately, but will be considered subsidiary to placing bituminous pavement of the type specified.

B. Bituminous pavement will be not be measured, but will be paid for at the lump sum price for “Hot Mix Asphaltic Concrete Pavement” for each type for each location.

C. Bituminous pavement, prime coats, and tack coats used as temporary pavement structure for the purpose of traffic maintenance and control will not be measured or paid for, but will be considered subsidiary to the work described in Section 01570, “Maintenance and Control of Traffic”.

TABLE 02511 - 1
CONSTITUENT PROPORTIONS
GRADING OF TOTAL AGGREGATE
(COARSE, FINE, MINERAL FILLER: AS NECESSARY)

FINE BASE COURSE (TYPE B)

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight or Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch sieve</td>
<td>100</td>
</tr>
<tr>
<td>7/8 inch sieve</td>
<td>95 - 100</td>
</tr>
<tr>
<td>5/8 inch sieve</td>
<td>75 - 95</td>
</tr>
<tr>
<td>3/8 inch sieve</td>
<td>60 - 80</td>
</tr>
<tr>
<td>No. 4 sieve</td>
<td>40 - 60</td>
</tr>
<tr>
<td>No. 10 sieve</td>
<td>27 - 40</td>
</tr>
<tr>
<td>No. 40 sieve</td>
<td>10 - 25</td>
</tr>
<tr>
<td>No. 80 sieve</td>
<td>3 - 13</td>
</tr>
<tr>
<td>No. 200 sieve</td>
<td>2 - 8</td>
</tr>
</tbody>
</table>

The asphaltic material shall form from 3.5 to 7.0 percent of the mixture by weight.

FINE SURFACE COURSE (TYPE D)

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing by Weight or Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 inch sieve</td>
<td>100</td>
</tr>
<tr>
<td>3/8 inch sieve</td>
<td>85 - 100</td>
</tr>
<tr>
<td>No. 4 sieve</td>
<td>50 - 70</td>
</tr>
<tr>
<td>No. 10 sieve</td>
<td>32 - 42</td>
</tr>
<tr>
<td>No. 40 sieve</td>
<td>11 - 26</td>
</tr>
<tr>
<td>No. 80 sieve</td>
<td>4 - 14</td>
</tr>
<tr>
<td>No. 200 sieve</td>
<td>2 - 8</td>
</tr>
</tbody>
</table>

The asphaltic material shall form from 4.0 to 8.0 percent of the mixture by weight.

END OF SECTION 02511
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing and installing unit pavers on prepared surfaces in conformance with the lines, grades, and sections as shown.

1. This Section includes the following:

   a. Brick pavers set in aggregate setting bed.

   b. Concrete pavers set in aggregate setting bed.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

   1. ASTM C33 - Standard Specification for Concrete Aggregates
   2. ASTM C902 - Standard Specification for Pedestrian and Light Traffic Paving Brick
   3. ASTM C936 - Standard Specification for Solid Concrete Interlocking Paving Units
   4. ASTM D1752 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

1.3 SUBMITTALS

A. Product Data: For the following:

   1. Brick pavers.
   2. Concrete pavers.

B. Samples for Verification: Full-size units of each type of unit paver indicated; in sets for each color, texture, and pattern specified, showing the full range of variations expected in these characteristics.

   1. Include Samples of exposed edge restraints.

C. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed unit paver installations similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Source Limitations: Obtain each type of unit paver, joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

C. Mockups: Before installing unit pavers, build mockups for each form and pattern of unit pavers required to verify selections made under sample Submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for the completed Work, including same base construction, special features for expansion joints, and contiguous work as indicated:

   1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Contracting Officer.
   2. Notify Contracting Officer seven days in advance of dates and times when mockups will be constructed.
   3. Demonstrate the proposed range of aesthetic effects and workmanship.
   4. Obtain Contracting Officer's approval of mockups before starting unit paver installation.
   5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect unit pavers and aggregate during storage and construction against soiling or contamination from earth and other materials.

   1. Cover pavers with plastic or use other packaging materials that will prevent rust marks from steel strapping.
UNIT PAVERS

1.6 PROJECT CONDITIONS
A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 - PRODUCTS
2.1 UNIT PAVERS
A. Brick Pavers: Light-traffic paving brick; ASTM C902, Class SX, Type I, Application PX. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
B. Concrete Pavers: Solid, interlocking paving units, ASTM C936, made from normal-weight aggregates in sizes and shapes indicated.

2.2 SIZES, COLORS AND TEXTURES
A. Sizes, Colors and Textures: As scheduled on Drawings using manufacturer’s designations.

2.3 ACCESSORIES
A. Cork Joint Filler: Preformed strips complying with ASTM D1752, Type II.
B. Job-Built Concrete Edge Restraints: Comply with requirements of Section 03300, "Cast-In-Place Concrete" and use Concrete Mix S-7, as specified in Section 03305, “Portland Cement Concrete”.

2.4 AGGREGATE SETTING-BED MATERIALS
A. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements of ASTM C33 for fine aggregate.
B. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 sieve and no more than 10 percent passing No. 200 sieve.

PART 3 - EXECUTION
3.1 EXAMINATION
A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Where pavers are to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations. Examine areas where waterproofing system is turned up or flashed against vertical surfaces and horizontal waterproofing. Proceed with installation only after protection is in place.

3.2 PREPARATION
A. Vacuum clean concrete substrates to remove dirt, dust, debris, and loose particles.

3.3 INSTALLATION, GENERAL
A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible or cause staining in finished work.
B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

1. For concrete pavers, a block splitter may be used.

D. Joint Pattern: As indicated.

E. Pavers over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.

1. Provide joint filler, where indicated, at waterproofing that is turned up on vertical surfaces; or, if not indicated, provide temporary filler or protection until paver installation is complete.

F. Tolerances: Do not exceed 1/16-inch unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches and 1/4 inch in 10 feet from level, or indicated slope, for finished surface of paving.

G. Expansion and Control Joints: Provide joint filler at locations and of widths indicated. Install joint filler before setting pavers. Make top of joint filler flush with top of pavers.
H. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.

1. Install job-built concrete edge restraints to comply with requirements in Section 03300, "Cast-In-Place Concrete."

3.4 AGGREGATE SETTING-BED PAVER APPLICATIONS

A. Place leveling course and screed to a thickness of 1 to 1-1/2 inches, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

B. Treat leveling base with soil sterilizer to inhibit growth of grass and weeds.

C. Set pavers with a minimum joint width of 1/16 inch and a maximum of 1/8 inch, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch with pieces cut to fit from full-size unit pavers.

1. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.

D. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf compaction force at 80 to 90 Hz. Perform at least three passes across paving with vibrator. Vibrate under the following conditions:

1. After edge pavers are installed and there is a completed surface or before surface is exposed to rain.

2. Before ending each day's work, fully compact installed concrete pavers to within 36 inches of the laying face. Cover open layers with nonstaining plastic sheets overlapped 48 inches on each side of the laying face to protect it from rain.

E. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

F. Do not allow traffic on installed pavers until sand has been vibrated into joints.

G. Repeat joint-filling process 30 days later.

3.5 REPAIR, CLEANING, AND PROTECTION

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units as intended. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for unit pavers per location indicated wherein no measurement will be made.

END OF SECTION 02515
PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Concrete Pavers:
   1. Setting: Thinset mortar.

B. Cast Iron Paving Plates:
   1. Setting: Cast-in-place concrete grout

1.2 RELATED SECTIONS

A. Section 02220 - Grading, Excavating and Backfilling.
B. Section 02515 - Unit Pavers.
C. Section 02525 - Combined Curb and Gutters, Curb Ramps, and Walks.
D. Section 03300 - Cast-In-Place Concrete.
E. Section 07900 - Seals and Sealants.

1.3 REFERENCED STANDARDS

A. American Society for Testing and Materials (ASTM):
   1. ASTM C 33 - Specification for Concrete Aggregates.
   4. ASTM C 140 - Specification for Concrete.

B. Tile Council of America (TCA):
   1. TCA F102 - Installation Method Cement Mortar Bonded.

C. American National Standards Institute (ANSI):
   1. ANSI A-118.4 - Latex Portland Cement Mortar.
   2. ANSI A-118.6 - Grout - Latex.

1.4 SUBMITTALS

A. Submit under provisions of Section 01330 - Submittals.
B. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Test Reports: 3 copies, showing compliance with specified ASTM requirements.
   2. Preparation instructions and recommendations.
   3. Storage and handling requirements and recommendations.
   4. Installation methods.
C. Shop Drawings:
   1. Layout drawings of each paved area showing the pattern of pavers, indicate pavers requiring cutting, indicate setting bed methods in each area, drainage patterns and drains. Include details of setting beds, noting all materials and their thickness, show details at curbs and vertical surfaces.
   2. Details of custom (nonstandard) curbs and stair tread/risers, include methods of installation.
D. Selection Samples: For each finish product specified, 2 complete sets of color chips representing manufacturer's full range of available colors and patterns.
E. Verification Samples: For each finish product specified, 3 sample pavers of each manufactured, type, size and color selected or specified.
1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Products shall be produced by a single manufacturer unless otherwise specified.

2. Manufacturer shall submit evidence of having not less than 15 years successful production of this product.

3. Paver manufacturer shall demonstrate, either by proven field performance or a laboratory freeze-thaw test, that the paving units have adequate durability if they are to be subjected to a freeze-thaw environment.
   a. Satisfactory field performance is indicated when units similar in composition and made with the same manufacturing process as those to be supplied to the purchaser, do not exhibit objectionable deterioration after at least 3 years.
   b. The units used as the basis for proven field performance shall have been exposed to the same general type of environment, temperature range and traffic volume as is contemplated for the units supplied to the purchaser.

B. Product Qualifications:

1. Products shall be fully shop cured and shall meet ultimate design compressive strength requirements prior to shipment to project site.

2. Manufacturer shall submit evidence that design compressive strength has been met.

C. Installer Qualifications:

1. Subcontractor shall submit evidence of skill and not less than 5 years specialized experience with this product.

D. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.

1. Finish areas designated by Architect.

2. Do not proceed with remaining work until workmanship, color, and sheen are approved by Architect.

3. Refinish mock-up area as required to produce acceptable work.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver and handle precast concrete pavers and cast-iron paving plates in such a manner as to prevent damage. Units shall be stored above ground on pallets. Pallets shall be clean and non-staining. All damaged or otherwise unsuitable material shall be immediately removed from the job site.

B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.7 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

1. Do not work during freezing weather or on wet or frozen sub-base.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer (Precast Concrete Pavers): Wausau Tile Co., which is located at: P. O. Box 1520 9001 Bus Hwy. 51; Wausau, WI 54402-1520; Toll Free Tel: 800-388-8728; Tel: 715-359-3121; Email: wtile@wausautile.com; Web: www.wausaupaving.com; or Approved Equal.

B. Acceptable Manufacturer (Cast Iron Paving Plates): Neenah Foundry Co. which is located at: 2121 Brooks Avenue, Neenah, WI 54956; Toll Free Tel: 800-558-5075; Tel: 920-725-7000; Email: conssales@nfco.com; Web: www.nfco.com; or Approved Equal.

C. Requests for substitutions will be considered in accordance with provisions of Section 01630 – Product Substitution Procedures.
2.2 PRECAST CONCRETE PAVERS

A. Concrete Pavers: Detectable Warning Pavers as manufactured by Wausau Tile Co. or Approved Equal.
   1. Thickness: Standard, 2 inches to 2-3/4 inches
   2. Nominal Size: 12 inches square.
   4. Color: As indicated on Drawings.
   5. Installation Patterns: As indicated on Drawings.

B. Concrete Pavers: Engraved Series Pavers as manufactured by Wausau Tile Co. or Approved Equal.
   1. Thickness: Standard, 2 inches to 2-3/4 inches
   2. Nominal Size: 12 inches square.
   3. Design: As indicated on Drawings.
   4. Color: As indicated on Drawings.
   5. Engraving: Epoxy filled.
   6. Installation Patterns: As indicated on Drawings.

C. Precast Material Requirements:
   2. Aggregates shall conform to ASTM specifications, except that grading requirements shall not necessarily apply, ASTM C33 for concrete aggregates, normal weight.
   3. Other Constituents: Coloring pigments, integral water repellents, etc., shall be previously established as suitable for use in concrete and either shall conform to ASTM Standards where applicable, or shall be shown by test or experience not to be detrimental to the durability of the concrete.

D. Paver Performance Requirements:
   1. Compressive Strength: At the time of delivery to the work site, the average compressive strength shall not be less than 8,000 psi with no individual unit less than 7,000 psi (48,000 kPa) per ASTM C140.
   2. Absorption: The average shall not be greater than 6 percent per ASTM C140.
   3. Flexural Strength: Not less than 800 psi (5500 kPa) per ASTM C293.
   4. Load carrying capacity: Paver units shall have a tested center load capacity of 1,850 lb (840 kg). WT CL96
   5. Freeze/thaw: Durability of the paver shall meet the freeze/thaw tests in accordance with Section 8 of ASTM C1260. Specimens, when tested, shall have no breakage and not greater than 1 percent loss in dry weight of any individual unit when subject to 50 cycles of freeze/thaw.
   6. Sizing: Permissible variations in dimensions shall not differ by more than 1/16 inch from width, height, length or thickness. Standard units are manufactured with a 3/16 inch bevel on all four sides of finished surface. Unit shall conform to a true plane and not differ by more than 1/16 inch in either concave and/or convex warpage.

2.3 CAST IRON PAVING PLATES

A. Cast Iron Plate with Directional Arrow: Detectable Paving Plates as manufactured by Neenah Foundry Co. or Approved Equal.
   1. Plate Thickness: Standard, 1/2 inch.
   2. Overall Thickness including support ribs: 1 ½ inches.
   3. Nominal Size: 10 inches wide by 36 inches long.
   6. Installation Patterns: As indicated on Drawings.
   7. Approximate Weight: 67 pounds

B. Cast Iron Accessible Staging Plate with ISA Symbol: Detectable Paving Plates as manufactured by Neenah Foundry Co. or Approved Equal.
   1. Plate Thickness: Standard, 1/2 inch.
DIRECTIONAL DETECTABLE PAVERS AND PLATES

2. Overall Thickness including support ribs: 1 ½ inches.
3. Nominal Size: 30 inches square.
4. ISA Symbol Size: 10 inch square, centered on plate
7. Installation Patterns: As indicated on Drawings.
8. Approximate Weight: 67 pounds

6. Cast Iron Material Requirements:

2.4 INSTALLATION MATERIALS
1. Portland Cement Mortar Mix: ASTM C150 Custom Bldg Products thick Bed Mortar Mix with Admix, or approved equal.
2. Reinforcement: 2 inches by 2 inches - 16/16 welded galvanized wire mesh used in thick mortar bed.
3. Water: Clean and free of deleterious acids, alkalis or organic materials.
4. Grout: Custom Bldg Products Grout with Admix, color as selected or approved equal.
5. Bond Slurry: Custom Bldg Products bond coat or approved equal.
8. Bond Breaker: As specified in Section 07900 – Seals and Sealants.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Do not begin installation until substrates have been properly prepared.
B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
C. Concrete shall not exceed 1/8 inch in 10 feet from required plane.
D. Concrete to be steel troweled with fine broom finish. No curing or sealing compound used.

3.2 PREPARATION
A. Clean surfaces thoroughly prior to installation.
B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.3 INSTALLATION
A. Install in accordance with manufacturer's instructions.
B. Placement Tolerance:
1. Maximum of 1/16 inch height variation between adjacent pavers.
2. Individual pavers shall not vary more than 1/16 inch from level across width of the paver.
3. Paved areas shall not vary more than 1/4 inch from level in a distance of 10 feet measured at any location and in any direction.
4. Joints between pavers to be 3/16 inch or 1/8 inch.
C. Thinset Mortar Method - Pedestrian Installation:
1. Locate and delineate area of existing concrete pavers to be removed. Sawcut existing pavers as necessary to achieve desired shape. Remove existing pavers to be removed.
2. Installation of Mortar bed as per TCA F102. Materials use shall follow instructions of manufacturer for use in mortar method.
3. Install precast concrete pavers.
4. Grouting of pavers in strict accordance with grout manufacturer's directions and instructions. Latex or acrylic additives of the same manufacturer as the grout.
5. Control and expansion joints shall be installed per TCA EJ 171. Joint materials used shall follow manufacturer’s directions and instructions.

6. Rework mixes from time to time to maintain proper consistency, as recommended by manufacturer but do not add ingredients. Discard mortar that has reached its initial set.

7. Field cut precast pavers in accordance with manufacturer’s recommendations for methods, equipment and precautions.

8. Cleaning: Remove mortar stains and all other types of soiling from exposed paver surfaces, wash and scrub clean.

D. Portland Cement Setting Bed Installation for concrete pavers:

1. Locate and delineate area of existing concrete pavers to be removed. Sawcut existing pavers as necessary to achieve desired shape. Remove existing pavers to be removed.

2. Installation of mortar bed as per TCA F101. All materials used follow instructions of manufacturer for use in mortar method.

3. Install precast concrete pavers.

4. Grouting of pavers in strict accordance with grout manufacturer’s directions and instructions. Latex or acrylic additives of the same manufacturer as the grout.

5. All control and expansion joints to be installed as per TCA EJ 171. All joint materials used shall follow manufacturer’s directions and instructions.

6. Field cut precast pavers in accordance with manufacturer’s recommendations for methods, equipment and precautions.

7. Cleaning: Remove mortar stains and all other types of soiling from exposed paver surfaces, wash and scrub clean.

E. Cast in Place Concrete Grout Setting Bed Installation for cast iron paving plates:

1. Locate and delineate area of existing concrete pavers to be removed. Sawcut existing pavers as necessary to achieve desired shape. Remove existing pavers to be removed. Remove sand bedding as required.

2. Installation of cast-in-place concrete grout in void created by removed pavers and bedding sand. Finish with trowel to within ½ inch of top of adjacent pavers.

3. Install cast iron paving plates by evenly pressing into prepared concrete grout bed. Ensure that top of plate is flush with surrounding pavers.

4. Ensure no air pockets exist between plate and grout bed.

5. Field cut cast iron plates as necessary prior to installation in accordance with manufacturer’s recommendations for methods, equipment and precautions.

6. Cleaning: Cast iron will oxidize and may stain surrounding area until iron patina has formed. Remove grout stains, rust stains and all other types of soiling from exposed plate and surrounding surfaces, wash and scrub clean.

F. Concrete Slab Installation:

1. Locate and delineate area of existing concrete pavers to be removed. Sawcut existing pavers as necessary to achieve desired shape. Remove existing pavers to be removed.

2. Install precast concrete pavers, slabs and curbs in locations, patterns and at elevations and with slopes for surface drainage as shown on the Drawings. Install precast concrete pavers, slabs and curbs in accordance with the manufacturer’s printed installation instructions and the final reviewed shop drawings.

3. Apply neoprene modified asphalt adhesive on the cured setting bed by squeegeeing or troweling. If troweled on, use a trowel with serrations not exceeding 1/16 inch depth. Place adhesive to not more than 1/16 inch thickness over the total surface of the setting bed. Do not begin installation of pavers, slabs and curbs until adhesive is dry to the touch.

4. Lay out pavement in 30 feet working area modules. Set precast concrete pavers, slabs and curbs by hand on
dry adhesive in patterns shown on the Drawings with hand tight joints 1/16 inch to 1/8 inch wide joints and uniform top surfaces.

5. Field cut precast concrete pavers in accordance with manufacturer's recommendations for methods, equipment and precautions.

6. Maintain accurate alignment and check for creep and shrinkage. Make adjustments to creep and shrinkage within the 30 feet module area.

7. Sweep fine dry sand over pavement surface to fill joints immediately after installing pavers, slabs and curbs on setting bed. Brush in sand until joints are completely filled, remove surplus sand. Do not allow traffic on installed pavers, slabs or curbing until the joints have been filled.

8. Protect newly laid pavers, slabs and curbs with plywood panels on which workers stand. Advance protective panels as work progresses but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of installed pavers, slabs and curbs.

9. Install the specified joint filler where precast concrete pavers, slabs and curbs abut curbs, other vertical surfaces and other construction.

10. Backfilling: After the precast concrete paving is completed, backfill the spaces along the edges of the walks, metal edging and pavements to be required elevations with material reviewed by the Testing Laboratory. The Material shall then be compacted until firm and the surface neatly graded, with allowance made for top soil.

G. Sand Setting Bed Installation:

1. Locate and delineate area of existing concrete pavers to be removed. Sawcut existing pavers as necessary to achieve desired shape. Remove existing pavers to be removed. Repair sand bedding as required.

2. Place solid steel 3/4 or 1 inch (19 mm or 25 mm) thick control bars directly on the base. Install shims under bars for minor adjustment of depth and finish paver elevations and slopes. Space bars approximately 11 feet (3.4 m) apart and parallel to each other to serve as guides for strike-off boards.

3. Place sand setting bed between control bars on the binder course to not less than thickness of the designated control bars. Spread material and strike off by pulling the material with a 12 feet long by 2 inches by 6 inches wood board several times to produce a smooth firm and even setting bed. Add fresh material in low areas after each pass of the strike off board. After each panel is complete remove and advance the first control bar to the next panel position in readiness for placing and striking adjacent panels. Fill in depressions left by the control bar and any shims.

3.4 PROTECTION

A. Protect installed products until completion of project.

B. Remove and replace pavers which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment to eliminate evidence of replacement.

C. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION 02521
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing combined curb and gutters, curb ramps, and sidewalks to the sections, lines and grades shown on the Contract Drawings.
B. For work done in the right-of-way of other jurisdictional agencies, the minimum requirements of the jurisdictional agency shall apply, unless otherwise indicated in the Contract Documents.

1.2 REFERENCED STANDARDS
A. American Concrete Institute (ACI):
   1. ACI 318 - Building Code Requirements for Structural Concrete
B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   2. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
   3. ASTM A663/A663M - Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties
   4. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
   5. ASTM C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
C. North Central Texas Council of Governments (NCTCOG)
   1. Standard Specifications for Public Works Construction, as revised (NCTCOG Standard Specifications).

1.3 SUBMITTALS
A. Shop drawings for joint devices.
B. Certification: As specified in Section 03305, "Portland Cement Concrete", including design mixes.

PART 2 - PRODUCTS

2.1 GENERAL
A. Materials (including their delivery, storage, handling, and testing) necessary for the completion of the work described in this Section shall be in complete accordance with the NCTCOG Standard Specifications except as otherwise specified herein.

2.2 MATERIALS
A. Concrete: In accordance with Section 03305, "Portland Cement Concrete", Mix S-7.
B. Benches and Chairs: as per ACI 318
C. Tie Bars: ASTM A615, Grade 60, of type and size indicated.
D. Dowels: Plain round bars meeting requirements of ASTM A615, Grade 60, or ASTM A663, Grade 80, epoxy coated bars, furnished with approved snug-fitting ASTM A53 galvanized pipe sleeve. Provide sleeve with one end closed. Sleeves for dowel ends may be plastic.
E. Weep Holes: ASTM A53 galvanized pipe of size indicated.
F. Expansion-Joint Filler and Joint-Sealant Compound: as per Section 07900.
G. Concrete curing compound: ASTM C309, Type 1
H. Epoxy Adhesive: ASTM C881, Type V for load bearing concrete, Grade and Class as determined by project conditions and requirements.
I. Color Hardener: Lithochrome Color Hardener, as manufactured by L. M. Scofield Company, 4155 Scofield Road, Douglassville, GA 80134, (800) 800-9900, or approved equal. Color as designated by jurisdictional agency. If no color is designated, then color to match: L. M. Scofield Classic Gray - A-33.

PART 3 - EXECUTION

3.1 CONSTRUCTION
A. Concrete combined curb and gutters, curb ramps, and sidewalks shall be constructed in accordance with the NCTCOG Standard Specifications (including hot weather and cold weather concrete) except as otherwise indicated.
B. Provide cast-in-place concrete construction, plain or reinforced as indicated. Curbs and gutters shall be formed accurately to indicate section profile with template screed.
C. Extruded curbs and gutters, placed by an extrusion machine, may be provided where site conditions are suitable and the extrusion process is appropriate for the purpose.

D. Random Cracking: Through the Contract period and until the end of the Warranty period (refer to General Provisions, “WARRANTY OF CONSTRUCTION”) random drying shrinkage cracks or stress cracks of any nature in Portland cement concrete sidewalks constructed under the Contract will be unacceptable and are subject to being rejected at the discretion of the Authority. Rejected concrete shall be removed and replaced at no additional cost to the Authority. Routing, by any means, and sealing random cracks will not be permitted. Randomly cracked Portland cement concrete sidewalks will require removal and replacement of only the five feet long section or sections containing random cracks. This process is subject to review and should be conducted within reason. Cracks should be rejected if excessive and not superficial. The area of removal and replacement of slabs containing longitudinal random cracks will be determined by the Authority.

E. Curb Ramps:

1. Construct curb ramps in accordance with the applicable standards shown on Contract Drawings and applicable jurisdictional agencies.

2. Curb Ramp Surface: For purposes of warning, curb ramps shall have a light reflective value and texture that contrasts with that of pedestrian route.
   a. Texture shall consist of truncated domes extending the full width and depth of curb ramp as indicated on the Contract Drawings.
   b. Contrast: Apply color hardener to the full width and depth of curb ramps not including side slopes. Apply and cure in accordance with manufacturer’s instructions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Curb ramps, reinforcing steel, dowels, texture, and color will not be measured or paid for separately, but will be considered subsidiary to the construction of curb, gutters, and sidewalks.

B. Curb and combined curb and gutter specified in this Section will not be measured, but will be paid for at the lump sum prices for “Curb” and “Combined Curb and Gutter”, complete-in-place, for the various types and colors.

C. Sidewalks specified in this Section will not be measured, but will be paid for at the lump sum prices for “Sidewalk”, complete-in-place, for the various thicknesses, colors, and types.
SECTION 02550
CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies providing reinforced Portland cement concrete pavement in conformance with the sections, lines, and grades shown on the Contract Drawings.

B. For work done in the right-of-way of other jurisdictional agencies, the minimum requirements of the jurisdictional agency shall apply, unless otherwise indicated in the Contract Documents.

1.2 REFERENCED STANDARDS

A. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised (NCTCOG Standard Specifications).

1.3 SUBMITTALS

A. Shop Drawings for Joint. Submit pavement joint types and layout of expansion, contraction, and construction joints.

B. Product Data: Submit product data on joint filler and curing compound.

C. Concrete Submittals: As specified in Section 03305, "Portland Cement Concrete", including design mixes.

1.4 QUALITY ASSURANCE

A. Comply with codes and regulations of the jurisdictional authorities.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials (including their delivery, storage, and handling) necessary for the completion of the work described in this Section shall be in complete accordance with the NCTCOG Standard Specifications except as otherwise specified.

B. Concrete for roadway paving, integrally-placed curbs, driveways, street headers, and median noses: In accordance with Section 03305, "Portland Cement Concrete". Mix P-1, if machine placed, and P-2, if hand placed.

C. Concrete for median paving: In accordance with Section 03305, "Portland Cement Concrete". Mix S-7.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Concrete pavement shall be constructed in accordance with the NCTCOG Standard Specifications (including hot weather and cold weather concrete) except as otherwise indicated.

B. Random Cracking: Through the Contract period and until the end of the Warranty period (refer to General Provisions, "WARRANTY OF CONSTRUCTION") random drying shrinkage cracks or stress cracks of any nature in Portland cement concrete pavement constructed under the Contract will be unacceptable and are subject to being rejected at the discretion of the Contracting Officer. Rejected concrete shall be removed and replaced at no additional cost to the Authority. Routing, by any means, and sealing random cracks will not be permitted. When Portland cement concrete pavement must be removed and replaced, the area of removal shall extend from the nearest contraction or dummy joint or construction joint a minimum distance of 10 feet, measured parallel to the longitudinal axis of the pavement, and include that portion of the concrete pavement containing the random crack. A sawed dummy joint will be required to be sawed across the opposing, non-damaged, slab in line with the saw cut made for the removal of the damaged slab. The area of removal and replacement of slabs containing longitudinal random cracks will be determined by the Contracting Officer.

C. Dowels at expansion joints shall be supported by dowel baskets as approved.

3.2 CONCRETE TESTING AND QUALITY CONTROL

A. As specified in Section 03305, "Portland Cement Concrete", with the exception of thickness testing which shall be in accordance with NCTCOG Standard Specifications for Concrete Pavement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Concrete pavement specified in this section will not be measured, but will be paid for at the lump sum prices for "Reinforced Concrete Pavement, "Concrete Median Pavement," and "Reinforced Concrete Driveways," for the various thicknesses.

B. Monolithic median noses will not be measured, but will be paid for at the lump sum price for "Monolithic Median Nose".
C. Integral curb and reinforced concrete street headers shall be measured by and paid for at the lump sum prices for “Integral Curb” and “Reinforced Concrete Street Header” for the various types and dimensions.

D. Reinforcing steel will not be measured separately, but will be considered subsidiary to the construction of concrete pavement and other work specified in this section.
1.1 DESCRIPTION
A. This section specifies furnishing and installing pavement markings, object markers, and delineators.

B. For work done in the right-of-way of other jurisdictional agencies, the minimum requirements of the jurisdictional agency shall apply, unless otherwise indicated in the Contract Documents.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C321 - Standard Test Method for Bond Strength of Chemical-Resistant Mortars
   5. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
   6. ASTM E28 - Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus

B. Federal Standards (FED STD):
   1. FED STD 141 - Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing
   2. FED STD 595 - Colors Used in Government Procurement


D. Texas Department of Transportation (TxDOT): Standard Specifications for Construction of Highways, Streets, and Bridges (TxDOT Standard Specifications).

E. Texas Department of Transportation (TxDOT): Material Specifications:
   1. DMS-8200 – Traffic Paint.
   2. DMS-8290 – Glass Traffic Beads.


1.3 SUBMITTALS
A. Product Data: Submit manufacturer's product data including specifications for each of the following products:
   1. Paint: For each color.
   2. Spheres.
   3. Thermoplastic compound: For each color.
   4. Preformed plastic markings.
   5. ReflectORIZED Traffic Buttons: For each type and color
   6. Delineators.

B. Submit certification, manufacturer's recommendations, and test results for each product. Test results shall not be older than 6 months.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Deliver materials in factory-sealed containers plainly marked as follows:
   1. Manufacturer's name and address.
   2. Location of plant.
   4. Color of material.
   5. Amount of contents.
   6. Date of manufacturer and lot number.
1.5 JOB CONDITIONS

A. Environmental Requirements:

1. Traffic zone paint:
   a. Apply only when ambient air temperature is above 40 degrees F and temperature of surface to be painted is above 45 degrees F.
   b. If pavement is wet, allow surface to dry for eight hours minimum after surface appears dry.
   c. Do not apply glass spheres in strong windy conditions.

2. Extruded thermoplastic compound:
   a. Apply by extrusion at 400 degrees F minimum when air temperature is more than 35 degrees F and pavement temperature is above 45 degrees F, or in accordance with manufacturer's recommendations.
   b. If pavement is wet, delay application until the pavement has been exposed to at least two hours of direct sunlight after surface appears dry.

3. Preformed plastic traffic markings:
   a. Apply on dry pavement when ambient temperature and temperature of pavement surface is above 60 degrees F.
   b. When temperature of pavement surface is less than 60 degrees F and when approved, apply surface heating to degree necessary for application of plastic marking.

B. Refer to Section 01570, "Maintenance and Control of Traffic," and to Section 01500, "Temporary Facilities and Services Required During Construction," for requirements traffic control, barricades, and protective devices.

2.2 GLASS BEADS

A. Retroreflective Glass Spheres: TxDOT DMS-8290, Type I.

2.3 EXTRUDED THERMOPLASTIC COMPOUND

A. Thermoplastic compound:

1. Mixture of thermoplastic resins and other substances compounded for use in traffic markings which, when extruded hot in place and cooled to ambient temperature, will produce stark white or yellow reflective marking stripe.

2. Pigmented binder well dispersed and free from skins, dirt, foreign objects, or ingredients that will cause bleeding, staining, or discoloration and consisting of mixture of non-drying synthetic resins at least one of which is solid at room temperature.

3. Total binder content of thermoplastic compound: 15 percent minimum, 35 percent maximum by weight.

4. Filler incorporated with resins or binder: White calcium carbonate with compressive strength of 5,000 psi.

5. Permanently white or yellow, without blemish or discoloration, with straight, clean cut, sharply defined, parallel edges, and of uniform cross section.

6. Shaped to minimize tire impact and adhere permanently to road.

7. Set to solid, non-tacky, non-slippery line of sufficient elasticity to resist cracking and chipping caused by weather and temperature changes, traffic action, as well as pavement crawl, and lift in freezing weather.

8. After curing, does not react with nor deteriorate in contact with snow removal chemicals, oil and other substances common to roadway surfaces.

9. Chemically stable and emitting no dangerous fumes.

10. Especially compounded for traffic markings, with no change in color and brightness characteristics after prolonged exposure to sunlight.
11. No breakdown or deterioration when held at plastic temperature for extended periods of time nor when repeatedly reheated to plastic temperature.

12. No change in temperature versus viscosity characteristics through repeated reheatings and from batch to batch.

B. Properties of Thermoplastic Compound:

1. Water absorption: 0.5 percent maximum by weight of retained water when tested in accordance with ASTM D570.

2. Softening point: 90 degrees C minimum when tested in accordance with ASTM E28.

3. Specific gravity: From 1.80 to 2.50 at 25 degrees C when tested in accordance with ASTM D792.

4. Low temperature stress resistance: No cracking or flaking, after 24 hours at 20 degrees C, when applied to asphalt surface.

5. Resistance to impact: Not less than 10 inches per pound at 77 degrees F using a 25 inch per pound scale, when tested in accordance with ASTM D256, Method A.

6. Bond strength: 150 psi minimum when tested in accordance with ASTM C321.

7. Drying time: Not exceeding straight line graphic established between two points representing two minutes at 50 degrees F and fifteen minutes at 90 degrees F respectively, when both ambient air temperatures are measured at maximum relative humidity of 70 percent.

8. Indentation Resistance Procedure:

<table>
<thead>
<tr>
<th>Temperature of Compound</th>
<th>Durometer Reading</th>
<th>Rd</th>
<th>Reflectance</th>
<th>Definition</th>
<th>Standardized</th>
<th>Sample</th>
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</thead>
<tbody>
<tr>
<td>115 degrees F</td>
<td>65</td>
<td>Rd</td>
<td>Reflectance</td>
<td>100</td>
<td>70 minimum</td>
<td>Sample</td>
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<tr>
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<td>95</td>
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<td>Redness</td>
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<td>-5 to +5</td>
<td>Sample</td>
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<tr>
<td>40 degrees F</td>
<td>95</td>
<td>b</td>
<td>Yellowness</td>
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<td>-10 to +10</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Blueness</td>
<td></td>
<td></td>
<td>Sample</td>
</tr>
</tbody>
</table>

3. The white compound pigment containing not less than six percent titanium dioxide (TiO2).

D. Yellow thermoplastic compound: After drying, yellow, FED STD 595, Color 33538, tested in accordance with FED STD 141, Method 4252.

E. Binder Sealer: Epoxy sealer, in accordance with manufacturer's recommendations.

2.4 PREFORMED PLASTIC TRAFFIC MARKINGS

A. Composed of preformed plastic, smooth on top surface, undersurfaces factory-coated with pressure-sensitive adhesive coating overlaid with protective paper, polyethylene or other suitable material which remains in place until plastic is ready for application to pavement.

B. Composition:

1. Nonreflectorized plastic material: Consisting of basic plastic and plasticizers, 50 percent minimum by weight.

2. Reflectorized plastic material: Consisting of 40 percent minimum by weight of basic plastic and plasticizer and 30 percent minimum by weight of clear, reflective glass spheres, thoroughly and uniformly dispersed throughout plastic.

C. Pigmentation:

1. White plastic markings: Pure white, free from tint, and containing not less than six percent titanium dioxide.

2. Yellow plastic markings: Yellow, FED STD 595, Color 33538, FED STD 141, Method 4252.

3. Uniform coloring throughout cross section of plastic.

D. Low temperature stress resistance: No indication of breaking, chipping or cracking when sample of specified thickness is abruptly bent to right angle.
after being immersed in water at 32 degrees F for 30 minutes.

E. Resistance to wear: Endure not less than 2,500 cycles of a Taber Abraser, using CS-17 wheels under a load of 1,000 grams when each 0.001 inch thickness of plastic is tested at 21 degrees C.

F. Tensile strength: Nonreflectorized markings not less than 1500 psi; reflectorized markings not less than 750 psi when tested in accordance with ASTM D638.

G. Bond strength: Withstand 50-pound static shear load for 15 seconds average at 21 degrees C before complete parting of bond when pair of 2 inch wide strips are overlapped 2 inches and adhesive faces placed together.

H. Preformed plastic traffic markings:
   1. Thickness: 0.095 inch, minus 0.005 inch or plus 0.010 inch.
   2. Width: Plus or minus 1/8 inch per 12 inch length.

2.5 REFLECTORIZED TRAFFIC BUTTONS

A. Permanent: In accordance with jurisdictional authorities and related standard construction details with all revisions thereto.

B. Temporary: Raised pavement markers shall conform to FP-85, Section 634. They shall be white (crystal), yellow, or red, or a combination thereof, as specified in the drawings.

2.6 Delineators

A. Delineators’ geometric shape, composition, and reflective characteristics shall be in accordance with requirements of the TMUTCD and the jurisdictional agency where the work is being performed.

2.7 CONCRETE FOR DELINEATORS

A. In accordance with Section 03305, "Portland Cement Concrete," Mix S-7.

2.8 HARDWARE FOR DELINEATORS

A. Brackets, straps, braces, bolts, and appurtenances as shown on the drawings, or if not shown, these items shall be of the size, shape, material, and workmanship necessary to make final product acceptable to jurisdictional agency where the work is being performed.

B. Approved commercial quality hardware is acceptable.

PART 3 - EXECUTION

3.1 GENERAL

A. The work of this section shall be executed in accordance with the NCTGOC Standard Specifications, and as specified herein.

B. Surface Preparation: Prior to application of pavement markings, clean asphalt and concrete pavements as specified herein to remove foreign matter, including direct, loose material, and other contaminants in accordance with TxDOT Standard Specifications, Item 678, “Pavement Surface Preparation for Markings.”
   1. Clean asphaltic pavement surface by brushing, washing, compressed air, high-pressure water, or any combination thereof to remove contamination and loose materials.
   2. Clean concrete pavement surfaces by blast cleaning sufficiently to remove loose and flaking materials and contaminants. Concrete pavement surfaces shall not be cleaned by grinding.

3.2 LAYOUT

A. Layout of Pavement Markings: Lay out pavement markings in accordance with regulations of jurisdictional authorities and as shown on the drawings.

B. Pavement Markings and Symbols:
   1. Unless otherwise shown or specified, install pavement markings of size and configuration as shown in jurisdictional authorities standard construction details, the TMUTCD, or as shown in the "Standard Alphabet for Highway Signs and Pavement Markings".
   2. Apply letters, directional arrows and other markings in color shown.

C. Length, width, and color of pavement markings, as shown on the drawings.

D. Delineators:
   1. Set markers and delineators at locations shown, secure to posts so that top of reflecting head is 4 feet above adjacent roadway.
2. Space delineators as shown.

3.3 APPLICATION - TRAFFIC ZONE PAINT

A. Equipment:
   1. Use equipment suitable for mechanical application of paint and glass spheres.
   2. Apply paint with atomizing spray machines designed for striping to apply stripes of uniform cross section, and thickness, at specified coverage with clear cut edges permitting easy and accurate adjustment of width and rate of application as well as immediate shut off.
   3. Use automatic mechanical equipment designed and constructed to distribute glass spheres in uniform pattern and at prescribed coverage regardless of variation in speed of travel. Equipment may be integral part of striping machines or self-contained unit designed for attachment to striping machines, so that glass spheres will be applied immediately following application of paint. Use equipment designed and constructed to permit adjustment of coverage rate.

B. Method of application:
   1. Schedule marking and striping operations to permit paint to set and harden before roadway is opened to traffic.
   2. Allow hot laid bituminous material to cool, prior to beginning striping operations.
   3. Prepare surfaces as specified in Article 3.1 herein.
   4. Apply paint and glass spheres, mix and thin paint in accordance with manufacturer's recommendations.
   5. Apply glass spheres uniformly, immediately following application of paint. Do not pre-mix paint and spheres.
   6. Apply pavement markings accurately with straight clean cut, sharply defined parallel edges and of uniform cross section.
   7. Clean striping machines as often as necessary to ensure application of markings of specified quality and physical requirements.

3.4 APPLICATION - EXTRUDED THERMOPLASTIC COMPOUND

A. Master kettle:
   1. Minimum capacity: 800 pounds of melted compound.
   2. Double oil jacket.
   3. Thermostatic controls.
   4. Approved heating device.
   5. Temperature gauges for oil and compound.
   6. Integrally mounted chopping device to chop and drop solid compound into kettle.

B. Liner:
   1. Use liners with self-contained heat source, such as propane heater, capable of maintaining compound at drawing temperature of not less than 400 degrees F as well as radiant heater installed over die for same purpose.
   2. For installation of crosswalk lines, stop lines and solid center lines, use liner with capacity of approximately 150 pounds and automatic sphere dispenser capable of distributing reflective spheres on surface of line while still plastic.
   3. For centerline and lane line installation, use mobile unit equipped to automatically install dashed lines in combinations of line and skip up to 40 feet and for application of reflective spheres as specified for smaller liner.
   4. Provide for varying die widths in liner to produce indicated line widths, including shaping die cutoff device to provide clean, square ends at beginnings and ends of lines.

C. Application of binder sealer:
   1. Before applying binder sealer, prepare roadway surface as described under job conditions as specified herein.
   2. Where thermoplastic stripe is to be installed spray surfaces with binder sealer immediately prior to installation of compound.
   3. Mix binder-sealer fresh each day. Do not pre-mix.
D. Application of thermoplastic compound:
   1. Apply compound in colors shown and at locations shown.
   2. Do not use pans and aprons to control width of lines.
   3. Use equipment including extrusion dies capable of maintaining compound at specified extrusion temperature and density and capable of producing stripe of specified width.
   4. Do not apply thermoplastic marking in gutters; stop marking approximately 12 inches from face of curb.

E. Application of glass spheres:
   1. Perform reflectorizing of thermoplastic compound by immediate application of glass spheres to specified density.
   2. Perform reflectorizing so that completed line registers not less than 55 on Hunter Nite Visibility Meter.

3.5 APPLICATION - PREFORMED PLASTIC TRAFFIC MARKINGS

A. Prepare roadway surface by removing dirt, dust, oily substances, and other foreign matter before installing plastic markings as specified in Article 3.1 herein.

B. Do not install plastic marking on wet or damp pavement.

C. Make installations in neat, workmanlike manner with ends and edges of successive strips of material even.

D. Position center and lane markings using chalk as guides.

E. Installation on new asphaltic concrete surfaces:
   1. When plastic markings are to be installed on new asphalt surfaces, install while asphalt is still hot and immediately before final rolling is performed.
   2. As part of final rolling operation, position and embed plastic marking into surface.

F. Installation on existing asphaltic concrete surfaces:
   1. Apply prime coat recommended by manufacturer of plastic markings to pavement surface prior to installation of markings.
   2. Accurately locate and press marking into place and obtain final bond by at least two longitudinal passes of ten-ton roller.

G. Installation on Portland cement concrete pavement:
   1. Prepare roadway surface by removing dirt, dust, oily substances, and other foreign matter before installing plastic markings as specified in Article 3.1 herein.
   2. Seal surface of concrete pavement with quick setting primer to reduce capillary action and improve bond between marking and pavement surface.
   3. Otherwise install as specified for asphaltic pavement.

3.6 PAINTING OF CURBING

A. Paint curbing and raised traffic bars with traffic zone paint.

B. Clean surfaces to be painted of dirt, dust, oil, and other foreign substances.

C. Allow 14 days minimum after installation of Portland cement concrete curbing before painting.

D. Paint top and front of curbing in locations shown with one coat of nonreflectorized traffic zone paint as specified.

E. Painting of curbing and wheel stops: Wet film thickness - 0.015 inches minimum.

3.7 PAINTING OF FIRE LANES

A. The Fire Lane pavement shall be painted lines of red traffic zone paint, 6 inches wide to show the exact boundary lines of the fire lane. The boundary lines shall be on the curbs when present or may be on the flat pavement where curbs are not provided. The lines shall be marked by 4 inch high lettering, using a 1 inch stroke of white paint on the contrasting red background stating: "NO PARKING - FIRE LANE". This marking shall be placed at 25-foot intervals along each boundary line. Text markings on the red stripe shall right reading from the center of the fire lane.

3.8 APPLICATION - TRAFFIC BUTTONS

A. Prepare roadway surfaces by removing dirt, dust, oily substances, and other foreign matter before installing buttons as specified in Article 3.1 herein.
B. Do not install on wet or damp pavement.

C. Make installations in neat, workmanlike manner.

D. Position center and lane marking buttons using chalk as guides.

E. Installation on new asphaltic concrete surfaces:
   1. Apply prime coat recommended by manufacturer of buttons to pavement surface prior to installation of markings.
   2. Accurately locate and press marking into place and obtain final bond.

F. Installation on existing asphaltic concrete surfaces:
   1. Apply prime coat recommended by manufacturer of buttons to pavement surface prior to installation of markings.
   2. Accurately locate and press marking into place and obtain final bond.

G. Installation on Portland cement concrete pavement:
   1. Seal surface of concrete pavement with quick setting primer to reduce capillary action and improve bond between marking and pavement surface.
   2. Otherwise install as specified for asphaltic pavement.

3.9 FIELD QUALITY CONTROL - ALLOWABLE TOLERANCES AND COVERAGE

A. Traffic-zone paint:
   1. Width of lines not to vary from indicated width by more than 1/8 inch in each linear foot.
   2. Lengths of skip or lane lines and unpainted surface between skip lines not to vary by more than 3 inches from indicated length.
   3. Coverage rate maximum: 100 square feet minimum and 110 square feet maximum of surface coverage per gallon of paint, yielding wet film thickness of 0.015 inch minimum.
   4. Coverage rate of glass spheres: 10 pounds per gallon of paint minimum.

B. Extruded thermoplastic compound:
   1. Thickness of stripe: 90 to 125 mils.

2. Rate of application of binder-sealer: Between 800 linear feet and 1,000 linear feet per gallon for 4-inch wide lines. For lines of other widths, apply in proportion based on such rate.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Traffic Zone Paint will be measured and paid for at the unit price per linear foot for “Traffic Zone Paint”, for each color and width, and type of line (solid or broken line).

B. Thermoplastic markings specified for placement in the form of lines, except at specified parking lots and the “RRXING” transverse lines, will be measured and paid for at the unit price per linear foot for “Thermoplastic Markings” for each color, width, and type of line (solid or broken).

C. Preformed plastic traffic markings will be measured and paid for at the unit price per each and per linear foot for “Preformed Plastic Traffic Markings” for each type, color, and shape of marking.

D. Glass beads will not be measured or paid for separately but will be considered subsidiary to the work of providing traffic zone paint and thermoplastic pavement markings.

E. “RRXING” markings at railroad crossings shall include the RXR symbol and the three 24 inch transverse lines needed for each approach lane to the crossing. The RXR symbol will not be measured, but will be paid for at the lump sum price for “RRXING Symbol and Lines” for each crossing.

F. Reflectorized traffic buttons will be measured and paid for at the unit price for “Reflectorized Traffic Buttons” for each type.

G. Delineators will be measured and paid by at the unit price for “Delineators” per each.

H. Temporary pavement markings, temporary raised traffic buttons and temporary delineators designated for use during construction operations will not be measured directly, but will be considered subsidiary to the pay item for “Maintenance and Control of Traffic” specified in Section 01570, "Maintenance and Control of Traffic".

I. Marking of pavement and curbs in parking lots and areas outside the designated right-of-way will not be measured directly, but shall be paid for at the lump sum price for “Miscellaneous Striping and Buttons” per each location.
J. Replacement of existing pavement markings and buttons beyond the limits designated on the permanent signage and marking plans, required as a result of removal for installation of temporary traffic control plans, will not be measured directly, but will be considered subsidiary to the pay item for “Maintenance and Control of Traffic” specified in Section 01570, “Maintenance and Control of Traffic”.

K. Surface preparation will not be measured by and paid for but will be considered subsidiary to the pertinent pay item for the various markings and the various raised markers, words, shapes, and symbols.

END OF SECTION 02580
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the fabrication and installation of traffic signals and the related components.

1.2 REFERENCED STANDARDS
A. American Institute of Steel Construction (AISC):
   1. AISC 303 - Code of Standard Practice for Steel Buildings and Bridges
   2. AISC 348 - Specification for Structural Joints Using ASTM A325 or A490 Bolts
B. Americans with Disabilities Act Accessibility Guidelines (ADAAG)
C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   2. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
   3. ASTM A490 - Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength
   4. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
   5. ASTM F436 - Standard Specification for Hardened Steel Washers
   6. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
D. Institute of Transportation Engineers (ITE)
   1. Equipment and Material Standards of the Institute of Transportation Engineers
      a. Chapter 2: Vehicle Traffic Control Signal Heads (VTCSH)
      b. Chapter 3: Pedestrian Traffic Control Signal Indications
E. National Electrical Manufacturers Association (NEMA):
   1. NEMA C80.1 - Rigid Steel Conduit - Zinc Coated (GRC)
   2. NEMA 70 - National Electric Code (herein after referred to as NEC)
   3. Standard Specifications for Public Works Construction, as revised (NCTCOG)
   4. Texas Manual on Uniform Traffic Control Devices (TMUTCD)
   5. UL 651 - UL Standard for Safety Schedule 40 and 80 Rigid PVC Conduit
    1. Certification: Certification of compliance for each product to be used in the Work.
    2. Requests for Deviations: If the Contractor desires to deviate from any of the stated procedures or to make substitutions for any materials or equipment, submit written request accompanied by samples, product data, and other information, as appropriate. Obtain written approval from the Contracting Officer prior to proceeding.
1.4 SEQUENCING AND SCHEDULING

A. Schedule work so as to cause the minimum interference with traffic and the operation of the existing signal system. Existing signals may be shut down for modification and/or equipment installation only with the approval of the Contracting Officer and the jurisdictional authority and in accordance with the approved Traffic Control Plan. Refer to Section 01570, “Maintenance and Control of Traffic”, for Traffic Control Plan requirements.

PART 2 - PRODUCTS

2.1 TRAFFIC SIGNALS, GENERAL

A. Materials necessary for this completion of the work described in this Section shall be in accordance with the NCTCOG Standard Specifications, the requirements of the jurisdictional authority, and as indicated in the Contract Documents.

B. Furnish materials necessary to complete each traffic signal installation, whether the item is specifically mentioned or not. Unspecified materials (i.e., electrical tape, bolts and nuts, etc.) shall meet the requirements of the National Electrical Code.

C. If more than one unit of a given item is required, ensure that units are the product of one manufacturer, unless otherwise approved by the Contracting Officer.

2.2 VEHICLE SIGNAL HEADS

A. Each signal head shall be a weather tight assembly of one or more signal faces of the expandable, adjustable, light emitting diode (LED) type, together with brackets and fittings necessary for proper mounting with the type of signal support designated on the Contract Drawings. Each signal face shall consist of one or more signal sections, rigidly and securely fastened together, capable of being positively positioned to control the movement of one direction of traffic. Each signal section shall consist of an optical unit, housing, housing door, and visor. Tie rods shall not be used to fasten signal sections together to form a signal face. Signal heads on this Contract shall be the product of one manufacturer.

B. The housing for each signal head section shall be made of durable polycarbonate. Each traffic signal head shall be BLACK in color. Each head shall be clean, smooth and free from flaws, cracks, blowholes, and other imperfections. It shall be designed as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened and perfectly aligned together. It shall be equipped with round openings in the top and bottom so that it may be rotated between water-proof supporting brackets and thus be capable of being directed at any angle in the horizontal plane. It shall be equipped with positive locking devices to maintain a specific angle of direction when in place. The doors shall match the head housing in color and be suitably hinged and held securely to the body of the housing by simple stainless steel locking devices. Other door parts, such as hinge pins, lens clips, and screws, shall also be of stainless steel material. Neoprene gasketing shall be used between the lenses and reflectors to exclude dust and moisture. The depth of each housing section shall not be greater than 7-1/8 inches for 12 inch signal heads. Each signal housing shall accept both plastic and aluminum backplates.

C. Visors shall be made of durable polycarbonate and shall be formed such that approximately 2 inches of the visor's depth from the face of the housing forms a full circle and the remainder of the depth forms a tunnel visor. Visors shall match the color of the head, not less than 0.05 inches in thickness. Each visor shall be designed to fit tightly against the housing door, by the means of four standard twist-on type lugs secured with four stainless steel bolts for easy mounting and rotation. Visors shall be at least 9-1/2 inches deep for 12 inch signal sections, and have flat black finish on the inside surface. Visors supporting louvers shall be constructed of aluminum and have the same physical appearance as the polycarbonate visors.

D. Refer to Article 2.9 entitled “Optical System for Vehicle and Pedestrian Signals”, herein, for signal lamp unit requirements.

2.3 VEHICLE SIGNAL HEAD BACKPLATES

A. Backplates for 2, 3, 4, and 5 section signal heads shall be constructed from black virgin ABS plastic. Backplates shall contain ultraviolet inhibitors and stabilizers for protection against ultraviolet degradation, shall maintain their flexibility under freezing temperatures, and shall withstand wind loads of 100 MPH after installation.

B. Backplates shall be one piece, vacuum formed with a non-reflective front surface.

C. Outside and inside edges shall be formed with a 3/4 inch flat and straight flange turned away from the front surface. Backplates shall have a 5 inch border width, shall have a minimum corner radius of 1.5 inches, and shall have a nominal thickness of 0.125 inch.

D. The finished backplate shall be pre-drilled to fit the signal for which it is designed or shall contain drill starts for field drilling. Backplates shall be provided with necessary bolts, nuts and washers for attaching to the signal head.

E. Provide backplates compatible with the signal head furnished. Backplates provided shall be identical and the product of one manufacturer.

F. The following brand of backplates will be considered acceptable: Pelco Products, Inc.
Other brands of backplates meeting the above requirements and those of the jurisdictional authority may be substituted upon approval.

2.4 PEDESTRIAN SIGNAL HEAD

A. Each pedestrian signal head shall meet the requirements listed herein.

B. Pedestrian signal head dimensions:

1. Maximum height: 19 inches
2. Maximum width: 19 inches
3. Maximum depth: 19 inches high

C. The casing of the signal head shall be a one piece polycarbonate or corrosion resistant aluminum alloy with four integrally cast hinges to provide for operation of a swing down door. The casing shall be yellow in color.

D. The entire signal head assembly shall form a dust and weather proof unit after installation.

E. Each signal head shall be compatible with the mounting hardware specified herein.

F. Refer to Article 2.9 entitled “Optical System for Vehicle and Pedestrian Signals”, herein, for pedestrian signal lamp unit requirements.

G. Each pedestrian head shall include a 1-1/2 inch deep polycarbonate eggcrate or “Z” pattern visor with impregnated flat black color, designed to eliminate the interference of sunlight and to allow clear visibility of the symbols.

H. Each pedestrian signal door shall be designed with adequate hinges and latch slots to provide swing down door operation and thumb screw locking devices.

I. Associated pins, screws, bolts, and nuts shall be made of stainless steel material.

J. Pedestrian signals shall be furnished with the specified mounting hardware installed and completely wired to the signal head, suitable for mounting on the specified side of the pole (pole on the right side or pole on the left side). The casing shall include top and bottom openings that are sealed with removable plugs and that are designed for use with 1-1/2 inch pipe bracket mounting hardware.

2.5 VEHICLE SIGNAL HEAD MOUNTING HARDWARE

A. Each mounting hardware assembly shall be a universally adjustable signal bracket, meeting the requirements specified herein.

B. The bracket shall allow for signal head rotation about the bracket axis, rotation about the supporting member axis, rotation on the vertical plane, and sliding of the support tube against the bracket connection point on the supporting member.

C. The bracket shall be attached to the supporting member with a stainless steel band capable of withstanding 100 ksi tensile stress.

D. The bracket attachment to the signal head shall assume rigid connection through the top and bottom of the signal head and fit the brand of signal head required on this project.

E. The bracket shall be of the type to accept the number of signal sections specified in the drawings for each signal head.

F. Both arms of the bracket shall be cast from aluminum alloy and be secured about their rotational axis by set screws. The arm on one side of the tube shall be internally threaded to accommodate the threaded support tube.

G. The entire assembly shall be capable of securely supporting a signal head under 100 mph wind loading conditions on the attached member.

H. Parts used in this assembly shall be made of corrosion resistant material or be coated with a corrosion resistant finish.

I. Wiring from the supporting member (signal arm or pole) to the signal head shall be completely concealed within the mounting assembly.

J. Each bracket shall be furnished complete with the necessary hardware for installation on the signal supporting member.

K. The nominal arm length shall be 9 inches. Longer arms shall be substituted by the Contractor when maneuverability or visibility of the signal head is restricted.

L. The following brand of vehicle signal mounting hardware will be considered acceptable: "Astro-Brac" by Pelco Products, Inc. Other brands of vehicle signal mounting hardware meeting the above requirements and those of the jurisdictional authority may be substituted upon approval.

2.6 PEDESTRIAN SIGNAL HEAD MOUNTING HARDWARE

A. Each pedestrian signal mounting hardware assembly shall be a “clamshell” mount and meet the following requirements:

1. Each unit shall consist of a two-piece, cast aluminum alloy assembly, painted yellow, and be joined in the final assembly by the use of factory-installed stainless pins. After
mating, the two pieces shall have the following dimensions:

a. Maximum height: 11-1/4 inches
b. Maximum width: 5-1/2 inches (including hinge ears)
c. Maximum depth: 3-3/4 inches

2. Pole connection surface shall be configured to accept connections to poles of 4 inches minimum diameter. The hardware shall allow pole mounting by means of a band strap.

3. The head half of the assembly shall be secured to the pedestrian signal with four 5/16 inch bolts.

4. A minimum of three sets of screw terminal pairs shall be located on a terminal block in either the head or pole half of the assembly.

5. The terminal block compartment shall be watertight to prevent moisture from reaching the terminals.

B. Electrical wiring shall be completely concealed within the mounting assembly.

C. Parts used in this assembly shall be made of corrosion resistant material or be coated with a corrosion resistant finish.

D. Each bracket shall be furnished complete with the necessary hardware for installation on the signal supporting member.

E. The following brand of pedestrian signal head mounting hardware will be considered acceptable. Pedestrian signal head mounting hardware produced by other manufacturers may be substituted providing they meet the jurisdictional authority's requirements and are approved.

1. Indicator Controls Corporation Part Number 4835
2. McCain Traffic Supply Part Number P9050

2.7 SIGNAL HEAD LOUVERS

A. Louvers shall be provided for those signal sections indicated in the Contract Drawings. Louvers shall be of such design as to provide visibility of the lens for the intended lane of traffic as indicated by the Contract Drawings and block visibility to other lanes.

B. The internal arrangement of each louver shall consist of 5 vanes with 5 degree cut-offs right of center. Louvers shall have a flat black finish on the external surfaces and a dull black finish on the inside surfaces. Each louver shall be of suitable weight and size to fit inside the tunnel visor furnished for the intended signal section.

C. A "chicken wire" screen with sufficient mesh size to prevent entry by birds shall be securely fastened to the front face of each louver.

D. When indicated on the Contract Drawings, a Pelco Model SP-1010-TX geometrically programmed louver with visor and clip shall be used to shield the signal displays. Other louvered signal displays shall be shielded with the louver specified above.

2.8 PEDESTRIAN PUSHBUTTON ASSEMBLIES

A. Each pedestrian pushbutton assembly shall be of one piece cast aluminum construction which includes a pushbutton switch, sign frame, and sign.

B. The housing of the pushbutton switch shall be completely dust and moisture resistant.

C. The sign frame for each assembly shall accept a 9 inch by 12 inch sign.

D. The sign shall have a white reflective background with black lettering and border meeting the graphical and textual requirements as specified on the Contract Drawings and the jurisdictional authority's requirements.

E. Curve back assemblies shall be provided for mounting on round poles of 4 to 15 inches in diameter.

F. The pushbutton housing and sign frame shall have a yellow, corrosion resistant finish.

G. The pushbutton shall have an easy to push 2-inch "ADA" style button that meets ADA requirements as published in the Federal Register.

2.9 OPTICAL SYSTEM FOR VEHICLE AND PEDESTRIAN SIGNALS

A. The optical system for each signal section shall meet the requirements specified herein.

B. Each LED signal lamp unit shall be a single, self-contained, watertight silicon sealed unit, consisting of a UV stabilized polymeric outer shell, multiple LED light sources and a regulated power supply. LED’s shall be mounted on a polycarbonate positioning plate or conformally coated PC board.

C. LED’s shall be manufactured using AlInGaP (Aluminum-Indium-Gallium-Phosphorous) technology or other technology with as low or lower susceptibility to temperature degradation than AlInGaP. AlGaAs (Aluminum-Gallium-Arsenic) LED’s will not be allowed.
D. Color and Design:

1. The color of the LED lamps shall be as specified herein and on the Contract Drawings.

2. Pedestrian signal lamp unit shall display a uniform, bright alternate symbol message of “HAND” in portland orange and “WALKING PERSON” in lunar white. The countdown part of the module must consist of 2 digits and must be located immediately adjacent to the associated “UPRAISED HAND” icon and integrated into the module. Each message shall be a minimum of 12 inches in height and 7 inches in width. A 30 second countdown timer shall be included with the pedestrian signal.

E. Each LED traffic signal lamp shall meet minimum laboratory light intensity values, color (chromaticity), and light output distribution as described in ITE Standards, Chapter 2.

F. Each LED pedestrian signal lamp shall meet minimum laboratory light intensity values for color (chromaticity) as described in the ITE Standards, Chapter 3.

G. The LED signal lamp unit shall operate on a 60 Hz AC line voltage ranging from 80 volts RMS to 135 volts RMS without flickering.

1. For traffic signal lamps: Two captive, color coded, 36 inches long, 600V, 18 AWG minimum jacketed wires shall be provided for an electrical connection to the signal head terminal block.

2. For pedestrian signal lamps: The conductors to the lamp unit shall be copper, 12 inches long, 221 degrees F insulation, and shall conform to the 1999 NEC Article 402, “Fixture Wires”.

H. LED’s shall be arranged in no less than 5 equally loaded circuits. For traffic signal lamps only: The module shall be designed to sense a loss of light output due to catastrophic LED failures of between 25 and 40 percent. Loss of light output due to LED failure shall not be detected for losses of less than 25 percent but shall be detected for any loss of light greater than 40 percent.

I. Acceptable brands of LED’s are listed on the TxDOT website’s Prequalified Products List. Other brands of LED’s meeting the above requirements and those of the jurisdictional authority may be substituted upon approval.

2.10 CONDUITS AND RELATED HARDWARE

A. Conduits shall be in compliance with Section 16111, “Conduits”, and as specified herein.

B. Metal Conduits: Conduit, including elbows and couplings shall be standard weight schedule 40 zinc-coated steel rigid threaded conduit (hot-dip galvanized), conforming to NEMA C80.1, and Underwriters’ Laboratories Specifications.

C. PVC Conduits: Polyvinyl chloride conduits, including elbows and couplings shall be schedule 40 PVC conduit, conforming to UL 651.

D. Weatherheads shall be made of aluminum and attached to conduit by means of a clamp-on strap.

E. Splice/terminal cans shall be no less than 6 inches deep, 6 inches wide, and 6 inches high. Terminal cans shall be made of a rust resistant, weatherproof material. Plastic terminal cans will not be acceptable.

2.11 GROUNDING CONDUCTORS AND RODS

A. Grounding and bonding shall be in compliance with Section 16450, “Grounding and Bonding”, and as specified herein.

B. The grounding conductor shall be a No. 6 AWG stranded copper wire.

C. Ground rod electrodes shall be copper-bonded steel being at least 5/8 inch in diameter and a minimum of six feet long.

2.12 MULTI-CONDUCTOR SIGNAL CABLE/WIRE

A. Conductor cable for intersection signalization and interconnect shall be multi-conductor capable of operating at 600 volts maximum, and suitable for use at conductor temperatures not exceeding 167 degrees F. Such cable shall meet the requirements of NEC. Interconnect cable size and type shall be as described in the Contract Drawings.

B. Signal conductor cable shall be No.14 AWG/THHN/multi-conductor, stranded copper, the number of conductors as specified on the Contract Drawings. The copper wire (before insulating) shall meet the requirements of the latest ASTM standards for uncoated wire.

C. Wire running from the pole base to the pedestrian signal head shall be No. 14 AWG stranded multi-conductor jacketed cable.

D. Refer to Paragraph entitled “Identification of Signal Wires and Cables” for additional product requirements.

E. Wire and cable shall be compliance with Section 16120, “Wire and Cable”.

2.13 A.C. POWER AND LUMINAIRE POWER WIRE

A. A.C. Power Wire shall be No. 4 AWG/XHHW, with the number of conductors being specified in the
Contract Drawings, and meeting the provisions of NEC.

B. Luminaire Wire shall be No. 8 AWG/XHHW, with the number of conductors being specified in the Contract Drawings, and meeting the provisions of NEC.

C. The cable shall be capable of operating at 600 volts maximum and suitable for use at conductor temperatures not exceeding 167 degrees F. Material and construction shall be in accordance with the applicable requirements of the "Insulated Power Cable Engineers Association" (I.P.C.E.A) Standards.

2.14 CABLE INSTALLATION LUBRICANT

A. Cable installation lubricants shall be commercially available wire pulling compounds suitable for PVC sheathed cables consisting of soap, talc, mica, or similar materials designed to have no deleterious effect on the cables being used. Lubricant shall not be the grease or oil type used on lead sheathed cables.

2.15 PULL BOXES

A. The pull box cover shall be constructed of galvanized steel and its top surface shall have a minimum co-efficient of friction of 0.5.

B. The words "DANGER HIGH VOLTAGE TRAFFIC SIGNAL" shall be imprinted as an integral part of pull box covers.

C. Pull box covers shall be furnished with a locking mechanism to prevent access to the pull box without the use of tools.

D. Pull boxes shall be of a stackable design so that they can be joined together to achieve an extra-height box.

E. Pull box enclosures shall be constructed of concrete, and when covered, shall meet AASHTO standard specifications for H20 loading (32,000 pound, single axle load over a 10 inch by 10 inch area). Enclosures and covers shall be rated for a minimum of 5,000 lbs over a 10 inch by 10 inch area.

F. Pull box components shall be designed and tested to withstand temperatures as low as minus 20 degrees F.

G. Pull boxes designated as Type C on the Contract Drawings shall be 15.25 inches in width by 28.25 inches in length by 10 inches in depth.

2.16 TRAFFIC SIGNAL STRUCTURES

A. General:

1. Furnish traffic signal structure components in compliance with the designs, dimension, strength, and material quality specified in the Contract Drawings to assure structural consistency of components in future improvements.

2. Components of Traffic Signal Structures listed in this subsection shall be hot dipped galvanized to resist corrosion.

B. Other hardware necessary for complete installation of traffic signal structures, i.e., simplex plates, pole caps, transformer bases, and anchor bolts, shall be hot dipped galvanized and conform to the design, dimension, and strength requirements of said items as indicated in the Contract Drawings.

2.17 TRAFFIC SIGNAL CONTROLLERS AND CABINETS

A. Refer to the Contract Drawings for specifications for a traffic signal controller, cabinet, and related equipment based on the requirements of the jurisdictional authority.

2.18 ANCHOR BOLTS (BOLTS, NUTS, AND WASHERS)

A. Anchor Bolts: ASTM F1554, Grade 55, unless noted otherwise on Contract Drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers.

B. Galvanized per ASTM A153/A153M

C. Bolts hooked, unless otherwise shown or recommended by manufacturer of pole or structure being anchored.

1. Two nuts and one washer for each anchor bolt for plumbing pole or leveling structure.

2.19 CONCRETE

A. In accordance with Section 03305, "Portland Cement Concrete", Mix S-2.

PART 3 - EXECUTION

3.1 GENERAL

A. Construction within shall be in accordance with the NCTCOG Standard Specifications as revised, the requirements of the jurisdictional authority, and as specified herein.

B. Install and activate completed signals and signal systems.
C. Installation work shall be in accordance with the applicable sections of the NEC, local ordinances and regulations, the Contract Drawings, these Specifications and relevant sections of the NCTCOG Standard Specifications. Finished work shall be neat and uncluttered in appearance.

D. Furnish and install signal equipment including: controller cabinets (unless noted otherwise), signal structures, conduits, pull boxes, signal head assemblies, detector units, AC service, conductors, concrete, reinforcing steel, forms for structure foundations, grouting materials, painting materials, miscellaneous nuts, bolts, and washers, and other miscellaneous equipment that is required to complete the Work.

E. Obtain and install a meter base for electrical power service for each signal installation on this contract. Obtain the meter base from the electrical utility company.

F. Maintain existing traffic signal operations during the installation of new signals. Where controllers, cabinets and/or, signal heads exist on foundations that are to be removed, maintain the signal in proper working order by use of an existing controller or temporary controller, and/or temporary head(s) and cables. Provide temporary materials, as required.

G. Removal and Salvage of Existing Equipment:
   1. Remove existing traffic signal equipment as designated in the Contract Drawings. If equipment/materials are to be salvaged, obtain from the jurisdictional authority through the Contracting Officer a list of salvage materials. Deliver the salvage materials to the jurisdictional authority’s designated storage location. Give the Contracting Officer 1 week notice prior to removing or dismantling any traffic signal cabinet or structure in order to receive any special instructions.
   2. Ship and handle salvage material (heads, poles, cabinets, cable, signs, amplifiers, etc.) in a manner so as to prevent damage to these items. Signal heads shall be removed from poles prior to shipping. Secure cables in controller cabinets to prevent damage during shipment and handling. Tighten screws into their respective slots to prevent loss during shipping. Remove the controller and supplemental control equipment (conflict monitors, detector amplifiers, load switches, etc.) from the cabinet prior to cabinet removal and give them to an authorized representative of the jurisdictional authority at the time of the signal turn-on.
   3. The representative of the jurisdictional authority will identify existing damage to salvageable material and mark damaged items in the field. The Contractor will not be held responsible for damage not caused by the Contractor or for existing damage. If damage to material is the fault of the Contractor, make repairs or supply equal items within three working days, at the Contractor’s expense. If the Contractor fails to repair or replace damaged items in said time, the Contractor will be charged for the assessed value.

H. Notify the jurisdictional authority a minimum of 2 days prior to delivering salvaged materials and schedule delivery at a time convenient to the jurisdictional authority. Deliver salvaged material to the storage area designated by the jurisdictional authority. Obtain receipt for Contractor’s records.

I. The initial acceptance of the work performed by the Contractor for each signalized intersection shall take effect at the time the intersection is put in operation. The warranty period required under General Provisions, “Warranty of Construction”, shall start at the date the signal is put in operation with complete permanent equipment.

J. The locations of traffic signal foundations, bases, conduit, detectors, and similar work shown on the Contract Drawings are approximate. Exact locations shall be determined by the Contractor at the time of construction.

K. Although the Contract Drawings are drawn approximately to scale, the positional relationship of some system components and equipment (e.g., cabinet and pole locations) have been distorted for purposes of clarity.

L. The locations and lengths of existing conduit and other utility facilities shown on these Contract Drawings are approximate, exact locations and lengths shall be determined by the Contractor. Refer to Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”, for requirements for locating and protecting existing utilities.

3.2 TRAFFIC SIGNAL COMPONENTS - INSTALLATION OF ELECTRICAL SERVICE

A. Furnish and install conduit and wire from service connections for AC Service as shown on the Contract Drawings and as required by the electrical utility company for traffic signal controllers and
3.3 TRAFFIC SIGNAL COMPONENTS - INSTALLATION OF CONDUIT

A. Comply with the requirements of the jurisdictional authority for street and sidewalk cutting, excavation, and repair and the applicable provisions of the specifications.

B. Conduit installation shall comply with Section 16111, “Conduits”.

C. Trench excavation, support, and backfilling shall comply with Section 02221, “Utility Excavation and Backfilling”.

D. Install underground cable facilities required to satisfy the requirements of the new signal system. Route cable through existing conduits and new conduits installed by the Contractor as shown in the Contract Drawings.

1. If any of the available cable routing paths utilize existing duct space of the local tele/communications provider, the Contractor shall be responsible for detailed coordination of proposed cable routing and actual installation, with local tele/communications provider before any work is started. Installation of conduit and cable in local tele/communications provider manholes shall be per local tele/communications provider Specifications, which includes adequate ventilation to prevent injury to personnel caused by toxic or harmful gases.

E. New Conduit:

1. Unless otherwise shown on the Contract Drawings, conductors shall be in conduit except when in metal poles. Conduit and fittings shall be of the sizes and types shown on the Contract Drawings. Exposed conduits and related parts shall be rigid metal. Each section of conduit shall bear evidence of approval by Underwriter's Laboratories.

2. Conduit terminating in posts or pedestal bases shall not extend vertically more than 3 inches above the concrete foundation. Field bends in rigid metal conduit shall have a minimum radius of 12 inch diameters times the nominal size of the conduit.

3. Each length of galvanized rigid metal conduit, where used, shall be reamed and threaded on each end and couplings shall be made tight. Joint PVC conduit by the solvent-weld method in accordance with the conduit manufacturer's recommendations. Use no reducer couplings unless specifically indicated on the Contract Drawings.

4. Conduit and fittings shall have burrs and rough places smoothed and shall be clean and free of obstructions before the cable is installed. Make field cuts with a hacksaw only. Make field cuts square and true so that the ends will butt or come together for the full diameter thereof. Use no cutting torch to cut or join conduit. Slip joints or running threads will not be permitted for coupling conduit unless approved by the Contracting Officer. When a standard coupling cannot be used, use an approved union coupling and provide a water-tight coupling between the conduit. Install couplings properly to bring their ends of connected conduit together to produce a good rigid connection throughout the entire length of the conduit run. Where the coating on a conduit run has been damaged in handling or installation, such damaged parts thoroughly painted with rust preventive paint. Cap or plug ends of conduits until installation of the wire is complete. When directed, draw a full-size metal wire brush, attached by swivel joint to a pull tape, through the metal conduit to ensure that the conduit is clean and free from obstructions. Place conduits in an open trench at a minimum 24 inches depth below the curb grade in the sidewalk areas, or 18 inches below the finished street grade in the street areas. Paint shall be in accordance with Section 09970, “Coatings for Steel”.

5. Secure and support conduit placed for concrete encasement in such a manner that the alignment will not be disturbed during placement of the concrete. Place no concrete until of the conduit ends have been capped and box openings closed. Place concrete in accordance with Section 03300, “Cast-In-Place Concrete”.

6. Jacking or Boring: Place PVC conduit, which is to be placed under existing pavement, sidewalks, and driveways, by first providing a void through which the PVC conduit shall be inserted. The void may be
made by either boring or jacking a mandrel. Place metal conduit, which is to be placed under existing pavement, sidewalks, and driveways, by jacking or boring.

a. If it is determined by the Contracting Officer that it is impractical to place the conduit by jacking or boring due to unforeseen obstructions, written permission will be granted for the Contractor to cut the existing pavement.

7. Pits for jacking or boring shall not be closer than 2 feet to the back of the curb or the outside edge of the shoulder unless otherwise directed. The jacking and boring method used shall not interfere with the operation of streets, highways, or other facilities, and shall not weaken or damage any embankment structure, or pavement. Use heavy jacks for jacking. Perform boring by mechanical means providing a maximum 1 inch overcut for the conduit to be placed. Use of water or other fluids in connection with the boring operation will be permitted only to lubricate cuttings. Water jetting will not be permitted.

8. Where conduit is to be placed under existing asphaltic pavement, use the jacking method unless written approval is given by the Contracting Officer for placement of conduit by boring.

9. Tamp backfill for excavations with mechanical tamps in 6 inch layers (compacted) to the density of the surrounding ground.

10. Provide adequately bent conduit and properly excavate so as to prevent damage to the conduit or conductor by a bend radius which is too short.

11. Where conduit is installed into an existing base, cut base as shown in the Contract Drawings and install conduit into the base without interfering with the operation of the signal.

12. Make conduit runs continuous and of the same material (metal only or PVC only). Where tying into existing conduit, continue with the same material (metal to metal or PVC to PVC).

F. Existing Conduit:

1. Prior to pulling cable in existing underground conduit, clean conduit with a mandrel or cylindrical wire brush and blow out with compressed air. If conduit appears to be blocked, make an attempt to clear the conduit by rodding. (The Contractor will not receive extra compensation for rodding.) Notify the Contracting Officer prior to disconnecting or removing existing interconnect cable.

2. Where existing conduit is found to be unusable (conduit has collapsed or the cable is unable to be pulled from the existing conduit), upon approval, install new rigid metal or PVC conduit.

3.4 TRAFFIC SIGNAL COMPONENTS - CABLE

A. General:

1. Wire and cables shall comply with Section 16120, “Wires and Cables”, and requirements specified herein.

2. Install cables in conduit unless indicated as an “overhead” cable run. Conduit shall be continuous, free of debris, reasonably dry, and without sharp projections, edges, or short bends. If required by the Contracting Officer, demonstrate that the conduit is dry and free of debris by pulling a swab and/or mandrel through the conduit. Install conductors in a manner so as to ensure against harmful stretching of the conductors or damage to the insulation. Installation methods shall conform to the recommendations of the cable manufacturer.

3. Pull cables in a given conduit run at the same time and assemble conductors to form one loop in such a manner that the pulling tension is equally distributed to the cables. For long, hard pulls use pulling eyes. For short runs, the cables may be gripped directly by the conductors by forming them into a loop to which the pull wire or rope can be attached. Select method that is appropriate for the anticipated maximum pulling tension in each case.

4. In many instances, existing conduits which contain signal cable shall be used for the installation of new cables. In locations where new cables are to replace existing cables, the existing cables may be used to pull in the new cables. At locations where new cables are to be added to existing cable runs, first pull out the existing cables, then replace, adding the new cables to the existing cables to form one cable pull. Installation and removal shall be done in such a way as to prevent damage to the existing and/or new cables. In the event of damage, the Contractor shall bear the responsibility of providing the material and labor for replacement of defective cables at no extra cost.

5. Measure conduit runs accurately for determining cable lengths to be installed. Insert a measuring device into the conduit,
and measure the length (to the nearest foot) from entry point to exit point. Make conduit run measurements in the presence of the Contracting Officer. Record cable measurements and include the distances on an as-built drawing. In locations where new cables are to replace existing cables, the Contractor may use the removed cables as a measuring device to determine the lengths of the new cables to be installed; however, this does not relieve the Contractor of his responsibility to record accurate measurements of cable lengths.

6. Do not exceed manufacturer's recommended maximum pulling tensions under any circumstances. If so required by the Contracting Officer, insert a dynamometer in the pull wire as the cables are being pulled into the conduit to demonstrate that the maximum tensions are not being exceeded. The cable shall be fed freely off the reel into the conduit without making a reverse curve. At the pulling end, draw the pull wire and cables from the conduit in direct line with the conduit. Use sheaves or other suitable devices as required to reduce any hazards to the cable during installation. Lubricate cables to reduce friction and further minimize possible damage.

7. Neatly train cables to their destinations in manholes, cabinets, pole bases, pullboxes, and other terminations. Adhere to the cable manufacturer's recommended values for the minimum bending radii to which cables may be bent for permanent training during installation. These limits do not apply to conduit bends, sheaves, or other curved surfaces around which these cables may be pulled under tension while being installed. Larger radius bends are required for such conditions.

8. Pack plumbers putty around cables at the end of each conduit run to seal the conduit openings and prevent moisture and debris from entering.

B. Controller Cabinet Wiring:

1. Wiring for the controller cabinet shall consist of connecting (1) signal wires, (2) power wires, (3) ground wires, and (4) pedestrian push-button wires, to their respective terminals in the cabinet. In the controller cabinet, stranded signal conductors from the field shall be stripped back and a solderless terminal connector shall be attached by means of a special crimping tool manufactured by AMP, Inc. of Harrisburg, Pennsylvania (Model #AB59250). These terminal connectors shall be inserted under the binder head screw and tightened securely. Other wiring for the controller cabinet shall be completed as shown on the wiring diagrams and in the instructions furnished with the controller cabinet by the manufacturer.

2. Neatly install field wiring in cabinets. Train incoming cables to their destination and neatly face together. Trim spare wires and neatly coil with the ends taped. Detector lead-in cables shall have their insulation jackets removed from their terminal strip connection to the bottom of the cabinet, and have their ground wires tied together in the bottom of the cabinet.

3. Pedestrian pushbuttons shall have a common ground wire that is completely isolated and independent from other ground wires. Connect this wire to the designated terminal in the controller cabinet.

C. Signal Head Wiring: Wire signal heads to tie each head into the signal cable for the system. Wiring for the signal head shall consist of connecting the terminal block in each signal section to the common terminal block in each signal face, and where applicable, connecting the common terminal block in each signal face to the terminal block in the signal-head terminal compartment. Wire feeding through the mast arm pole structure shall be wrapped once with plastic electrical tape and wrapped again with electrical friction tape extending 12 inches on each side of the pole opening for a total of 24 inches. For mast arm and pole mounted heads, conductors running from the pole's terminal compartment or transformer base to the signal head terminal shall be No.14 stranded wire. Span wire heads shall be wired with No.14 stranded wire.

D. Terminals: The ends of stranded wires which are to be attached to terminal posts shall be provided with solderless terminal connectors, specified herein.

E. Splices:

1. Make no splices inside conduit runs. Splice signal cables only at locations that are specified in the Contract Drawings. Splicing signal cable in pull boxes is prohibited.

2. Splicing methods shall be in accordance with good electrical practice and the cable manufacturer's recommendations. Materials used shall be of high quality and specifically intended for this purpose. Train cables to their final position and cut to proper lengths. Remove the cable's jacket and insulation as required. In doing this, use care to ensure against nicking the conductors. Install connection tightly and remove burrs, rough edges, and similar imperfections.

3. If wire nuts are used to secure the connection, then splice no more than three
wires together. If more than three wires are connected, then use a Kearney connector or mechanical clamp. Secure splices involving grounding conductors with Kearney connectors or mechanical clamps.

4. When directed that the connections shall be soldered, apply heat by use of a hot soldering iron. Heating the connection with a direct flame will not be permitted. Use care to protect the insulation when soldering. Clean entire surface; take special care in cleaning the outside jacket in order to remove the wax finish. Before the first layer of tape is wrapped, coat entire area with an electric grade rubber cement. After this solvent has dried, insulate the connection to the proper thickness with electrical grade rubber splicing compound tape. This tape requires a pressure and temperature in service to complete its vulcanizing process and shall be stretched to 2/3 its normal width when applied. Cover the completed splice with a half-lap layer of vinyl plastic electrical tape. This wrapping shall be smooth but the tape shall not be stretched more than necessary.

5. Splices in communication cables shall include the shield. Splices between cable pairs shall be made with "Scotchlock" solderless connectors designed for this purpose. The completed splice shall be insulated with a re-enterable plastic splice case. Splices at points other than those shown on the Contract Drawings may be made only with the written approval of the Contracting Officer.

F. Enclosed Wiring: Except for cables suspended by span wire and electrical wiring within steel signal poles, enclose cables and single conductor wire above the ground surface in metal conduit up to but no closer than 1 foot of the lowest power conductor source. Place power-tap lines carried down poles in metal conduit.

G. Identification of Signal Wires and Cables:

1. Follow color codes as shown in the Contract Documents. Make colors continuous from the point of origin to the point of termination. Splices will be permitted only if the same colors are spliced.

2. Designate each communication cable with permanent marking labels at each pull box and in the controller cabinet.

H. Installation of New Signal Cable: Installation of new signal cable in existing conduit will not be permitted until foundations subject to removal have been eliminated. The Contractor may deviate from this requirement in special cases only, after obtaining the approval of the Contracting Officer.

3.6 TRAFFIC SIGNAL COMPONENTS - CONCRETE FOUNDATIONS FOR SIGNAL STRUCTURES

A. Concrete foundations for signal structures shall be located so that the closest structure leg is a minimum of 4 feet from the face of the nearest vertical curb.

B. Excavate for foundations in accordance with lines and depths indicated on the Contract Drawings and as specified in Section 02220, "Grading, Excavating and Backfilling," and Section 02375, "Drilled Shaft Foundation Piers," as applicable. Loose material shall be removed from the excavation before concrete is placed. Water shall be removed by pumping or bailing. The use of explosives will not be permitted.

C. Concrete placement shall comply with Section 03300, "Cast-in-Place Concrete".

D. Construct foundations shall be constructed to the dimensions shown on the Contract Drawings or as
directed by the Contracting Officer. Form and make level the top of the finished foundation. Hold anchor bolts and conduits rigidly in place by a template until the concrete is set. Use a mechanical vibrator for compacting and working the concrete.

1. After the concrete has been placed and the top struck off, it shall be covered with wet cotton or burlap mats, for not less than 96 hours. Bracing and templates for anchor bolts shall remain in place for 96 hours after the concrete is poured. During that time, the anchor bolts and conduit shall not be subjected to any applied strain. Transformer bases shall not be installed on any foundations until approval has been obtained from the Contracting Officer.

E. Backfill shall be tamped with mechanical tamps in 6 inch layers to the density of the surrounding ground. Where excavation is made in the roadway shoulder, the shoulder shall be replaced with material equal to the original composition.

F. Excavated material, not required for backfill, shall be promptly removed and disposed of by the Contractor, as specified in Section 02220, “Grading, Excavating, and Backfilling”. The work site shall be kept clean and neat.

G. No concrete shall be placed when the atmospheric temperature drops below 40 degrees F (temperature reading taken in the shade away from artificial heat) unless permission to do so is given by the Contracting Officer.

3.7 TRAFFIC SIGNAL COMPONENTS - TRAFFIC SIGNAL STRUCTURES

A. Examine foundations, which are to receive traffic signal standards, to assure proper anchorage alignment. Report discrepancies to the Contracting Officer.

B. Level transformer bases, if used, and tightly secure to the foundation before the structure is placed on the base. If shims are required for leveling, total shim height shall not exceed 1/2 inch. Extend foundation anchor bolts a minimum of three threads through each nut in the base.

C. Except as modified herein, erect traffic signal structures in accordance with the applicable Specifications and Standards of the AISC Manual of Steel Construction. Erecting equipment shall be suitable for the work and shall be in first class condition. Where parts cannot be assembled or fitted properly as a result of errors in fabrication or deformation due to handling or transportation, report such condition immediately to the Contracting Officer for approval of the method of correction that shall be used. Straightening of plates and angles or other shapes shall be done by approved methods. Bent or damaged heat-treated parts will be rejected. Steel work shall be drained properly. Fill pockets in structures exposed to the weather with a waterproof material approved by the Contracting Officer. The Contractor shall correct shrinkage and distortion of butt welds. Moment connections in the field on beams and girders shall have a minimum of 3/16 inch root opening prior to welding for flange preparations. Correct loose joints by cutting with a hand guided torch, if necessary.

D. Erect and assemble in accordance with manufacturer’s detailed instructions.

E. Field welding shall be as specified for shop fabrication of welded construction. Any shop paint on surfaces adjacent to joints to be field welded shall be wire brushed to reduce the paint film to a minimum.

F. Grouting: Pack void between concrete base and pole base plate with nonshrink grout, as specified in Section 03305, “Portland Cement Concrete”, and install as specified in Section 05130, “Structural Steel - Buildings”. Install a waterproof silicone-based sealer between the controller cabinet and the controller foundation in accordance with Section 07900, “Seals and Sealants”.

3.8 TRAFFIC SIGNAL COMPONENTS - SIGNAL HEADS

A. Assemble signal head units as specified in the Contract Drawings or as directed. Mount signal heads level and plumb. Position and secure the signal heads so they are visible at a minimum of 200 feet back from the stop bar.

B. Cover signal heads or parts of heads not in operation with burlap until placed into operation. When the signal heads become operational, immediately remove existing heads no longer required.

C. Hardware in each signal head assembly shall be completely tight. Securely tighten signal and pedestrian heads immediately after the signal head assembly has been installed. If any signal head assembly is found to be loose or asymmetrical in any manner, remove and rebuild the signal head assembly to the satisfaction of the Contracting Officer.

3.9 TRAFFIC SIGNAL COMPONENTS - FIELD PAINTING

A. No painting will be required for the signal heads except those parts on which the paint has been scratched or marred, and such parts shall be given two coats of high-grade enamel or paint of the same color as the factory paint.

B. Surfaces where the shop coat of paint has been damaged shall be retouched using the same system as the original shop painting. Promptly after the acceptance of the weld, clean, pretreat,
and prime welds and the areas adjacent thereto as specified under the shop painting.

3.10 FIELD QUALITY CONTROL

A. Perform Contractor-conducted testing in the presence of the Contracting Officer.

B. Signal Cables:

1. Check cables for insulation resistance upon installation and prior to termination. Perform the tests with a test set operating at a minimum of 500 volts D.C. applied to the conductors.

2. Test each conductor in the multiconductor signal cables for insulation resistance relative to each other and to the outer covering of the cable. The minimum acceptance value for insulation resistance shall be 1 megohm.

C. Traffic Signal Cable Splices: The Contracting Officer will select at random at least five splices to be inspected. In the presence of the Contracting Officer, sectionize each selected splice to expose the various layers of materials and the connector. These splices will be thoroughly checked by the Contracting Officer for compliance to these specifications. If any splices fail to meet these requirements, then the Contracting Officer will select ten more splices at random for inspection. The Contractor shall then remake each splice.

3.11 TRAFFIC SIGNAL MAINTENANCE DURING CONSTRUCTION

A. Refer to General Provisions “Protection of Existing Site Conditions”. While performing work under this contract, the Contractor bears the sole risk of loss for damages to or destruction of any traffic signal equipment or appurtenances, on equipment that was not to be replaced or installed under this Contract, but which was damaged or destroyed through the fault or negligent act of the Contractor. The Contractor shall replace such damaged or destroyed equipment, etc., at no cost to the Authority or the jurisdictional authority, regardless of whether or not the damaged or destroyed equipment or other element, was a part of this Contract or any warranties under this Contract. The Contractor’s responsibility shall cease under this Article upon written acceptance of an intersection by the Contracting Officer.

B. The Contractor shall provide, at his expense, temporary signal cable systems and signals mounted on span wires, portable bases, or other locations as specified in the Contract Drawings and necessary during the project to ensure that signal head displays are always in operation. Temporary signal assemblies shall feature 12 inch lenses on signal faces. Such temporary signals shall be finished in appearance, meet the requirements of TMUTCD, shall conform to the jurisdictional authority’s standards for temporary box span traffic signals, and be approved by the Contracting Officer.

C. The Contractor’s responsibility for full operation and maintenance of traffic signal equipment shall begin when he starts any type of work which affects active intersection control at the first intersection and shall extend through the period of final project acceptance of each intersection. This maintenance responsibility includes existing controllers/masters, existing interconnect and cabling systems, existing signal indications, new controllers/masters, new signal hardware, new cabling systems, and other hardware elements which are considered part of either the existing or the new traffic signal system.

D. The Contractor shall utilize qualified personnel to respond to trouble calls and to repair any malfunctions. Provide a local telephone number (not subject to frequent changes) where trouble calls are to be received on a 24 hour basis by the Contractor. Respond to reported trouble calls within a reasonable travel time from a Dallas address, but not more than 2 hours maximum. Make appropriate repairs within 12 hours.

E. It is recognized that the jurisdictional authority may make a first response to any trouble call. Action on such response will, however, be limited to placing the intersection on flash, replacing load switches or detector amplifiers, erecting temporary control devices, requesting immediate traffic control by uniformed police officer, or other such action deemed necessary to provide a safe operation. Such action will in no way relieve the Contractor of his operation and maintenance responsibility or the cost of the jurisdictional authority to respond and take appropriate action to provide public safety.

F. Provide police traffic control assistance for planned controller change-outs or any other operational procedures in accordance with the requirements of the jurisdictional authority and as requested by the Contracting Officer. Arrange for police assistance directly, at least 24 hours in advance. If the Contracting Officer discovers that the Contractor has failed to provide adequate police assistance, the Contracting Officer may order additional assistance. Police traffic control assistance, for any purpose, shall be the financial responsibility of the Contractor, regardless of who obtains the assistance.

G. Temporary signalization will be coordinated with time base coordination. A representative of the jurisdictional authority will "punch in" traffic signal settings during construction, and Authority’s forces will prepare the initial traffic signal timing in a timing sheet format.

H. The Contractor may use existing signal heads and signal controllers for temporary control. Temporary signal controllers shall be Model 170 or as approved by the jurisdictional authority. With the approval of the Contracting Officer and the
jurisdictional authority, the permanent signal controller and cabinet may be used for temporary control in its permanent location; however, the Contractor shall be responsible for damage to permanent equipment.

I. Refer to Sections 01500, “Temporary Facilities and Services Required During Construction”, and Section 01570, “Maintenance and Control of Traffic”, for related provisions for temporary traffic signals and traffic controls.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section, traffic signal construction, will be measured and be paid for at unit price for “Traffic Signalization” for each intersection as follows:

1. Traffic signal poles shall be measured and paid for each pole installed, including pole foundation, anchor bolts and all necessary hardware.

2. Traffic Pull Boxes shall be paid for each pull box installed, including frame and cover, all excavation, backfill and surface restoration.

3. Pedestrian Signal Heads and Vehicle Signal Heads shall be paid for each signal head installed, including all signal head mounting hardware, signal cable, louvers and signal head back plates.

4. Pedestrian pushbutton assemblies shall be paid as each pedestrian pushbutton assembly installed, payment will also include all pushbutton switches, sign frame, signs and related hardware and wiring.

5. Conduit shall be measured and paid per linear foot of conduit installed, including all excavation and backfill. Conduit installed under pavement shall include the cost of any necessary pavement restoration to restore the pavement to its original condition.

6. Traffic Signal Controller, cabinet and all vehicle detector equipment shall be furnished by the City of Dallas.

7. Concrete for the controller foundation shall be measured and paid in accordance with Section 03300, “Cast-In-Place Concrete.”


9. Pay for “Install Highway Traffic Signal" each, install equipment furnished by others. Removal of existing signal equipment to be subsidiary to this item.

B. Temporary signalization will not be measured but will be paid for at the lump sum price for “Temporary Traffic Signals”.

C. No separate measurement or payment will be made for the following work required for work of this section. Such work will be considered subsidiary to the various bid items:

1. Installation of materials furnished by the Authority or the jurisdictional authority.

2. Costs associated with obtaining meter bases.

3. Foundations for traffic signals and for other work of this section, including work caused by obstructions.

4. Concrete work, including reinforcing steel.

5. Excavating, backfilling, jacking, boring, and tunneling, including concrete encasement, bedding material, and disposal of surplus material.

6. Support of excavation for depths not exceeding 5 feet

7. Dewatering.

8. Removal or abandonment of existing conducts and associated items.

9. Removal and replacement of existing bases, pavements, sidewalks, curbs, and gutters.

10. Barricading and maintenance and control of traffic, including police traffic control assistance.

11. Maintenance and support of existing utility facilities, except as otherwise indicated in Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities”.

D. Trench Support System for trenches exceeding a depth of 5 feet will be measured and paid for as specified under Section 02221, "Utility Excavation and Backfill".

END OF SECTION 02590
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the furnishing, installation, testing, and disinfection of water mains and appurtenances.

1.2 REFERENCED STANDARDS

A. North Central Texas Council of Governments (NCTCOG)


1.3 SUBMITTALS

A. Submit manufacturer’s data and shop drawings, as applicable, for fittings, valves, vaults, hydrants, meters, meter boxes, valve boxes, RCCP layouts, and appurtenances.

B. Certification. Submit certifications for water piping and casings.

C. Documentation:

1. Submit bill of materials for materials used on this Project for approval.

2. Tests shall conform to requirements of the authority in charge of water line.

1.4 QUALIFICATIONS

A. Fire Protection Specialist: A certified fire protection specialist shall be required to install components of fire protection lines, hydrants, valves, risers, and nozzle assemblies. This does not apply to fire hydrant laterals and normal appurtenances of water lines.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials (including their delivery, storage, handling, and testing) necessary for the completion of the work described in this section shall be in accordance with the NCTCOG Standard Specifications, requirements of the jurisdictional authority, and as indicated in the Contract Documents.

B. Obtain equipment and appurtenances designated to be furnished by jurisdictional agency and pay associated costs.

C. Commercial Service:

1. Meter with detector check device of size indicated on drawings. Items shall be furnished by the Contractor or by the jurisdictional authority as applicable.

2. Meter Vault shall be sized for meter and detector check device as shown on drawings or by the jurisdictional authority as applicable.

3. Meter Vault Lid: Furnished by the jurisdictional authority.

D. Irrigation Service: Furnish copper service, backflow preventer, meter box, and lid.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to Section 02220, “Grading, Excavation, and Backfilling,” for excavation and backfill. Refer to Section 02221, “Utility Excavation and Backfill”, for support of excavation.

B. Make arrangements with jurisdictional authority for tie-ins and for testing, inspections, installation, or other services to be performed by jurisdictional authority and pay associated costs.

C. Provide cathodic protection as shown on drawings as specified Section 13100, “Corrosion Control”.

D. Provide grounding and bonding as shown on drawings as specified in Section 16450, “Grounding and Bonding”.

E. Install water distribution system in accordance with NCTCOG Standard Specifications, the requirements of the jurisdictional authority, and the Contract Documents.

1. Fire Hydrants to be installed as follows:

a. Fire hydrants, in accordance with the local jurisdictional Authority, shall be provided within 300 feet of Traction Power Substation, Signal and Communication facilities. Clean agent extinguishing system may be used to increase this distance with approval from the local jurisdictional Authority.

F. Protect and maintain existing utility services in accordance with Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.
3.2 WATER SERVICE CONNECTIONS
A. Make residential, commercial and irrigation water service connections at locations shown on the Contract Drawings in accordance with the requirements of the jurisdictional authority.
B. Residential Service: Transfer existing water services from the new water main to the meter. The size of each transferred service shall be the same as the existing service, unless otherwise indicated.
C. Commercial Service: Install water service and meter with detector check device in vault.
D. Irrigation Service: Tap existing main and install copper service, backflow preventer, and meter box and lid.

3.3 FIRE LINE CONNECTIONS
A. Make fire line connection. Install fire protection lines, hydrants, valves, risers, and nozzle assemblies

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. Water mains will be measured by and paid for at the unit price for “Water Main” per linear foot for each type and size, including furnishing and installing the pipe with incidentals necessary to complete the water distribution system work except for the items listed for separate payment herein.
B. Connections to existing water mains will be measured by and paid for at the unit price for “Connect to Existing Main” per each for each type and size.
C. Fire hydrants will be measured by and paid for at the unit price for “Fire Hydrants” per each for each type and size. No separate measurement or payment will be made for thrust blocks, removing existing fire hydrants, or any other incidentals necessary to complete the work.
D. No separate measurement or payment will be made for the following work required for work of this section. Such work will be considered subsidiary to the various bid items:

1. Testing, purging and sterilization of water mains; new water and irrigation service connections to existing or new water mains; and new water service lines.
2. Water meters, vaults, boxes, lids, valves, tapping sleeves, flush points, and iron fittings; replacement of existing service connections to the new or existing water mains; cutting and plugging the existing service lines and water mains; tapping the water main for service connection; installing a new service line from the new meter box to the property line; removing and installing valve boxes; removing existing fire hydrants; transferring (connecting) the new service line to the meter; and other associated items.
3. Concrete work, including reinforcing steel.
4. Excavating, backfilling, jacking, boring, and tunneling, including bedding material.
5. Concrete encasement, carrier pipe, welding, enclosures, jacks, cushions and other accessories as required for utility crossings, whether constructed in open cut or by other than open cut.
6. Support of excavation for depths not exceeding 5 feet.
7. Dewatering.
8. Removal or abandonment of existing pipelines and associated items.
9. Removal and replacement of existing bases, pavements, sidewalks, curbs, and gutters.
10. Barricading and maintenance and control of traffic.
11. Maintenance and support of existing utility facilities, except as otherwise indicated in Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities".
E. Trench Support System for trenches exceeding a depth of 5 feet will be measured and paid for as specified under Section 02221, "Utility Excavation And Backfill".
F. Cathodic protection will be measured and paid for under Section 13100, "Corrosion Control".

END OF SECTION 02660
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies installing storm sewers and underdrains.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M33 - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
   2. AASHTO M36 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains
   3. AASHTO M153 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
   4. AASHTO M175 - Standard Specification for Perforated Concrete Pipe
   5. AASHTO M190 - Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches
   6. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe
   8. AASHTO M294 - Standard Specification for Corrugated Polyethylene Pipe, 300- to 1200-mm Diameter

B. American Concrete Institute (ACI)
   1. ACI 318 - Building Code Requirements for Structural Concrete

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   4. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   7. ASTM C32 - Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale).


24. ASTM F449 - Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control.


D. Military Specification (MIL):

1. MIL-PRF-23236 - Paint Coating Systems, Fuel and Salt Water Ballast Tanks (Metric)

E. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

1. SSPC-SP 6 - Commercial Blast Cleaning

F. Texas Department of Transportation, Standard Specifications for Construction of Highways, Streets, and Bridges (TxDOT Standard Specifications).

G. Standard Specifications for Public Works Construction, North Central Texas Council of Governments, as revised (NCTCOG Standard Specifications).

1.3 SUBMITTALS

A. Shop Drawings:

1. Drawings for each size and configuration of precast manhole with details of accessories and joints.

2. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.

B. Documentation:

1. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a Professional Engineer, licensed in the State of Texas.

2. Submit videotapes and run sheets of television inspections.

C. Certification:

1. Reinforced Concrete Pipe: Manufacturer's certification.

2. Casting: Manufacturer's certification.


4. Concrete: Certifications and test results for aggregates and cement no older than 6 months.

5. Geotextile Filter Fabric: Manufacturer's certification.

1.4 PRODUCT SHIPPING, HANDLING, AND STORAGE

A. Geotextile Filter Fabric: Labeling, shipment and storage: In accordance with ASTM D4873, including the following:

1. Each roll of filter fabric will include a product label clearly showing the name of the manufacturer or supplier, the product and style name, the roll number, and shall state that the geotextile is in accordance with the manufacturer's certification.

2. Each roll of filter fabric will be wrapped with a material to protect the geotextile from damage due to shipment, water, sunlight, and contaminants. The integrity of the protective wrapping shall be maintained during periods of shipment and storage.

3. During storage, rolls of filter fabric shall be elevated off the surface of the ground and
adequately covered to further protect them from site construction damage; precipitation; extended exposure to ultraviolet radiation; chemicals, including strong acids or bases; flames, including welding sparks; temperatures in excess of 160 degrees F.; and any other potentially damaging physical or environmental conditions.

PART 2 - PRODUCTS

2.1 CONCRETE WORK

A. Formwork: In accordance with Section 03100, "Concrete Formwork".

B. Reinforcing Steel: In accordance with Section 03200, "Concrete Reinforcement".

C. Portland Cement Concrete: In accordance with Section 03305, "Portland Cement Concrete," Mix S-2, and Section 03300, "Cast-in-Place Concrete".

2.2 AGGREGATES

A. Aggregate for Pipe Cradle:
   1. For plastic pipe: ASTM C33, sand or coarse aggregate No. 8.
   2. For other pipe: ASTM C33, coarse aggregate No. 67.

2.3 CONCRETE PIPE

A. Concrete Pipe, General:
   1. If proposed circular pipe is to have elliptical reinforcement, indicate the location of the minor axis either by applying 12 inch long by 3 inch wide waterproof stripes on the inside and the outside of the pipe, or by a lift hole or lift holes along the minor axis.
   2. If pipe is to have one lift hole, locate the lift hole at the balance point. If pipe is to have two lift holes, locate each hole equidistant from the balance point. Do not locate lift holes where the holes will expose or interfere with the reinforcement.
   3. Stamp each pipe length at the manufacturer's plant in a manner which will clearly and legibly show the following:
      a. Pipe strength or reinforcement class.
      b. Wall thickness designation.
      c. Manufacturing date.
      d. Manufacturer's Symbol.
      e. When required, municipality's acceptance.
      f. Use no pipe which has not been stamped in the Work.

B. 10-inch diameter and smaller:
   1. ASTM C14, Class 2, nonreinforced concrete pipe.
   2. Bell-and-spigot type, joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.

C. 12-inch diameter and larger:
   1. ASTM C76, reinforced, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
   2. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
   3. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
   4. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
      a. 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
      b. Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.

D. Perforated nonreinforced concrete pipe: AASHTO M175, Type 1 or 2, bell-and-spigot or tongue-and-groove type as shown.


F. Concrete Box Culvert and Box Sewers: Box Culverts and Box Sewers shall be in accordance
with TxDOT Standard Specifications Item 462, unless otherwise shown.

2.4 JOINT MATERIAL

A. Rubber gaskets: ASTM C443.

B. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
   1. When applied to a vertical metal surface and heated to 120 degrees F, jointing mastic will neither slump nor lose plasticity.
   2. When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20 degrees F to 100 degrees F.

2.5 PLASTIC PIPE AND FITTINGS

A. Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings:
   1. For 4 Inch to 15 Inch Size: ASTM D3034, SDR-35.
   2. For 18 Inch to 27 Inch Size: ASTM F679, T-1 Wall Thickness.
   3. Roadway and Track Crossings:
      a. 12 Inches and Smaller: ASTM D3034, ADS N-12
      b. Larger Than 12 Inches: ASTM D2241, SDR-21 (200 psi).

B. Corrugated Polyethylene (PE) Tubing With Smooth Lining: Pipe and fittings shall be made of polyethylene (PE) compounds which conform to cell Class 324420-C as described in ASTM D3350 except that the carbon black content shall not exceed 5%.
   1. For 4 Inch to 10 Inch Size: AASHTO M252.
   2. For 12 Inch to 36 Inch Size: AASHTO M294.

C. Perforations:
   1. For PVC pipe sizes up to and including 8 inches, perforations shall be in accordance with Table 5 of ASTM F758 unless otherwise specified on the Contract Drawings. For pipe sizes greater than 8 inches, perforations shall be as specified on the Contract Drawings.

2.6 CORRUGATED METAL PIPE

A. Bituminous-Coated Corrugated Metal Pipe: AASHTO M190, Type A or C as shown, with connecting bands, AASHTO M36.

2.7 LUBRICANTS

A. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.

2.8 CAULKING AND JOINT FILLERS

A. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.

B. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.


2.9 BRICK

A. Brick: ASTM C32; solid brick; Grade SS; 2-1/4 inches by 3-3/4 inches by 8 inches.

2.10 PRECAST CONCRETE SEWER STRUCTURES

A. Cylindrical, eccentric and conical: ASTM C478.

B. Other configurations: ACI 318.

2.11 PIPE CASING MATERIAL

A. Steel, corrugated metal pipe, or concrete pipe, as shown.

2.12 MANHOLE STEPS

A. Rebar: No. 4 reinforcing bar with molded polypropylene or rubber encasement.

2.13 METAL CASTINGS

A. Manholes, Frames and Covers, Inlet Frames, and Grates: Section 05500, "Metal Fabrication".

2.14 WATER SEALS

A. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or approved equal.
2.15 **COAL-TAR EPOXY COATING**

A. Two-component; chemically cured, conforming to MS DOD-P-23236A, Type I, Class 2.

B. Thinner: As recommended by manufacturer of coating and as approved.

2.16 **STEEL**

A. Structural Steel Members: ASTM A36/A36M.

B. Steel Pipe: ASTM A53, black finish, extra strong wall class.

C. Stainless Steel Angle: ASTM A167, Type 03400.

D. Galvanizing: ASTM A123/A123M or ASTM A153/A153M.

E. Miscellaneous Metal: Section 05500, "Metal Fabrication".

2.17 **GEOTEXTILE FILTER FABRIC**

A. In accordance with AASHTO M 288, geotextile filter fabric shall comply with the requirements specified herein.

1. Fabric: Shall consist of long-chain synthetic polymers composed of at least 95 percent by weight of polyolefins or polyesters.

2. Filter fabric shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

3. Fabric edges shall be selvaged.

4. Physical properties: Property values listed below shall be minimum average roll values in the weakest principal direction except for grab tensile elongation and apparent opening size. Grab tensile elongation shall be minimum or maximum average roll values, as indicated. Apparent opening size shall be maximum average roll values.

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subsurface Drainage</td>
</tr>
<tr>
<td>1. Grab Tensile Strength, ASTM D4632, lbs.</td>
<td>160</td>
</tr>
<tr>
<td>2. Grab Tensile Elongation, ASTM D4632, percent.</td>
<td>50 max.</td>
</tr>
<tr>
<td>4. Trapezoidal Tear Strength, ASTM D4533, lbs.</td>
<td>60</td>
</tr>
<tr>
<td>5. Puncture Strength, ASTM D4833, lbs.</td>
<td>60</td>
</tr>
<tr>
<td>6. Mullen Burst Strength, ASTM D3786, lbs.</td>
<td>190</td>
</tr>
<tr>
<td>7. Permittivity, ASTM D4491, 1/sec.</td>
<td>0.2</td>
</tr>
<tr>
<td>8. Apparent Opening Size, ASTM D4751, US Standard Sieve Size No.</td>
<td>60</td>
</tr>
<tr>
<td>9. Flow Rate, ASTM D4491, gpm/sf</td>
<td>50</td>
</tr>
<tr>
<td>10. Ultraviolet Stability, ASTM D4355, percent</td>
<td>50</td>
</tr>
<tr>
<td>11. Weight, oz/sq yd</td>
<td>5</td>
</tr>
<tr>
<td>12. Thickness, mils</td>
<td>50</td>
</tr>
</tbody>
</table>

* Note: Erosion protection refers to use in permanent erosion control applications; for example, as an underlayment for riprap.

B. Securing Pins: When required according to the plans, shall be as recommended by the geotextile manufacturer.

C. Certification: Manufacturer's certificate shall include the following information.

1. Name of manufacturer.

2. Product name.

3. Style number, if applicable.

4. Chemical composition of the filaments or yards.

5. Other pertinent information required to fully describe the product.

6. Shall state that the furnished geotextile meets the physical property average roll value requirements of these specifications.
as determined by the manufacturer’s product quality control program.

7. Shall be attested to by a person legally authorized to bind the manufacturer.

2.18 MORTAR AND GROUT MIXES

A. General Requirements:
   1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
   2. Add sufficient water as specified to produce approved consistency.
   3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
   4. Do not retemper mix that has begun to set nor use such mix in the work.

B. Proportions:
   1. Mortar: One part Portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
   2. Grout: One part Portland cement, 2 parts sand and water sufficient to produce plastic flowable mix.

2.19 FILTER MATERIAL

A. This material is soil drainage material as defined in Section 02220, “Grading, Excavating, and Backfilling”.

2.20 CORRUGATED STANDARD DECK DRAINS:

A. In accordance with drawings and manufacturer’s recommendations.

B. Acceptable Manufacturer: Contech Construction Products, Inc. or approved equal.

2.21 DRAINAGE PANEL

A. Drainage Panel: Manufacturer’s standard vertical wall drainage composites panel system designed to withstand backfill operations and hydrostatic and earth pressures, and with adequate drainage media similar to Amerdrain 500 sheet drain, Enkadrain 9010 or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Storm sewer system construction shall be in accordance with the NCTCOG Standard Specifications, the requirements of the jurisdictional authority, and as specified herein.

B. Make arrangements with jurisdictional authority for tie-ins and for testing, inspections, installation, or other services to be performed by jurisdictional authority and pay associated costs.

C. Provide cathodic protection where required as specified Section 13100, “Corrosion Control”.

D. Provide grounding and bonding where required as specified in Section 16450, “Grounding and Bonding”.

E. Protect and maintain existing utility services in accordance with Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

3.2 EXCAVATION FOR STORM SEWER AND DRAINAGE STRUCTURES

A. Perform excavation for sewers and drainage structures to line and grade shown in accordance with Section 02220, “Grading, Excavating, and Backfilling”, install trench support in accordance with Sections 02221, "Utility Excavation And Backfill", and 02160, "Support Of Excavation", and the following additional requirements:

1. Excavate test pits sufficiently in advance of construction of sewers and drainage structures so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.

2. Excavate below horizontal plane extending 2 feet above top of sewer or drainage structures to the maximum width of trench required by the trench width.

3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength as required by the trench width.

4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

5. Soft, spongy or otherwise unstable material which will not provide a firm foundation for
the pipe shall be removed and replaced with a suitable material obtained from site excavation operations or from other sources approved by the Contracting Officer and shall be compacted as specified in Section 02220, "Grading, Excavation, and Backfilling". When unstable conditions are not corrected by the above means, the Contractor shall be required to use rock, gravel, or concrete foundations. There will be no extra compensation for this work.

6. The Contractor shall excavate all materials encountered regardless of the difficulties. There will be no extra compensation for rock excavation.

3.3 GEOTEXTILE FILTER FABRIC

A. Prepare surface to receive fabric to relatively smooth condition free of obstructions, depressions, debris, and soft or low density pockets of material.

1. Place fabric with long dimension parallel to centerline of trench and lay smooth and free of tension, stress, folds, wrinkles, or creases with sufficient excess to allow for minimum overlap of 12 inches.

2. Place strips in trench to provide minimum width of 12 inches of overlap for each joint.

3. Insert securing pins with washers through both strips of overlapped fabric at not greater than 3-foot intervals along a line through the midpoint of overlap at joints.

4. Where this method of placement conflicts with manufacturer's instructions, the manufacturer's instructions prevail.

B. At time of installation, reject fabric if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, storage, or handling.

C. Place fabric in manner and at locations shown.

3.4 PIPE CRADLE

A. Place pipes on cradle of aggregate or concrete where shown.

B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

3.5 LAYING PIPE, GENERAL

A. Excavate to lines and grades shown in accordance with Sections 02221, "Utility Excavation and Backfilling," and herein. Excavate depressions for bells.

B. Protect pipe and fittings during handling to prevent damage.

C. Place, shape, and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.

D. Start laying pipe at lowest point; lay true to line and grade shown.

E. Install pipe to bear on bedding material along entire length.

F. Do not place the pipe on blocking material of any type.

G. Do not use wedges while installing the pipe.

H. Install perforated pipe with perforations downward.

I. Install pipe so that bells and grooves are on upstream end.

J. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.

K. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.

L. Apply lubricant to rubber gasket (O-ring) immediately before joining pipe sections.

M. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.

N. Keep trenches and excavations free of water during construction and until backfilled.

O. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.

P. Cut pipe ends which project into a sewer structure flush with the inside face of the structure and cover exposed pipe reinforcement with grout or epoxy, as directed.

Q. Where length of stub is not shown, install 4 foot length and seal free end with brick masonry bulkhead or approved stopper.

R. Have work approved prior to covering pipe.
S. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding 6 inches loose. Place, compact and test each lift before placement of next lift.

T. Backfill in accordance with Section 02221, "Utility Excavation and Backfilling”.

U. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached 3 feet or half the pipe diameter, whichever is greater.

V. Where cathodic protection is shown, apply coal-tar epoxy coating. For other cathodic protection requirements, see Section 13100, “Corrosion Control”.

3.6 LAYING CONCRETE PIPE

A. Bell-and-spigot joints:
   1. Prevent damage to premolded joint rings or attached couplings.
   2. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers, or adhesives as recommended by pipe or joint manufacturer.

B. Tongue-and-groove joints:
   1. Clean groove end of preceding pipe and tongue end of succeeding pipe with wet brush and apply soft mortar to the pipe. Remove mortar from interior surface if squeezed out of joint.
   2. Perform final exterior mortaring of joints three lengths of pipe behind laying.

3.7 LAYING PLASTIC PIPE

A. Corrugated polyethylene pipe: ASTM F449.

B. Perforated pipe: Use sleeve couplings designed to hold pipe in alignment without use of sealing compound or gaskets.

3.8 LAYING CORRUGATED METAL PIPE

A. Perforated pipe for underdrains: Place aggregate filter material as indicated and in no case less than 12 inches above the bottom of the pipe.

B. Nonperforated pipe: When pipe is shown to be bituminous paved, place paved area on bottom.

3.9 LAYING POROUS CONCRETE PIPE FOR UNDERDRAINS

A. Fill joints with mortar as specified for tongue and groove joints of concrete pipe.

B. After pipe joints have been made, place additional filter material as specified.

3.10 BACKFILL

A. Perform backfilling only after inspection and approval of pipe laying.

B. On completion of construction, backfill excavation in accordance with Section 02221, “Utility Excavation and Backfill”.

3.11 JOINTS FOR CONCRETE STORM SEWER 12 INCHES TO 33 INCHES

A. Use cold applied jointing mastic for joints of storm sewer 12 inches to 33 inches in diameter.

B. Bell-and-Spigot Joints:
   1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
   2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
   3. Apply sufficient jointing mastic to fill remaining void in joint.
   4. Remove excess mastic from interior of pipe.

C. Tongue-and-Groove Joints:
   1. Clean groove. Apply mastic to lower half of groove.
   2. Clean tongue of next pipe and apply layer of mastic to upper half.
3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.

4. Remove excess mastic from interior of pipe.

### 3.12 JOINTS FOR CONCRETE STORM SEWER 36 INCHES AND LARGER

A. Where not prohibited by jurisdictional agencies, use mortar for joints of storm sewers 36 inches in diameter and larger.

B. Bell-and-Spigot Joints:
   1. Where pipe cradle is aggregate, place shallow bed of mortar under joint.
   2. Thoroughly wet bell and fill lower half with mortar.
   3. Thoroughly wet spigot and uniformly fit into bell so that sections are closely fitted and aligned.
   4. Fill remaining annular space in bell with mortar sufficient to form bead around outside of spigot end of pipe.
   5. Remove excess mortar from interior of pipe, and finish exterior and interior to smooth surfaces.

C. Tongue-and-Groove Joints:
   1. Thoroughly wet groove; apply mortar to lower half of groove.
   2. Thoroughly wet tongue of next pipe and apply a layer of mortar to top half.
   3. Fit tongue into groove until pipes are closely fitted and aligned and mortar covers inner and outer surfaces of the joint.
   4. Clean inner surface of pipes at joint and point up outside with bead of mortar.

### 3.13 JOINTS FOR WATERTIGHT STORM SEWER SYSTEM CONCRETE PIPE

A. Use rubber gasket and bell-and-spigot pipe as specified.

B. Prior to jointing pipe, liberally coat pipe joints with lubricant.

C. Fit bell or spigot with gasket in accordance with manufacturer’s instructions.

D. Joint pipes with equipment designed for purpose.

E. Before joint is completely home, check position of gasket using suitable gauge. If gasket is found to be dislocated, repeat entire joining process using new gasket.

### 3.14 CONNECTIONS TO EXISTING SEWERS

A. Make connections with existing public storm sewers in accordance with requirements of the jurisdictional authority.

B. Obtain approval prior to connecting existing sewer to sewer under construction.

### 3.15 TUNNELING AND JACKING

A. Perform tunneling and jacking by approved methods.

B. Make horizontal borings necessary to lay pipe lines true to line and grade.

C. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.

D. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.

E. Methods of boring and filling of voids between pipe and boring are subject to approval.

### 3.16 SEWER STRUCTURES CONSTRUCTION, GENERAL

A. Shape the bottom of new manholes and catch basins and the bottoms of existing manholes when new connections are made, to form an inlet channel from inlet pipe to outlet pipe. The channel shall be either cast-in-place concrete or sewer brick construction, unless otherwise shown.

B. Install the uppermost manhole step not more than 6 inches below the bottom of the manhole frame. Construct the manhole steps in two staggered vertical lines through the full depth of the structure. Install manhole steps to clear openings. Install drop-manhole steps directly opposite the drop.

C. Perform cast-in-place concrete in accordance with Sections 03100, “Concrete Formwork”, 03200, “Concrete Reinforcement”, and 03300, “Cast-In-Place Concrete”.

### 3.17 MODIFICATION TO EXISTING SEWER STRUCTURES

A. Perform modification of existing sewer structures as specified in Section 02150, “Underpinning, Support, And Restoration”, and Section 02760, “Maintenance, Support, and Restoration of Existing
Utility Facilities", with the following additional requirements:

1. Adjust to grade, remodel, or abandon existing sewer structures as shown.

2. When approved, reset existing manhole frames and covers and catch basin frames and gratings on sewer structures adjusted to grade.

3. When approved, existing manhole frames and covers and catch basin frames and gratings salvaged may be reset in new or remodeled sewer structures.

B. Remodeled Drainage Structures: Unless otherwise shown, perform remodeling of existing drainage structures as follows:

1. Remove the upper portion of the existing drainage structure to a depth two feet below the existing grade.

2. Dispose of existing brick, concrete, concrete block, or other material removed from the existing structure and expose a structurally sound surface.

3. Thoroughly clean the exposed surface.

4. Cover the exposed surface with a 1 inch thick mortar bed.

5. Set an 8 inch deep, reinforced, precast concrete slab, having an area sufficient to cover the drainage structure from outside face to outside face upon the prepared mortar bed.

3.18 MANHOLES

A. Construct manholes of precast sections or cast-in-place concrete. Manholes located within the rights-of-way of other jurisdictional authorities shall be constructed in accordance with jurisdictional authority's standards.

B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.

C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.

D. Construct appropriate flow channels in bottom of manholes.

E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.

F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.

3.19 CATCH BASINS AND INLETS

A. When grading has been substantially completed as approved, construct catch basins of cast-in-place concrete and steel reinforcement as shown, precast sections or brick as shown.

B. Cut pipe flush with inside wall of structure. Provide mortar joint between pipe and structure or install water seal as shown.

C. Install cast iron frame and grate or cover and adjust to proper grade.

D. Catch basins, curb inlets and wye inlets located within rights-of-way of other jurisdictional authorities shall be constructed in accordance with the jurisdictional authority's requirements.

3.20 CONCRETE HEADWALLS AND WINGWALLS

A. Excavation: Excavate for foundations and walls to lines and grades shown in accordance with Section 02220, "Grading, Excavating, and Backfilling".

B. Formwork and Reinforcement: Erect formwork and install reinforcement as shown and in accordance with Sections 03100, "Concrete Formwork" and 03200, "Concrete Reinforcement".

C. Concrete Work: Place concrete of class shown and protect and cure in accordance with Section 03300, "Cast-In-Place Concrete".

D. Backfilling: Backfill and compact in accordance with Section 02220, "Grading, Excavating, and Backfilling".

3.21 COATING APPLICATION AND REPAIR - METALLIC PIPES AND FITTINGS

A. Preparation of surface: Perform the following in order given:

1. Clean surfaces contaminated with oil or grease using naphtha or xylene.

2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP 6.

3. Coat surfaces within 24 hours and before dew point is reached.
STORM SEWER SYSTEMS

4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.

B. Application of coating:

1. Mix coating in quantity which can be applied within its pot life in accordance with manufacturer's recommendation. Thin only with approval.

2. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
   a. Two coats of equal thickness.
   b. Total dry film thickness: 20 mils.
   c. Pretreat first coat as required prior to application of second coat.
   d. Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
   e. Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.

C. Test coating as specified in Section 13100, "Corrosion Control".

3.22 SUBWAY DRAINAGE SYSTEMS

A. As specified in Section 02710, "Subway Drainage Systems".

3.23 AERIAL STRUCTURES DRAINAGE SYSTEMS

A. As specified in Section 02711, "Aerial Structural Drainage Systems".

3.24 PIPE CONNECTIONS

A. Wye Connections: The connection of one pipe to another may be accomplished with a precast wye or by means of pipe to pipe connection. A pipe to pipe connection shall be made by cutting a hole in the larger pipe slightly larger than the outside diameter of the pipe to be connected. The smaller pipe to be connected shall not project into the larger pipe. A concrete collar not less than six inches thick and six inches wide shall be placed around the smaller pipe on the exterior surface of the larger pipe.

B. End-to-End Connections: Wherever a smaller pipe is jointed end-to-end to a larger pipe, the inside tops of the two pipes shall be matched, unless otherwise shown on the Plans. The void between pipes shall be filled with cemented brick work or, where this is not possible, the void shall be filled with concrete mortar. In either case, a concrete collar not less than six inches thick and six inches wide shall be placed around the pipes over the joint.

3.25 CLEANOUTS

A. Cleanouts shall be installed as shown on the Standard Drawings.

3.26 CORRUGATED STANDARD DECK DRAIN

A. In accordance with drawings and manufacturer's recommendations for installation.

3.27 FIELD QUALITY CONTROL

A. Visual Test Method: Personnel shall inspect storm sewer systems for alignment, visual leaks, and cracks in pipe. Repair leaks, then re-inspect pipe.

B. Obstruction Tests:

1. Perform field tests to verify that installed storm sewer systems are free from obstructions.

2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Contracting Officer.

C. Testing of Mortar and Grout:

1. Mortar composition and properties shall be evaluated per ASTM C780.

2. Grout shall be sampled and tested for compressive strength per ASTM C1019.

3.28 FIELD QUALITY CONTROL - TELEVISION INSPECTION

A. In order to ensure that the storm sewer conduit performs the function for which it was designed and constructed, perform a television inspection. Perform inspection of the installed storm sewer conduit after construction of the project is substantially complete at a time directed by the Contracting Officer. Generally, this inspection shall take place prior to the "make ready" inspection and final acceptance of the Project.
B. Schedule the television inspection no later than 72 hours in advance with the Contracting Officer and ensure the Contracting Officer’s representative is present for the television inspection. The Contracting Officer’s representative shall be present during the television inspection unless otherwise authorized.

C. Television inspect, as specified herein, all storm sewer conduits constructed as part of the Work including mains and laterals, unless otherwise directed.

D. When the inspection is run in an upstream direction, transitions to smaller pipe shall be ramped on 12:1 slope or flatter as required to permit television inspection without snagging or television disruption.

E. If the test is being run from manhole to manhole, the camera shall move downstream. If the test is being run from manhole to inlet, the camera shall move upstream.

F. Storm sewer conduits shall be laced with enough water to fill low points. Television inspection shall be done immediate following the lacing of the main with no water flow.

G. Equipment and Medium:
   1. Television equipment used shall have at least 450 lines of horizontal resolution and shall provide a pan of 360 degrees and tilt capacity of 240 degrees.
   2. Picture shall be in color. Videotapes shall be VHS format unless otherwise noted and shall be compatible with the Authority’s equipment.

H. Information gathered shall be legible, easily read, and of high quality.

I. A run sheet, compatible with the videotape shall be made noting deficiencies.

J. By voice on the videotape, the operator shall note the following data:
   1. Date and time the recording was made.
   2. Contractor’s name, project name, and contract number.
   3. Name of company performing the television inspection and name of operator.
   4. Location, designation, and size of the main and the direction in which test was made.

K. Criteria for acceptance:
   1. No pulled or slipped joints.
   2. No low points.
   3. Correct pipe sizes and grade
   4. No structural damage to pipe
   5. No excessive silt or debris is present in conduit as determined by the Contracting Officer.

L. The Contracting Officer will determine if repairs are required and the Contracting Officer’s decision will be final.

M. If repairs are required, another television inspection shall be made after the repairs are complete, at no cost to the Authority.

N. Tapes and run sheets shall be submitted to the Contracting Officer for storage and review and shall become the property of the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Storm sewer pipe and reinforced concrete box culvert specified in this section will not be measured, but will be paid for at the lump sum prices for “Storm Sewer Pipe” and “Reinforced Concrete Box Culvert” of each size and type.

B. Manholes, catch basins, and inlets will be measured by and paid for at the unit price for “Manhole,” “Catch Basin,” and “Inlet” per each for each size and type, including steps, frames, grates, and lids.

C. Underdrains will not be measured, but will be paid for at the lump sum price for “Underdrain” for each size and type, inclusive of perforations and geotextile.

D. Concrete headwall structures and concrete wingwalls will be measured and paid for at the unit price per each for “Concrete Headwall Structure” and “Concrete Wingwalls” for each type and size.
E. Corrugated standard deck drains will not be measured, but will be paid for at the lump sum price for "Corrugated Deck Drains", complete-in-place.

F. No separate measurement or payment will be made for the following work required for work of this section. Such work will be considered subsidiary to the various bid items:

1. Joints, cleanouts, pipe-to-pipe or wye connections, and connection to existing drainage systems.

2. Testing and inspection, including television inspection.

3. Filter fabric and filter material.

4. Concrete work, including reinforcing steel.

5. Excavating, backfilling, jacking, boring, and tunneling, including bedding material and disposal of surplus material.

6. Concrete encasement, carrier pipe, welding, enclosures, jacks, cushions and other accessories as required for utility crossings, whether constructed in open cut or by other than open cut.

7. Support of excavation for depths not exceeding 5 feet

8. Dewatering.

9. Removal or abandonment of existing pipelines, manholes, and associated items.

10. Removal and replacement of existing bases, pavements, sidewalks, curbs, and gutters.

11. Barricading and maintenance and control of traffic.

12. Maintenance and support of existing utility facilities, except as otherwise indicated in Section 02760, "Maintenance, Support, and Restoration of Existing Utility Facilities".

G. Trench Support System for trenches exceeding a depth of 5 feet will be measured and paid for as specified under Section 02221, "Utility Excavation And Backfill".

H. Cathodic protection will be measured and paid for under Section 13100, "Corrosion Control".

END OF SECTION 02700
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing subway drainage systems except drainage sump pumping systems.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):


1.3 SUBMITTALS

A. Samples: Submit proposed materials not less than 30 days prior to date of expected first shipment.

B. Shop Drawings: Include complete catalog information and shop drawings for material and equipment.

C. Certification.

PART 2 - PRODUCTS

2.1 CONCRETE PIPE


2.2 VITRIFIED CLAY PIPE

A. Standard strength or extra strength, as shown: ASTM C700.

2.3 PLASTIC PIPE AND FITTINGS

A. Polyvinyl chloride (PVC) pipe: ASTM D2729 or ASTM D1785.

B. Polyethylene, corrugated pipe:

1. AASHTO M252.
2. Individual lengths not less than 10 feet.
3. Coil pipe not permitted for pipe 8 inches in diameter or larger.

C. Fittings:

1. Polyvinyl chloride: ASTM D2729 or ASTM D1785.

2.4 MANHOLES

A. Formwork: In accordance with Section 03100, "Concrete Formwork".

B. Concrete Reinforcement: In accordance with Section 03200, "Concrete Reinforcement".

C. Concrete: In accordance with Section 03305, "Portland Cement Concrete", Mix S-7.

2.5 CASTINGS

A. Manhole frames and covers, inlet frames and grates: In accordance with Section 05500, "Metal Fabrication".
B. Drainage Castings:

1. Drain inlets, cleanouts, floor and scupper drains: Fabricated from cast iron, ASTM A48, Class 25B with brass parts, Alloy Number 844; or ductile iron, ASTM A536, Grade 60-40-18.

2. Leaded red brass and leaded semi-red brass sand castings: ASTM B584.


C. Drainage Casting Covers:

1. Cast iron: ASTM A48, Class 30B.


2.6 WIRE MESH SCREEN

A. Bronze or stainless steel wire, minimum 0.047 inch diameter, 1/4 inch mesh.

2.7 POROUS SUBGRADE MATERIAL

A. Coarse aggregate: ASTM C33, Size No. 67.

B. Maximum percentage of wear: 45 percent when tested in accordance with ASTM C131.

2.8 DRAINAGE SUMP PUMP STATIONS

A. As specified in Section 15160, "Pumps".

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavate to lines and grades shown on the Contract Drawing in accordance with Section 02221, "Utility Excavation and Backfill".

3.2 POROUS MATERIAL PLACEMENT

A. Place porous material for subgrade around main track drain and drain pipes and for trench backfill as shown.

B. In rock excavation, place material only on stable rock surfaces. Do not place porous subgrade material on excavated rock surface until surface has been flushed with water to remove fine dust and sludge.

3.3 VITRIFIED CLAY PIPE

A. Place vitrified clay pipe to lines and grades shown.

B. Make joints in accordance with manufacturer's instructions.

C. Place concrete encasement where shown in accordance with Section 03300, "Cast-In-Place Concrete." Secure pipe to avoid displacement during concrete placement.

3.4 POROUS CONCRETE PIPE

A. Lay pipe on porous subgrade material so as to provide full bearing and grades shown.

B. Install joints in accordance with the manufacturer's instructions.

C. Place porous material over and around the pipe as shown.

D. Place perforated pipe as shown.

E. Place concrete for encasement in accordance with Section 03300, "Cast-In-Place Concrete".

F. Place and brace pipe for encasing to prevent displacement during placing of concrete.

3.5 PLASTIC PIPE

A. Lay plastic pipe as specified for porous concrete pipe.

B. Use cast iron, concrete, or vitrified clay pipe for last two feet at exposed termination points. Provide standard adapter fittings for connections between differing pipe materials.

C. Use nonpressure pipe for drainage.

D. Plastic pipe may be used only if buried or encased in concrete. Its use is prohibited in exposed locations.

3.6 MANHOLES

A. Construct cast-in-place concrete manholes as shown.

B. Construct flow channel in manhole where shown.

C. Place axis of manholes directly over centerlines of pipes unless otherwise shown.

D. Set manhole frame and cover or grate to required elevation. Set ballast screen where shown.
3.7 INSTALLATION OF PIPE AND CASTINGS

A. Install cast iron, ductile iron, nickel-copper alloy steel pipe and fittings in accordance with Section 15060, "Piping and Accessories".

B. Install drainage piping to the lines and grades shown.

C. Locate drainage castings and set to the finished floor elevation, slabs, or inverts.

D. Install cleanouts at the locations shown.

3.8 PROTECTION OF DRAINAGE SYSTEM

A. During the course of construction, maintain drainage lines free of debris and in undamaged condition.

B. Plug or close ends of completed runs of piping until the Contracting Officer approves their use.

C. Cover the inlet end of drainage piping used to convey water to wet wells at the existing drainage pumping stations with wire mesh screen.

3.9 FIELD QUALITY CONTROL

A. Where drainage piping is located below invert slabs, conduct a ball, shuttlecock, or mandrel test to ensure that the line is free of obstructions subsequent to the placing of porous subgrade material over the line and prior to the placement of the concrete invert slab.

B. Upon completion of the test and determination that the line is free of obstructions, plug, cap or otherwise close the open end or ends of the installed piping to prevent the entrance of debris into the lines.

C. Immediately prior to final inspection of the work, remove debris from manholes, drain inlets, and floor scupper drains. In the presence of the Contracting Officer, prove by one of the methods specified above that the piping is free of obstructions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will not be measured but will be paid for at the lump sum price for "Subway Drainage Systems".

END OF SECTION 02710
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies aerial structure drainage systems.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M190 - Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches
   2. AASHTO M218 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized), for Corrugated Steel Pipe

B. American Water Works Association (AWWA):
   1. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in. (76 mm Through 1219 mm), for Water
   2. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
   3. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast, for Water

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   3. ASTM D2287 - Standard Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds

1.3 SUBMITTALS

A. Samples: Submit samples of proposed materials not less than 30 days prior to date of expected first shipment.

B. Shop Drawings: Include complete catalog information and shop drawings for material and equipment.

C. Certification.

PART 2 - PRODUCTS

2.1 CAST IRON PIPE AND FITTINGS

A. In accordance with AWWA C 110, C 111, and C 151, extra heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets.

2.2 CASTINGS:

A. Drainage Castings:

B. Drainage Casting Covers:
   1. Cast Iron: ASTM A48, Class 30B.

2.3 WIRE MESH SCREEN

A. Bronze or stainless steel wire, minimum 0.047 inch diameter, 1/4 inch mesh.

2.4 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

A. Marking and identification: PVC pipe shall be continuously and permanently marked with the following information: manufacturers name, size, type of pipe and material, SDR number, product standard number and the National Sanitation Foundation (NSF) seal.

B. PVC pipe fittings shall be of the same material as the PVC pipe to be joined.

C. Flexible PVC shall be made from virgin PVC material and shall comply with ASTM D2287.

2.5 SPLIT 8-INCH DECK DRAIN PIPE

A. Fabricate form zinc-coated galvanized sheets in accordance with AASHTO M218: bottom pan, 12 gage steel; end plates, 14 gage steel. Bituminous coated in accordance with AASHTO M190; perforated as indicated on Drawings.

2.6 FILTER FABRIC

A. As specified in Section 02220, "Grading, Excavation and Backfill".
PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE AND CASTINGS

A. Locate drainage scuppers, inlets, and castings, and set to finished deck or slab elevation.

B. Piping layout is diagrammatic. Route pipe in such a way as to maintain proper reinforcement spacing. Piping shall be adequately supported to prevent damage and displacement during concrete placement.

C. Install cleanouts at the locations shown.

D. Cover scuppers and inlets with wire mesh screen, as shown.

E. Paint exposed metal surfaces in accordance with Section 09970, "Coatings for Steel".

3.2 PIPE INSTALLATION

A. General:
   1. Lower and place pipe in manner which will prevent damage.
   2. Lay pipe true to alignment and grades indicated, beginning at low point of system.
   3. Assemble joints in accordance with manufacturer’s recommended installation procedures.

B. Deck Drain: Place deck drain pipe at locations and in position indicated on Drawings.

3.3 PROTECTION OF DRAINAGE SYSTEM

A. During the course of construction, maintain drainage lines free of debris and in undamaged condition.

3.4 FIELD QUALITY CONTROL

A. Immediately prior to final inspection of the work, remove any debris from scuppers, inlets, and drainage lines.

B. In the presence of the Contracting Officer, demonstrate that the piping is free of obstructions by mandrelling lines.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Aerial structure drainage systems will not be measured, but will be paid for at the lump sum price for “Aerial Structural Drainage System”.

B. Downspout piping, cleanout, bends, and fittings and connection to storm sewer system will not be measured separately, but will be considered subsidiary to the aerial structure drainage system.

C. Wire mesh screen, where required, will not be measured for payment, but will be considered as subsidiary to the work specified in this section.

END OF SECTION 02711
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the furnishing, installing, and testing of sanitary sewer systems (called hereafter wastewater in the specifications).

1.2 REFERENCED STANDARDS

A. North Central Texas Council of Governments (NCTCOG)

1. Standard Specifications for Public Works Construction, as revised (NCTCOG Standard Specifications).

B. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1926 Subpart P; 1926.652 – Requirements for Protective Systems

1.3 SUBMITTALS

A. Shop Drawings.

B. Certification.

C. Documentation:

1. Submit bill of materials for materials used on this project for approval.

2. Submit videotapes and run sheets of television inspections.

D. Procedures for tunneling, jacking, or boring, if required.

E. Submit concrete mix designs and test data. Test data shall not be older than 6 months.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials (including their delivery, storage, handling and testing) necessary for the completion work described in this Section shall be in accordance with the NCTCOG Standard Specifications, the requirements of the jurisdictional authority, and indicated in the Contract Documents.

PART 3 - EXECUTION

3.1 CONSTRUCTION

A. Wastewater systems construction shall be in accordance with NCTCOG Standard Specifications,

3.2 EXCAVATION

A. Perform excavation as specified in Section 02221, “Utility Excavation and Backfill”.

B. Protect and maintain existing utility services in accordance with Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

3.3 WASTEWATER SERVICE CONNECTIONS

A. Make residential and commercial wastewater service connections as described below:

B. Replacement of existing service: Replace all existing services from the new wastewater main to existing laterals at the property line with a clean-out per the requirements of the jurisdictional authority. The minimum size of all wastewater laterals shall be 6 inches or the same size as the existing lateral whichever is larger. Refer to Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”, for additional information.

C. Connection of new service: Connect all new wastewater services to the new or existing wastewater main per the requirements of the jurisdictional authority, with a clean-out at the property line. Connect the service line from the clean-out to the proposed or existing facility or as shown on the Contract Documents.

3.4 FIELD QUALITY CONTROL - TELEVISION INSPECTION

A. In order to ensure that the wastewater system performs the function for which it was designed and constructed, perform a television inspection. Perform inspection of the installed wastewater conduit after construction of the project is substantially complete at a time, at a time directed by the Contracting Officer. Generally, this inspection shall take place prior to the “make ready” inspection and final acceptance of the Project.

B. Schedule the television inspection no later than 72 hours in advance with the Contracting Officer and ensure the Contracting Officer’s representative is present for the television inspection. The Contracting Officer’s representative shall be present during the television inspection unless otherwise authorized.

C. Television inspect, as specified herein, all wastewater conduits constructed as part of the Work including mains and laterals, unless otherwise directed.
D. When the inspection is run in an upstream direction, transitions to smaller pipe shall be ramped on 12:1 slope or flatter as required to permit television inspection without snagging or television disruption.

E. Test shall be run from manhole to hole and the camera shall move downstream.

F. Equipment and Medium:
   1. All television equipment used shall have at least 450 lines of horizontal resolution and shall provide a pan of 360 degrees and tilt capacity of 240 degrees.
   2. Picture shall be in color. Video recordings shall be digital recordings, format unless otherwise noted and shall be compatible with the Authority’s equipment.

G. All information gathered shall be legible, easily read, and of high quality.

H. A run sheet, compatible with the videotape shall be made noting deficiencies.

I. By voice on the videotape, the operator shall note the following data:
   1. Date and time the recording was made.
   2. Contractor’s name, project name, and contract number.
   3. Name of company performing the television inspection and name of operator.
   4. Location, designation, and size of the main and the direction in which test was made.
   5. Identify every 50 station.
   6. Identify the station of each manhole.
   7. Identify the location and station of deficiencies.
   8. Identify the location and direction of entry of laterals.

J. Criteria for acceptance;
   1. No pulled or slipped joints.
   2. No low points.
   3. Correct pipe sizes and grade
   4. No structural damage to pipe
   5. No excessive silt or debris is present in conduit as determined by the Contracting Officer.

K. Contracting Officer will determine is repairs are required and the Contracting Officer’s decision will be final.

L. If repairs are required, another television inspection shall be made after the repairs are complete, at no cost to the Authority.

M. Tapes and run sheets shall be submitted to the Contracting Officer for storage and review and shall become the property of the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Wastewater pipe and wastewater pressure pipe will not be measured, but will be paid for at the lump sum prices for “Wastewater Pipe” and “Wastewater Pressure Pipe”, for each diameter and type of pipe material.

B. Wastewater manholes will be measured by and paid for at the unit price for “Wastewater Manholes” for each structure for each size and type, inclusive of pipe connections, frame and lid, existing manhole adjustments, and any other associated or incidental items.

C. Standard Mainline Clean-outs will be measured by and paid for at the unit price for “Standard Mainline Clean-Outs” per each.

D. No separate measurement or payment will be made for the following work required for work of this section. Such work will be considered subsidiary to the various bid items:
   1. Sanitary sewer service replacement, cutting and plugging existing service line, tapping, or providing the connection to new sewer main, lateral cleanouts, and other associated items related with service connection.
   2. Joints, cleanouts, pipe-to-pipe or wye connections, connection to existing systems
   3. Testing and inspection, including television inspection.
   4. Concrete work, including reinforcing steel.
   5. Excavating, backfilling, jacking, boring, and tunneling, including bedding material and disposal of surplus material.
   6. Concrete encasement, carrier pipe, welding, enclosures, jacks, cushions and other accessories as required for utility crossings, whether constructed in open cut or by other than open cut.
   7. Support of excavation for depths not exceeding 5 feet.
8. Dewatering.

9. Removal or abandonment of existing pipelines, manholes, and associated items.

10. Removal and replacement of existing bases, pavements, sidewalks, curbs, and gutters.

11. Barricading and maintenance and control of traffic.

12. Maintenance and support of existing utility facilities, except as otherwise indicated in Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

E. Trench Support System for trenches exceeding a depth of 5 feet will be measured and paid for as specified under Section 02221, “Utility Excavation and Backfill”.

F. Cathodic protection will be measured and paid for under Section 13100, “Corrosion Control”.

G. Standard Mainline Wastewater Access Devices will be measured by and paid for at the unit price for “Standard Mainline Wastewater Access Devices” per each.

### TABLE 02730 - 1
LOW PRESSURE AIR DROP TEST

<table>
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<tr>
<th>Length of Pipe (Ft)</th>
<th>Pipe Diameter, In Inches</th>
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Note: Time, in seconds, for pressure to drop from 3.5 to 2.5 psig shall not be less than that indicated.

1. Time for intermediate lengths shall be interpolated.

END OF SECTION 02730
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the installation of an underground sanitary sewer storage tank as shown on the Contract Drawings.

1.2 REFERENCED STANDARDS
A. American Society of Mechanical Engineers (AMSE):
   1. ASME/ANSI B16.5 – Pipe Flanges and Flanged Fittings
B. American Water Works Association (AWWA):
   1. AWWA D120 – AWWA Standard for Thermosetting Fiberglass-Reinforced Plastic Tanks
C. North Central Texas Council of Governments (NCTCOG)
   1. Standard Specifications for Public Works Construction, as revised (NCTCOG Standard Specifications)
D. Texas Commission on Environmental Quality
   1. TAC Title 30, Part 1, Chapter 285 – On-Site Sewage Facilities
E. Underwriters Laboratories, Inc. (UL):

1.3 SUBMITTALS
A. Product Data: Manufacturer’s data sheets on each product to be used, including:
   1. Certification reports showing compliance with AWWA D120 and UL 1316 Standards.
   2. Preparation instructions and recommendations
   3. Installation instructions and recommendations.
   4. Operation and Maintenance Data

1.4 QUALITY ASSURANCE
A. Comply with codes and regulations of the jurisdictional authorities including the following:
   1. NCTCOG Standard Specifications
   2. TAC Title 30, Part 1, Chapter 285

1.5 WARRANTY
A. Warranty shall be manufacturer’s standard limited warranty for underground septic tanks in effect at time of purchase.

PART 2 - PRODUCTS

2.1 SINGLE-WALL FIBERGLASS REINFORCED PLASTIC (FRP)
A. Underground Storage Tanks:
   1. Loading Conditions — Standard tank design shall meet the following criteria:
      a. Internal Load—Tank shall be designed to withstand a 5-psig air-pressure test (3 psig for a 12 foot diameter tank) with a 5:1 safety factor. When tank is designed for on-site testing, contractor shall individually test tank for leakage prior to installation. Maximum test pressure is 5 psig (3 psig for a 12 foot diameter tank).
      b. Surface Loads—Tank shall withstand surface H-20 axle loads when properly installed according to tank manufacturers current Installation Manual and Operating Guidelines.
      c. External Hydrostatic Pressure—Tank shall be capable of being buried in ground with 7 feet of overburden over the top of the tank, the hole fully flooded and a safety factor of 5:1 against general buckling.
      d. Tank shall support accessory equipment—such as inlet and outlet piping, effluent filter chamber, high level alarm, ladders and baffles—when installed according to tank
ON-SITE SANITARY SEWER FACILITY

B. Product Storage Requirements:

1. Tank shall be capable of storing wastewater products limited to the collection and storage of human solid or liquid organic sewage.
2. Tank shall be vented to atmospheric pressure.
3. Tank shall be capable of storing products identified in the manufacturer's current standard limited warranty.

C. Materials:

1. Tank shall be manufactured with 100% resin and glass-fiber reinforcement. No sand fillers.
2. Resin used in tank and accessories shall be premium isophthalic polyester.

D. Tank Dimensions (Refer to manufacturer’s literature on capacity):

1. Tank shall have a minimum nominal capacity of 3000 gallons.
2. Tank shall have a minimum nominal outside diameter of 7.5 feet.

2.2 ACCESSORIES

A. Piping:

1. Schedule 40 PVC or FRP pipe shall be used for inlet and outlet piping with a minimum size of 3 inches.
2. When a PVC pipe is affixed to the tank, a fiberglass lay-up is used.
3. All piping shall be factory-sealed to enable field tightness testing with at least one pipe opening provided with a threaded fitting for connecting a pressure-test manifold.
4. A 5 foot goose neck vent stack shall be installed to ventilate gas and vapor build up with in the tank.

B. Access Openings:

1. All access openings 24 inches in diameter or larger shall be manufactured of FRP.

2. Location(s) shall be as shown on tank drawings.
3. Optional riser extensions shall be FRP or PVC.
4. All access openings shall be factory-sealed to enable field tightness testing, and to prevent tank odors from escaping the tank when closed.

C. Anchor Straps:

1. Straps are required and shall be FRP anchor straps as supplied by tank manufacturer.
2. Number and location of straps shall be specified in current literature by tank manufacturer.

D. Fittings:

1. All threaded fittings shall be constructed of carbon steel or FRP.
2. All standard threaded fittings shall be half-couplings and shall be 2 inches, 4 inches or 6 inches in diameter. Reducers are to be used for smaller sizes where shown and provided by contractor.
3. All FRP and PVC nozzles shall be flat-faced and flanged, and shall conform to ASME/ANSI B16.5 Class 150 bolting pattern.

E. Ladders:

1. Ladders shall be the standard ladder as supplied by tank manufacturer.

F. Optional Internal Pump Platforms:

1. Pump platforms shall be FRP.
2. Contact tank manufacturer with pump details, such as dimensions and weight.

G. High Level Alarm:

1. High level alarm shall be linked to the local crew quarters facility as well as DART’s Central Rail Operating Facility and Operations Control Center.
2. Provide 2 sets of Form C Normally open and normally closed dry contacts in the sewer holding tank control panel. Refer to Specification 16868, “SCADA RTU Subsystem – Communications System”, for SCADA RTU Subsystem details.
a. The normally open contacts shall be connected to the station demarcation cabinet or Communications Room SCADA equipment for the following alarm function:

1) Sanitary sewer high level alarm.

PART 3 - EXECUTION

3.1 TESTING

A. Testing—Tank shall be tested according to the manufacturer’s Installation Manual and Operating Guidelines in effect at time of installation.

B. Tank-Tightness Testing — Prior to installation, a tank-tightness test consisting of a 5 psig air pressure/soap test shall be performed (3 psig for 12-foot-diameter tanks) per the tank testing procedures outlined in the manufacturer’s Installation Manual and Operating Guidelines in effect at time of installation.

3.2 INSTALLATION

A. The installation contractor shall purchase the required On Site Sewer Facility permit for the holding tank before installation begins.

B. Contractor shall be licensed in proper installation procedures by TCEQ, the tank manufacturer, or other approved agency.

C. A scheduling pumping contract with a waste transporter, holding a current registration with the TCEQ executive director, shall be provided to the permitting authority before the holding tank is installed.

D. Tank shall be installed according to the manufacturer’s Installation Manual and Operating Guidelines and TCEQ regulations in effect at time of installation.

E. Calculate the depth of hole considering 12 inches for bedding below the tank. Plan for all water lines and the tank bed “underdrain” when such a drain can be installed.

F. Back slope or bench the excavation walls to provide a safe working environment. Properly bed the entire floor of the hole with 12 inches of approved backfill gravel and rake it level where the tank and deadmen will be positioned.

G. Backfill Procedure:

1. Backfill must be applied in lifts no greater than 12 inches deep at any time to allow

proper hand shoveling and probing of the material between all ribs and under the tank’s belly and haunches. Work evenly around the tank, shoveling and probing until gravel fills all the voids and even resistance is felt as the probe is plunged in below the tank. Probing is time consuming and physically taxing, especially if the system is large. However, there is no other way to do this job properly and create the uniform balanced support required to cradle the many tons of water involved. Hand probe soil along any underground tank relative to the face of a clock, in multiple lifts from the 4:00 position around underneath to the 8:00 position.

H. Hydrostatic Leak Testing

1. Leak testing can only be done safely in the field by filling the tank with water and waiting to see if the level drops over a period of time. The tank must be backfilled for proper support before water is added beyond the 10 percent desirable for initial ballasting. Once the backfill gravel has reached the top of the tank and is at the natural angle of repose on all 4 sides, then and only then can the tank be completely filled. Plug the top mounted fittings and install the manway extension with gasket. Slowly fill the tank until the water is up even with the manway flange gasket, at the joint between the flanged tank collar and the extension. Observe the water level over a 24 hour period. Replace the cover securely overnight for safety. It may be necessary to add a small amount of water as the liquid temperature stabilizes to match the temperature of the soil. Trapped air at the top of the tank can also cause minor variations. Generally, the water will maintain a stable level at the gasket surface with less than 1/4 inch variation. In the unlikely event that you are experiencing a drop in water level after several additions, call the manufacturer for help in determining how to best proceed from this point.

I. Geotextile or “filter fabric” is recommended as a barrier or separator medium between the backfill gravel and the soil cover. Geotextile material is inexpensive, readily available, and keeps the cover soil from migrating down into the porous rock interface. This helps reduce subsidence of the cover mound over time and increases the frost resistance of the site in general by keeping the insulating air spaces open between individual gravel particles. It is not necessary to use filter fabric over the areas covered with foam board insulation since the insulation also effectively stops this downward soil migration.
J. Provide surface water a natural run off path, away from the tank site. Seed grass to prevent erosion and padlock or bolt the manway cover closed to discourage curious children. All PVC pipe & fittings exposed to sunlight should be painted to reduce long term ultraviolet degradation (unpainted PVC gets brittle with time).

K. Bolt or padlock the manway cover to discourage children and vandals.

L. Paint exposed PVC pipe risers for long term protection against sunlight.

M. Call for final inspection and notify the appropriate permitting agency or district.

PART 4 - MEASUREMENT AND PAYMENT

4.1 PAYMENT

A. The work describe in the section will be measured for payment but will be paid for on an each basis for “On Site Sanitary Sewer Facility”.

B. Excavation and earthwork, including backfill, soil reinforcing, and backfill material within the excavated area for the sanitary sewer facility will not be measured separately for payment, but shall be considered subsidiary to the construction of the facility.

END OF SECTION 02735
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies protecting, supporting, maintaining, and reconstructing existing utility facilities affected by construction and as shown or directed.

B. Existing Utility Facilities: Existing utility facilities include, the following facilities:
   1. Storm and sanitary sewer facilities.
   2. Water distribution and services.
   3. Gas distribution and services.
   4. Electric light and power facilities and services.
   5. Telephone, telegraph, and communication facilities and services.
   6. Police and fire alarm systems.
   7. Traffic signals and street lighting, temporary and permanent.
   8. Cable television and computer data transmission facilities and services.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1.3 DEFINITIONS

A. Facility: Utility structures and system components belonging to utility company including service lines which are used to provide service to utility's customers and product which these facilities convey.

B. Utility: Company, agency, owner, or operator of facility concerned.

C. Abandoned: Use of facilities shown as existing has been discontinued by the owners and operators. Demolish or remove such facilities to the extent they conflict with proposed work.

D. To be abandoned: Replace particular facility with new facility after written notice is received by Contractor that service is no longer required.

Perform work necessary to maintain service for as long as required, which may include temporary support, rerouting, substitution of temporary facility, or other measures. Demolish or remove such facilities to the extent they conflict with proposed work.

E. Maintenance: Ensuring continuous and satisfactory service during construction.

F. Proposed facility:
   1. Constructing new facility and, if necessary, temporarily supporting it in place.
   2. Constructing temporary facility, supporting it in place and ultimately removing it and constructing new facility.
   3. Constructing new facility at completion of rapid transit construction.

G. Temporary facility: Facility provided by the Contractor in lieu of existing or proposed facility to ensure continuity of service.

H. Maintain complete-in-place: Support and maintenance, in serviceable condition, of existing facilities during construction, which may include constructing permanent support, temporary support, or other measures necessary to maintain continuous service utilizing existing facility.

I. Maintain service and replace:
   1. Constructing new facility in same location and supporting it in place.
   2. Providing temporary facility and ultimately removing it and constructing permanent replacement facility in its original location.
   3. Temporarily supporting original facility and ultimately replacing it with new facility.
   4. Expose and maintain existing cables and replace ducts and manholes: Removal of existing duct and manhole structures, construction of temporary manholes, placement of existing cables in split conduits and replacement of spare ducts with whole conduit, maintenance of this system during construction, reconstruction of permanent concrete manholes and encasement of conduits in concrete as specified. Unless authorized by the utility owner, leave cables for electric power and telephone facilities exposed, separated, and supported by the electric power and telephone companies.
J. Remove and replace: Removing existing facility without providing temporary replacement and reconstructing new facility in same location at completion of construction.

1.4 SUBMITTALS

A. Shop Drawings and Working Drawings:

1. Submit to the utilities and the Contracting Officer working drawings showing plan and scheduling for performance of the Work.

2. Show actual location of existing facilities, interference which these facilities present to new work, proposed method of proceeding with actual construction and details of proposed support systems.

3. Do not commence work until written approval has been received from the utility and the Contracting Officer.

4. Submit working drawings of instrumentation location layout as specified under Section 02316, Geotechnical Instrumentation.

B. Documentation:

1. Notice of commencement of work: Submit copies of notices of commencement to the Contracting Officer.

2. Settlement measurement points: Submit monitoring documentation as specified under Section 02316, Geotechnical Instrumentation.

C. Upon delivery of salvaged items, submit the following: Inventory of all salvaged materials. When salvaged materials are delivered for storage, give one copy of inventory to the receiver at the delivery point and two copies to the Contracting Officer.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Coordinate with utilities who are furnishing materials for the work to determine availability, locations, and required methods of storage and care of materials prior to incorporation into the work.

B. Transport, store and handle materials in accordance with the requirements of the utilities.

1.6 NOTIFICATIONS

A. Notice of commencement of work: Give notice at least two weeks prior to date of intended commencement of operations to parties having surface, subsurface, or overhead structures in the construction area.

B. Establish and maintain direct contact with the owner or operator of each utility facility which may be affected by the Work.

C. Notify utility companies before beginning excavation work in accordance with each utility’s notification requirements and have them locate and mark the facilities as specified under the Article entitled “Location of Facilities” under Part 3 herein.

1. For those utilities that participate in Texas Excavation Safety System, call 1-800-DIG-TESS.

D. During the process of construction, if any utility is damaged or interrupted, notify the corresponding utility representative and the Contracting Officer immediately. List of utility agency contacts is included in the Contract Specifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials for Storm, and Sanitary Sewer: Section 02700, "Storm Sewer Systems", and Section 02730, "Sanitary Sewer Systems".

B. Materials for Water Distribution and Services: Section 02660, "Water Distribution Systems".

C. Materials for Ducts and Manholes: Section 02780, "Underground Electrical and Communications Distribution Systems".

D. Concrete: Section 03100, "Concrete Formwork", and Section 03300, "Cast-In-Place Concrete".

E. Reinforcement: Section 03200, "Concrete Reinforcement".
F. Sand Backfill Around High Voltage Conduits and Pipes

1. Thermal Resistivity Value (RHO) of not more than 70 and the following sieve analysis when tested in accordance with ASTM C136:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
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<tbody>
<tr>
<td>4</td>
<td>94-100</td>
</tr>
<tr>
<td>8</td>
<td>80-90</td>
</tr>
<tr>
<td>16</td>
<td>60-80</td>
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<tr>
<td>30</td>
<td>35-60</td>
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<td>50</td>
<td>31-35</td>
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<tr>
<td>100</td>
<td>3-13</td>
</tr>
<tr>
<td>200</td>
<td>1-5</td>
</tr>
</tbody>
</table>

2. The electrical utility, through the Contracting Officer, will inform the Contractor of approved sources for this material.

PART 3 - EXECUTION

3.1 GENERAL

A. Location of Facilities:

1. Utility facilities known to the Authority are shown on the Contract Drawings. Locations of existing facilities shown are plotted from available records; however, these locations are not guaranteed nor is it guaranteed that other utility facilities are not present.

2. Verify by field investigation locations of facilities within and adjacent to limits of project which may be affected by construction operations. Avoid damage or disruption of facilities during operation.

3. Notify utility companies which have underground facilities within the limits of work before beginning excavation work in accordance with each utility's notification requirements and have them locate and mark the facilities within the area of excavation. (Refer to Article entitled "Notifications" herein for additional notification requirements.)

   a. For those utilities that participate in Texas Excavation Safety System, call 1-800-DIG-TESS.

4. Potholing: Prior to any excavation, excavate, expose, and verify the location of existing utility mains and laterals and other existing underground facilities which cross or are in close proximity to proposed underground facilities through potholing. Locate existing facilities by hand digging where necessary. In addition to hand digging, use whatever means of potholing required by utility owner and the Contracting Officer. Do not proceed with underground installations until related pothole work has been completed to the satisfaction of the Contracting Officer.

   a. Immediately notify the Contracting Officer of conflicts in which there is less than one foot of separation between the existing and proposed facility.

5. Upon encountering existing facility which is not shown or upon ascertaining that facility differs from that shown, determine ownership, use and disposition of such facility and proceed as follows:

   a. If facility is abandoned or is to be abandoned, perform necessary work for either condition as specified.

   b. If facility is to remain in service, perform support and restoration work in accordance with these specifications and the "CHANGES" Paragraph of the General Provisions.

B. Responsibilities:

1. Maintain and protect facilities including building service connections.

2. Give notice of commencement of work in accordance with the General Requirements and as specified.

3. Notify the Contracting Officer and the utility of damage to facilities caused by construction operations. When authorized by the utility owner, repair such damage.

4. Provide access including temporary decking in accordance with Section 01533, "Temporary Decking," through the work for utility personnel for inspection of facilities and for emergencies involving utility services.

5. Permit free and clear access to utility personnel for purposes of inspection, maintenance, and providing additional service.

6. When approved working or shop drawings show temporary facility provided for the Contractor's benefit, supply necessary materials and perform necessary work.
7. The Contractor shall be directly responsible for payments to a utility when, as an aid to the Contractor's construction operations, the utility performs work not shown or required for the execution of this Contract.

8. Adjust existing manhole frames and covers, valve boxes, water meter boxes, and other utility facilities and service access structures which are to be left in place, as required, to the final finish surfaces.

C. Coordination with Utilities:

1. Establish, through the Contracting Officer, direct and continuous contact with respective utilities and cooperate with them in all phases of the work.

2. Contact utility early enough to allow them sufficient time to accomplish the work. Give special consideration to lead times required for cable work. Provide schedule of utility relocation to the utility to permit coordination with Authority's construction sequence.

3. Comply with printed standards and practices of Utilities affected by the work.

4. Aerial facilities shown to be relocated by others will be relocated by facility owner. The Contractor is responsible for coordinating relocation work with utility owner as far as possible in advance of required time of relocation.

5. Protect and support utilities in a manner satisfactory to the utility.

3.2 SETTLEMENT OR MOVEMENT

A. Where settlement or movement monitoring system is shown, provide monitoring program in accordance with Section 02316, Geotechnical Instrumentation.

B. Take immediate remedial measures to correct conditions causing settlement or other movement and to repair damages thus caused.

3.3 EXCAVATION AND BACKFILLING OF UTILITY TRENCHES

A. Excavate and backfill utility facility trenches in accordance with Section 02221, "Utility Excavation And Backfill".

B. Provide Trench Support System as specified under Section 02221, "Utility Excavation And Backfill".

C. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to facility owner.

3.4 PAVEMENTS, SIDEWALKS, CURBS, AND GUTTERS

A. Remove pavements, sidewalks, curbs and gutters where necessitated by utility trenches in accordance with Section 02072, "Removal and Restoration of Miscellaneous Existing Facilities".

B. Replace pavements, sidewalks, curbs and gutters in accordance with Section 02525, "Curbs, Gutters, and Walks", Section 02511, "Bituminous Pavement", and Section 02550, "Concrete Pavement".

C. Place temporary pavements where necessitated by sequence of operations.

3.5 UNSAFE AND UNSUITABLE UTILITY STRUCTURES

A. General Requirements: If, upon exposure, condition or location of facility requiring in place support is found to be unsafe for maintenance or support, replace or reconstruct facility as required after receiving prior approval of the Contracting Officer and utility.

B. Electric, Communication, and Similar Type Facilities:

1. If structures containing electrical, communication, and similar types of cables shown to be maintained complete in place are found upon exposure to be incapable of being maintained in place because of condition, location, or both, replace such structures with timber enclosures or split ducts after prior approval of the Contracting Officer and utility.

2. When service box, manhole, or conduit structure containing electrical or communication cables is broken away, replace it immediately with temporary structure having facilities for racking and supporting cables equivalent to existing facilities.

3. Exercise care when working in vicinity of telephone structures containing coaxial cable which cannot withstand movement.

4. Give timber enclosures one interior and one exterior coat of fire-retardant paint of type specified by owners and operators.

5. Replace temporary timber enclosures with permanent structures in accordance with details shown and restore facilities to the satisfaction of the Contracting Officer and
Utilities prior to completion of work. Remove materials of temporary nature after completion of permanent installation.

C. Procedures for payment of costs of work on unsafe and unsuitable utility structures are governed by the "CHANGES" Paragraph of the General Provisions.

3.6 STORM AND SANITARY SEWER FACILITIES

A. Maintain service in storm and sanitary sewers, house connections, and laterals at all times.

B. Perform work on storm and sanitary sewer facilities in accordance with Section 02700, "Storm Sewer Systems", and 02730, "Sanitary Sewer Systems".

C. Maintain connections between existing roof drains and storm sewers.

D. Take precautions to avoid flooding. When working in large storm sewers, provide safety measures to prevent increased flow due to sudden storms.

E. Prevent entry into sewers of material which might clog, damage or otherwise interfere with operation of sewer. Refer to Section 01560, "Environmental Protection", and Section 01562, "Soil Erosion and Sediment Control", for additional requirements.

F. Fully enclose flumes. Prevent flow of sewage across surface of streets or into excavation.

G. Work on Abandoned or To-Be-Abandoned Sewers, Culverts, Catch Basins, and Manholes:

1. For sewers under 36 inches in diameter and catch basin connections, construct bulkheads of brick masonry in accordance with Section 02700, "Storm Sewer Systems", Section 02730, "Sanitary Sewer Systems", Section 04100, "Mortar, Grout, and Masonry Accessories", and Section 04210, "Brick Masonry", or 3000 psi concrete 9 inches thick where shown.

2. For sewers 36 inches in diameter and larger, use one of the following methods for abandonment:
   a. Remove sewer completely.
   b. Remove top of sewer and fill remainder with sand or other approved material.
   c. Fill sewer with grout or lean concrete.
   d. Place bulkheads of brick masonry in accordance with Section 02700, "Storm Sewer Systems", Section 02730, "Sanitary Sewer Systems", Section 04100, "Mortar, Grout, and Masonry Accessories", and Section 04210, "Brick Masonry", or 3000 psi concrete 9 inches thick where shown.

3. Remove catch basins and sewer manholes to a minimum depth of 2 feet below finish grade. Punch holes not less than one square foot through base slab. Fill remainder of structure with sand or other approved material installed in layers and compacted.

4. Salvage frames and covers. Reuse them where approved. Deliver surplus and unapproved frames and covers to the utility.

3.7 WATER DISTRIBUTION AND SERVICES:

A. Ensure continuity of service, except when it is necessary to cut existing mains. Arrange and coordinate such work so as to minimize interruption of service.

B. Perform work on water facilities in accordance with Section 02660, "Water Distribution Systems".

C. Do not disturb, tamper with, or remove fire hydrants, water meters, meter pits, valves, and appurtenances without prior approval from responsible agency. Give not less than 10 days advance notice of work on such items. Water valves will be operated only by utility.

D. Work on Water Mains and Service Connections Which Are Abandoned or To Be Abandoned:

1. Cap ends of cut mains as shown. Place concrete blocking to bear between cap on line main and solid earth.

2. Where mains to be abandoned are removed to a tee or valve, provide tee or valve with harnessed cap or plug as required or remove tee and hook up straight.

3. Abandon house service connections by disconnecting them at corporation stop.

4. For water mains 20 inches in diameter and larger, construct bulkheads of 3000 psi concrete, minimum one pipe diameter thick at manholes, catch basins, and at cut ends.

5. For water mains smaller than 20 inches in diameter, install bulkheads using brick
masonry, 3000 psi concrete, cast iron plugs or cast iron caps at end of abandoned sections.

6. Remove valve vaults to a minimum depth of 2 feet below finish grade and punch holes not less than one square foot through base slab. Fill remainder of structure with sand or other approved material installed in 6 inch layers and compacted.

7. Salvage frames and covers. Reuse when approved. Deliver surplus and unapproved frames and covers to utility.

3.8 ELECTRIC TRANSMISSION, DISTRIBUTION, AND SECONDARY FACILITIES

A. Perform electrical work in accordance with applicable codes, regulations, reference standards, and specifications, with standard procedures and practices of the electric power company and with Section 02780, "Underground Electrical And Communications Distribution System".

B. Maintain continuity and integrity of existing facilities of electric power company.

C. Support vitrified clay and asbestos cement ducts independently of Authority decking system. Where these facilities are part of permanent system, do not expose to traffic vibrations. Support and maintenance of such ducts will be subject to critical inspection by the owners for acceptance as a permanent facility.

D. High-Voltage Facilities:

1. Support conduits or pipes containing high voltage cables. Protect conduit or pipe from puncture or vibration damage. Have mastic coating immediately repaired if damaged. Provide temporary saddles for supporting circuits, conduits and pipes.

2. After completion of transit structure, provide required permanent supports. Furnish and place sand backfill as specified herein around conduits and pipes.

E. Temporary Duct Systems:

1. Number of temporary ducts will be determined by electric power company.

2. Number of split ducts which house secondary cables and cables for street lights and traffic signals which may subsequently be encased as a permanent facility but may be limited in accordance with the requirements of the facility owner.

F. Work to be performed and materials to be furnished by electric power company is shown on the drawings.

3.9 TELEPHONE COMPANY FACILITIES

A. Maintain continuity of existing communications services of telephone company. Support, protect, relocate, and reconstruct facilities during construction operations and ultimately restore such facilities.

B. Furnish material and perform work in accordance with Section 02780, "Underground Electrical and Communications Distribution Systems", and telephone company practices.

C. Where shown, remove existing conduits and structures. Replace spare ducts with whole conduit and immediately replace conduit containing cable with split plastic duct approved by telephone company.

D. Where existing facilities are to be relocated and new ducts provided, provide whole ducts, construct new manholes, provide temporary supports and permanent concrete supports, and encasement. The Contractor may, at his option, provide temporary manholes where new manholes are shown and ultimately provide permanent concrete manholes.

E. Where whole thin-walled conduit is used, encase such conduit in concrete immediately upon installation. Encase thick-walled conduit and split conduit in concrete during backfilling.

F. Where new duct work is to be jointed to existing structure containing cable in service, break into structure wall under the supervision of telephone company.

G. Test new conduit for continuity by pulling test mandrel or by pneumatically rodding from structure to structure in accordance with telephone company practices. Leave polyethylene pull line in each conduit.
H. When existing conduits and manholes are shown to be abandoned, maintain complete-in-place until abandonment is allowed by telephone company.

I. Work to be performed and materials furnished by telephone company is shown on the drawings.

3.10 POLICE AND FIRE ALARM SYSTEMS

A. Maintain continuity of existing police and fire alarm services. Support, protect, and relocate police and fire alarm boxes and conduits serving them.

B. Should relocation or removal of any of police and fire alarm systems be required, inform the Contracting Officer of the requirement in writing so that three weeks advance notice can be provided to the appropriate department.

3.11 TRAFFIC SIGNALS AND STREET LIGHTING

A. Within limits of work shown, where transit construction or traffic maintenance require, existing street lights and traffic signals will be removed and ultimately replaced or relocated by jurisdictional agency and electric power company. Where street lights and traffic signals are removed for duration of construction, install temporary street lights and traffic signals in accordance with the approved Traffic Control Plan. Refer to Section 01570, “Maintenance and Control of Traffic”, for requirements.

B. Jurisdictional agency and electric power company will provide and subsequently remove luminaries, signal heads, and other appurtenances.

C. Make arrangements with appropriate agency to obtain temporary lighting poles for installation on traffic decking. Erect lighting poles and install temporary conduit on decking.

D. Upon completion of work, remove and dispose of temporary poles and conduit as directed.

E. Electric power company and appropriate agencies will provide permanent street and traffic lights where shown at completion of backfill operations.

F. Where street lights are to be mounted on brackets integral with subway vent shaft structures, provide conduit to within 1 foot of outside face of structure.

G. When necessary to have changes made to street and traffic light facilities, inform the Contracting Officer at least eight weeks before changes are to be effected. Furnish him a plan showing locations of temporary lighting and schedule of construction operations.

H. Traffic Control Detectors and Devices:

1. Traffic control detectors mounted on poles or standards will be disconnected, removed and ultimately replaced or relocated by the jurisdictional agency.

2. Remove detectors mounted in elongated trough boxes installed as treadles in traffic lanes and store as directed for reinstallation by the jurisdictional agency.

3.12 OTHER UTILITY FACILITIES

A. Maintain continuity of other existing utility facilities. Protect, support, relocate, and reconstruct such facilities, regardless of jurisdictional control.

3.13 SALVAGE

A. Salvage and clean material shown to be salvaged.

B. Reuse salvaged items after inspection and approval for reuse has been given by the utility.

C. Repair or replace salvaged items which are damaged or destroyed.

D. Where salvaged items are not designated for reinstallation as part of the work of the Contract or are otherwise not reused in the work, deliver such materials to the utility's storage area.

E. Salvage Records: Maintain records and storage facilities for salvaged items. Indicate in the records the condition of the salvaged items and their storage locations. Prepare inventory of delivered salvaged items. Have available for inspection a detailed record including signed vouchers and receipts.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Maintenance and support of existing utilities crossing or lying alongside excavations used to construct other facilities will not be measured for payment separately; such maintenance and support will be considered subsidiary to the cost of the new facilities being constructed.

B. Maintenance, support, or restoration of existing utilities as directed or shown in the Contract Documents will not be measured but will be paid for at the lump sum price for “Maintenance, Support, or Restoration of Existing Utility Facilities”. No separate measurement will be made for work related to “abandoned” and “to be abandoned” sewers and water mains and other utilities which
are considered an integral part of the finished work.

C. Relocated utilities are shown on the Contract Drawings. Trench Support System for trenches exceeding a depth of 5 feet shall be measured and paid for as specified under Section 02221, "Utility Excavation And Backfill". Support of excavation for depths not exceeding 5 feet will not be measured or paid for directly, but considered subsidiary to the various bid items.

END OF SECTION 02760
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the construction of new ducts, manholes, and handholes for underground electrical and communications facilities.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):
   1. ANSI A14.3 - Ladders - Fixed - Safety Requirements.
   2. ANSI A14.5 - Ladders Portable Reinforced Plastic - Supplement to Safety Requirements.
   3. ANSI C80.1 - Rigid Steel Conduit - Zinc Coated (GRC)
   4. ANSI/UL 651 - Standard for Schedule 40 and 80 Rigid PVC Conduit

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   4. ASTM A320/A320M - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service
   5. ASTM A536 - Standard Specification for Ductile Iron Castings
   6. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
   7. ASTM C33 - Standard Specification for Concrete Aggregates
   9. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete
   10. ASTM D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
   15. ASTM D3786 - Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit
   2. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   3. NEMA TC 6 and 8 - Polyvinyl Chloride (PVC) Plastic Utilities For Underground Installations
   4. NEMA Bulletin No. TCB 2-2000 - NEMA Guidelines For The Selection And Installation Of Underground Nonmetallic Duct

D. American Association of State Highway Transportation Officials, Inc. (AASHTO)
   1. AASHTO HB17 - Standard Specifications for Highway Bridges

1.3 DEFINITIONS

A. Conduit: Individual electrical raceway.

B. Duct: Assembly of conduits in configurations shown, concrete encased, with reinforcement.
1.4 SUBMITTALS

A. Shop Drawings:

1. Prior to manufacturing the Contractor shall submit for approval drawings for each cast-in-place manhole.

2. Prior to manufacturing the Contractor shall submit for approval typical drawings for each size and configuration of precast manhole, handhole, systems elements boxes and junction box with details of fabrication, assembly, accessories and joints.

3. Prior to manufacturing the contractor shall submit for approval diagrams of each manhole, handhole, system elements box and junction box, showing dimensioned locations for openings and knockout panels for express trough, duct and stub-up penetrations of manhole walls.

4. Prior to proceeding with Directional bores, Core bores and Hydro-jetting for duct bank and stub-up crossings/locations, submit for approval working plans, materials and installation details sufficient to fully indicate the crossing installation.

5. Submit, 21 days prior to installation, Shop Drawings representing planned conduit and/or Ductbank Work for this Specification Section.

B. Documentation: Prior to manufacturing the contractor shall submit for approval calculations to demonstrate compliance with required load-bearing capacity, certified by a Professional Engineer, registered in the State of Texas.

C. Certification: Submit certificates on furnished material from manufacturers of materials.

1. Product data or certification indicating compliance of all elements with the standards and requirements listed in this section.

D. Samples:

1. Submit for approval sample, specification data, and manufacturer’s installation instructions for nonwoven filter fabric.

2. Submit for approval sample and specification data for security bolts.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Receive, transport, and store until use, those materials supplied by utility companies.

1.6 QUALITY ASSURANCE

A. Comply with codes and regulations of the jurisdictional authority.

B. Ladders and steps shall comply with OSHA Standards.

1.7 MAINTENANCE MATERIALS PROVIDED

A. Furnish and deliver to the Contracting Officer, ten sockets to fit security bolts provided.

B. Furnish fiberglass extension ladders in quantity, length, and type as shown on Manhole Schedule drawings and deliver to the Authority as directed by the Contracting Officer.

PART 2 - PRODUCTS

2.1 CONCRETE WORK

A. Concrete formwork: As specified in Section 03100, “Concrete Formwork”.

B. Reinforcing steel: As specified in Section 03200, “Concrete Reinforcement”.

C. Concrete:

1. Cast-In-Place: As specified in Section 03305, “Portland Cement Concrete”, Mix S-7. Mix design for a Utility Company manhole shall be as required by the Utility Company for its facilities. Encasement for Underground Ducts shall be Mix M-1. Mix design for a Utility Company ductbank shall be as required by the Utility Company for its facility.

2. Precast: As specified in Section 03430, “Structural Precast Concrete”, Mix S-3 as specified in Section 03305, “Portland Cement Concrete”.

D. Flowable fill: As specified in Section 02220, “Grading, Excavating, and Backfilling”.

E. High-density polymer concrete (HDPC) for handholes, junction boxes and pull boxes: Sized as shown on the Manhole Schedule drawings.

1. HDPC or aggregates bound together with polyester resin and/or reinforced with continuous woven glass strands or glass
fiber. Precast concrete shall be fire resistant and electrically non-conductive.

2. Precast HDPC concrete mix shall have the following certified, tested minimum characteristics:
   a. Compressive strength (28-day): 10,300 psi
   b. Tensile strength: 1,800 psi
   c. Flexural strength: 3,600 psi
   d. Modulus of elasticity: $1.83 \times 10^6$
   e. Freeze/thaw resistance (2,500 cycles): No change
   f. Fire resistance (Maximum): 10 when tested in accordance with ASTM E84; or maximum burning rate of 0.3 inches per minute for each 0.1 inch of thickness when tested in accordance with ASTM D635
   g. Shear (Minimum): 6,000 psi

3. Concrete formwork: As specified in Section 03100, “Concrete Formwork”.

4. Quality assurance: As specified in Section 03300, “Cast-In-Place Concrete”.

2.2 COATINGS

Not used.

2.3 CONDUIT AND FITTINGS

A. PVC conduit and fittings:
   1. Concrete encased: ANSI/UL 651 or NEMA TC2; Type-Schedule 40 PVC.
   2. Direct burial: ASTM F512, Type DB-120.

B. Galvanized rigid steel conduit and fittings: ANSI C80.1.

C. Galvanized rigid steel conduit and fittings with polyvinyl-chloride external coating: NEMA RN 1

2.4 SPACERS

A. Conduit spacers shall be installed in duct banks at the rate of 3 spacers per 20 linear feet or the equivalent, maximum interval of 78 inch centers along the entire conduit run. Plastic conduit spacers provided shall be specified for use in duct banks and be standard factory preformed spacers.

2.5 END BELLS

A. Flared, smooth-surfaced fittings of same material as conduit; if fittings are of different material, include adapter for connection to conduit.

2.6 AGGREGATE

A. Aggregate for Subgrade Foundation where required: ASTM C33, coarse aggregate No. 4 or No. 67.

2.7 CHANNEL INSERTS

A. Fiber-reinforced polymer (FRP) channel shall be of pultruded glass-reinforced polyester or vinyl ester resin: ASTM D3917 and ASTM D4385, length and minimum width and depth sizes as shown on drawings, heavy duty, surface-mounted, slotted back with mounting slots on a maximum of 8 inch centers, channel configuration to accommodate standard metal framing fasteners.

2.8 CABLE PULLING IRON

A. Fabricated of plain steel reinforcement bar, ASTM A615, Grade 60; welded; size as shown: Hot-dip galvanized after fabrication, ASTM A123.

2.9 MANHOLE AND HANDBOLE FRAMES AND COVERS

A. Handhole Frame and Cover: Steel, ASTM A36/A36M; size as shown, with the DART Logo cast in the cover.

B. Manhole Frame and Cover:
   1. Authority manhole, rectangular access cover: Size as shown on drawings.
      a. Covers shall be designed by a registered Civil Engineer licensed in Texas in accordance with AASHTO HS20 loading requirements and ASTM C857.
      b. Each Access Door shall be provided with a zinc plated and chromate sealed torsion assist mechanism to reduce the lifting requirements and shall be able to open to a 90 and/or 180-degree position.
      c. Frames and covers shall be hot dipped galvanized per ASTM A123 as last revised to reduce corrosion.
      d. Each access door shall be manufactured with a minimum 1/4 inch steel floor plate.
      e. Torsion Bars shall be removable or exchanged without removing the covers from the frame assembly.
f. Covers shall have the DART logo as shown on the Contract Drawings.
g. Covers shall be provided with recessed flush lift handles to assist opening covers.
h. Miscellaneous hardware shall be zinc plated and chromate sealed for corrosion resistance.
i. Countersink hole at bolt locations to prevent bolts from extending more than 1/8 inch above cover. The hole shall have a diameter that is large enough to accommodate the socket for the bolt heads.

2. Authority manhole, round access cover: Size as shown on drawings.
   a. Cast iron, ASTM A48, Class 30, with the DART logo cast in the cover.
   b. Cast or drilled countersink hole at bolt locations to prevent bolts from extending more than 1/8 inch above cover. The hole shall have a diameter that is large enough to accommodate the socket for the bolt heads.


C. Impedance Bond Box: Frame with Lid and Fabricated Metal Box:
   1. Frame and lid shall adhere to the requirements of Section 05500, “Metal Fabrications”. Fabricated metal box shall be constructed of either galvanized ASTM A36/A36M Carbon Steel; Cast Iron, ASTM A48, Class 40; or ductile iron, ASTM A536. DART logo shall be cast into cast and ductile iron lids.
   2. Box elements shall be a minimum of 1/4 inch thick. Frame/lid assembly shall be connected to the fabricated metal box to form a monolithic item, resulting in a watertight case.

2.10 MANHOLE STEPS
   A. Unless otherwise shown: Fiberglass or rebar.
   B. As shown on Manhole Schedule drawings, provide at manhole steps a telescoping safety post as specified herein.

2.11 HANDBOLES AND MANHOLES
   A. Unless otherwise shown, Contractor’s option of either cast-in-place or precast.

1. Cast-in-place concrete:
   a. Size and configuration as shown on the detail drawings, the schedules, and as specified.
   b. Manholes shall be designed for AASHTO HS20-44 truck loading.
   c. Handholes shall be designed for AASHTO HS20-44 truck loading when indicated on the detail drawings and the schedules.
   d. Manhole: Include lifting rings, manhole steps, pulling irons, sump, hole through floor for ground rod. Precast extensions included where required by Utility or by manhole schedule or detail drawings.

2. Precast concrete:
   a. Size and configuration as shown on the detail drawings, the schedules, and as specified.
   b. Designed for AASHTO HS20-44 truck loading.
   c. Manhole: Include lifting rings, manhole steps, pulling irons, sump, hole through floor for ground rod, and seal or sealant for sealing joints between sections. Precast extensions included where required by Utility or by manhole schedule or detail drawings.

2.12 GROUNDING
   A. As specified in Section 16450, "Grounding and Bonding".

2.13 WARNING TAPES
   A. Polyethylene non-detectable tape for direct burial, extra stretch, minimum of 7 mil thick and a minimum of 6 inches wide for use in trenches. Approved manufacturers are Terra-Tape, Blackburn Manufacturing, Seton, or Authority approved equal.
   B. Provide printed warning label text. The text shall be placed on three foot centers with tape placed continuously over ducts and conduits. The tape shall be colored as follows:

1. For communication and signal ducts: Orange tape with black printed labeling: "Caution-Communications Cable Buried Below" or "Warning – Communications Cable Buried Below", or Authority approved standard language. Communication ducts are those that run between Communications/Signal Manholes (CSMH),
or run from a CSMH to a Communication Facility, stub-up, stub-out, handhole, or junction box.

2. For electrical ducts or cable: Red tape with black printed labeling: “Caution – High Voltage Cable Buried Below” or “Warning – High Voltage Cable Buried Below”, or Authority approved standard language. Electrical ducts are those that run between Utility Manholes (UTMH), between Traction Power Manholes (TPMH), between UTMH and TPMH and Traction Power Substations, or run from a UTMH or a TPMH to a stub-up.

2.14 CONCRETE COLORING AGENT

A. Red Iron Oxide: ASTM C979

1. Include in ductbank concrete encasement mix design, or apply and mix in top layer of ductbank concrete immediately following concrete placement, where indicated on drawings.

2.15 SECURITY BOLTS

A. Two security bolts shall be required to lock down a manhole, handhole, junction box, or pull box cover in order to prevent unauthorized access.

B. Security bolt shall be fabricated to be a direct replacement of existing bolts, where applicable, and shall comply with the following physical specifications:

1. Bolt shall be made from 304 Class 2 or equal stainless steel, conforming to ASTM A320/A320M.

2. Bolt shall be made with a flat pentagonal 0.845 inch head (0.56 inch side), 0.3 inch minimum depth.

3. Bolt shall be torqued by means of a matching tool steel socket, which fits a 1/2 inch drive wrench.

4. Bolt lengths shall be as required to fully engage the threads and shall be held to plus or minus 0.1 inch.

5. Bolt for junction boxes shall be 3/8 inch diameter, 16 threads per inch, class UNC-2A. Bolt for manholes, handholes, and pullboxes shall be 1/2 inch diameter, 13 threads per inch, class UNC-2A.

C. Apply marine grade anti-seize calcium sulfonate lubricant or equal to bolt threads prior to final installation of security bolt.

2.16 LADDERS

A. Authority manhole: Length and type of ladder as shown on Manhole Schedule drawings.

1. Structural steel ladders shall conform to Specification Section 05500, “Metal Fabrications”.

2. Fiberglass ladders shall conform to the requirements of ANSI A14.5, Type 1A - Industrial - Extra Heavy Duty.

3. Fiberglass extension ladders shall conform to the requirements of ANSI A14.5, Type 1A - Industrial - Extra Heavy Duty.

4. Fixed ladders shall conform to the requirements of ANSI A14.3.

B. Utility Company manhole: Ladder as required by the Utility Company.

C. As shown on Manhole Schedule drawings, provide at manhole ladders a telescoping safety post as specified herein.

2.17 TELESCOPING SAFETY POST

A. As shown on Manhole Schedule drawings, provide on manhole steps and ladders an aluminum telescoping safety post with stainless steel hardware conforming to OSHA requirements extending not less than 36 inches above the top of the manhole ring or cover.

2.18 NON-WOVEN FILTER FABRIC

A. Use non-woven material for subgrade separation/stabilization at locations indicted on the Contract Drawings.

B. Shall adhere to the following requirements:

<table>
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<th>Specification</th>
<th>Requirement</th>
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</thead>
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<tr>
<td>Unit Weight</td>
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<tr>
<td>Tensile Strength</td>
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<td>Elongation</td>
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<td>Mullen Burst Strength</td>
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<tr>
<td>Trapezoidal Tear Strength</td>
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<tr>
<td>Puncture Strength</td>
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</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.1 EXCAVATING AND BACKFILLING

A. Excavating and backfilling: In accordance with Section 02220, “Grading, Excavating, and Backfilling”. Refer to Section 02221, “Utility Excavation and Backfill”, for support of excavation.

1. Requirements for duct trench and manhole backfill material are modified to include native, excavated soil and similar borrow.
For duct banks, stub-ups and stub-outs, this only applies to backfill areas equivalent from the top of encasement to finished grade or stabilized base for track bed. All required level-up or other supporting materials shall remain as controlled flowable fill or select fill. Use of native, excavated soil for manholes and handholes/junction boxes shall be restricted to sidewalks and areas above the structural floor. Required level-up or support bedding material shall remain as indicated on the Contract Drawings or controlled flowable fill. Native excavated soil for backfill shall be free of roots, grass, trash and other organic material. The requirements for compaction and other items specified as Execution remain unchanged.

B. Ducts and manholes installed on backfill over utilities or structures:

1. Place and compact backfill up to grade shown for ducts and manholes; compact as specified in Section 02220, “Grading, Excavating, and Backfilling”; ensure the manhole sets level.

2. Schedule completion of backfilling to allow sufficient time for installation of ducts and manholes.

C. Where shown for subgrade foundation, use layers of coarse aggregate ASTM C33, No. 4 and No. 67 in combinations and proportions as determined by field conditions.

D. Protect and maintain existing utility services in accordance with Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

3.2 PAVEMENTS, SIDEWALKS, CURBS, AND GUTTERS

A. Remove pavements, sidewalks, curbs, and gutters where necessitated by construction of ducts and manholes in accordance with Section 02050, “Demolition”, as indicated on the drawings.

B. Place temporary bituminous pavement in accordance with Section 02511, “Bituminous Pavement”, when required by the sequence of operations.

C. On completion of distribution systems construction, replace pavements, sidewalks, curbs, and gutters, in accordance with Section 02525, “Combined Curb and Gutters, Curb Ramps, and Walks”, when required by the sequence of operations.

D. Reconstruction of roadway or track slab necessary for the installation of new power switches, insulated joints and related systems elements shall be completed in accordance with Section 03300 "Cast-In-Place Concrete", when required by the sequence of operations.

E. Upon completion of distribution system construction, replace and reset pavers in accordance with Section 02515, “Unit Pavers”, when required by the sequence of operations. The requirements of Section 02515 for the preparation, installation, and finishing of new unit pavers shall also apply to the preparation, installation, and finishing of existing pavers that are to be reused.

3.3 PLACING DUCTS

A. Depending on encasement necessary for duct formation, place conduits on spacers and, where required, construct concrete base prior to placing bottom tier of conduits.

B. Minimum bend radius for raceways installed underground shall be as shown in Specification Section 16110, Table 3.1, except where otherwise indicated.

C. Lay conduits for encased ductbanks and stub-ups/outs using preformed plastic spacers installed at maximum interval of 78 inch centers along the entire conduit run, to provide tier spacing as shown. For Utility Company facilities use spacers recommended by that Utility Company.

D. Make tight conduit joints by complying with recommendations of conduit manufacturer, using coupling jointing compound or solvent cement.

E. Use non-metallic conduit, unless otherwise shown.

F. Where required, properly place and compact concrete around conduits in accordance with Section 03300, “Cast-In-Place Concrete”. Where required, properly place and compact controlled flowable fill around conduits in accordance with Section 02220, “Grading, Excavating, and Backfilling”. Placing of flowable fill around conduits shall be performed in a manner that prevents conduit floating. Conduits shall be sufficiently restrained to a point that the duct bank conduit configuration has not been changed from that designed and that clearance and encasement dimensions are satisfied along the entire length of duct bank or bundled stub-outs.

G. Where shown, install reinforcing steel in encasement in accordance with Section 03200, “Concrete Reinforcement”.

H. If not already in concrete mix, immediately following concrete placement, substantially apply and mix concrete coloring agent in liquid form to fully saturate the entire top surface of encasement concrete and to provide a strong red color, where shown on drawings.

I. Clear conduit by rod and pull an approved test mandrel from structure to structure.

J. Install Authority approved nylon or polyester pull line in each conduit. Tag each pull line to identify the corresponding point of origin.
K. Directional Bore:

1. Where indicated, or used as an alternate means of construction, install conduit by directional bore. Excavation of the boring pits shall proceed in accordance with Section 02221 “Utility Excavation and Backfill”.

2. Where concrete casing is required for installation of the 4-inch communication conduits and duct banks, the borehole shall be a minimum of 10-inch diameter. Any voids that develop between communication conduits and walls of the borehole shall be filled with grout in accordance with Section 03305 “Portland Cement Concrete”.

L. Direct Burial:

1. Duct should be fully surrounded by a selected backfill to prevent more than the desired deflection and, in power ducts, to provide for heat dissipation. A separation of 1 inch both vertically and horizontally between ducts is a recommended minimum to provide room for heat dissipation and for good compaction of backfill. Other spacing may be required for different applications in which case the additional spacers manufacturing data shall be included in to submittal.

2. Duct formation may be built up layer by layer. After each layer is placed, the selected backfill should be placed over it to a minimum depth of 1-inches. This fill should be spread evenly and compacted to provide continuous support for the next tier of ducts. Any temporary spacers used should be removed from each layer of duct as soon as backfill is completed in that layer. To maintain clearance between ducts, joints for adjacent ducts should be offset about 6 inches both horizontally and vertically.

3. If alternate methods and materials are deemed necessary due to site conditions and other RR limitations, contractor shall submit a work plan of methods and material selections to the Authority for approval. See Article 1.4, Submittals for requirements.

M. Core-Bore:

1. Where indicated, or used as an alternate means of construction, install conduit by core-bore method.

2. Where concrete casing is required for installation of the 4 inch and 2 inch communication conduits and duct banks, the core-borehole shall be a minimum of 10 inch diameter for 4 inch conduit, and 8 inch diameter for 2 inch conduit. Any voids that develop between communication conduits and walls of the core-borehole shall be filled with grout in accordance with Section 03305 “Portland Cement Concrete”.

3.4 INSTALLATION OF WARNING TAPES

A. After placing a minimum of 6 or a maximum of 12 inches of backfill over the ducts, place the appropriate warning tapes above and parallel to the centerline of the duct for the entire length of the duct trench.

3.5 CONSTRUCTION OF MANHOLES AND HANDHOLES

A. Cast-in-Place:

1. Provide drainage facilities for manholes where shown. If connection is made to existing line, install connection in accordance with Section 02700, “Storm Sewer Systems”.

2. After pit excavation, place filter fabric, gravel setting bed & compact prior to forming the MH floor and walls. Wrap filter fabric completely around gravel setting bed and overlap loose ends. Secure in-place by forming MH on the fabric wrapped setting bed to line and correct elevation as indicated on the plans.

3. Erect formwork in accordance with Section 03100, “Concrete Formwork”.

4. Place reinforcing in accordance with approved shop drawings.

5. Provide for location of duct entrances and inserts in walls as shown.

6. Place concrete as specified in Section 03300, “Cast-In-Place Concrete”.

7. Install conduits of material shown.

8. Install end bells on conduits where ducts terminate in manhole and handholes.

9. Build duct formations into walls of manholes and seal around openings.

10. If location of manhole or handhole openings will be obstructed, inform the Contracting Officer immediately.

11. Install frame and cover, adjust to finished grade by using precast neck extenders, grout and, if necessary, brick chimney as specified in Section 02700, “Storm Sewer Systems”.

12. Seal conduit openings with approved conduit plugs.
13. Install ground rods where shown. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved.

14. Provide channel inserts along interior walls as shown. Perform pull-out test.

15. Backfill in accordance with Section 02220, "Grading, Excavating, and Backfilling", except as modified herein regarding the use of excavated soil, in accordance with Paragraph 3.1A.1.

16. Install ladder and telescoping safety post where required by Manhole Schedule drawings.

17. Complete grounding of metal components in accordance with Section 16450, "Grounding and Bonding":

B. Pre-cast:

1. Provide drainage facilities for manholes where shown. If connection is made to existing line, install connection in accordance with Section 02700, "Storm Sewer Systems".

2. After pit excavation, place filter fabric, gravel setting bed & compact prior to setting the MH section. Wrap filter fabric completely around gravel setting bed and overlap loose ends. Secure in-place by setting MH section on the fabric wrapped setting bed to line and correct elevation as indicated on the plans.

3. Install conduits of material shown.

4. Install end bells on conduits where ducts terminate in manhole and handholes.

5. Build duct formations into the bulkhead of manholes and seal around openings.

6. If location of manholes or handholes openings will be obstructed inform the Contracting Officer immediately.

7. Install factory provided asphaltic/poly-silicone type joint sealing strips to wall joints. Place and secure MH top including the frame and cover, adjust to finished grade by using precast neck extenders, when required.

8. Seal conduit openings with approved conduit plugs.

9. Install cable pulling irons and steps as shown.

10. Install ground rods where shown. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved.

11. When installing sections of precast manholes, prevent damage to joints seals.

12. Provide channel inserts along interior walls as shown. Perform pull-out test.

13. Paint exterior of manhole, which is below grade, with two coats of epoxy coal tar, 18 mils minimum total dry film thickness.

14. Backfill in accordance with Sec. 02220, "Grading, Excavating, and Backfilling", except as modified herein regarding the use of excavated soil, in accordance with Paragraph 3.1A.1.

15. Install ladder and telescoping safety post where required by Manhole Schedule drawings.

16. Complete grounding of metal components in accordance with Section 16450, "Grounding and Bonding":

3.6 CLEAN-UP

A. Remove debris from manholes and ensure complete installation is left in neat and finished condition.

3.7 CONSTRUCTION TOLERANCES

A. Construct System Elements to the following tolerances:

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<th>Offset</th>
<th>Slope</th>
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<tr>
<td>Cross bond/ Negative return Stub-ups</td>
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</table>
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Duct banks for electrical and communications facilities will not be measured, but will be paid for at lump sum price for “Duct Banks”.

B. Concrete encased PVC, galvanized rigid steel (GRS) and flex metal conduit stub-ups and stub-outs will not be measured separately, but shall be considered subsidiary to the related Duct Bank item.

C. Manholes will be measured by and paid for at the unit price for “Manholes” per each, for each type and size.

D. Handholes will be measured by and paid for at the unit price for “Handholes” per each, for each type and size.

E. Junction boxes, pullboxes, and systems elements boxes will be measured by and paid for at the unit price for “Junction Box”, “Pullbox”, “Impedance Bond Box”, and “System Element Box” per each, for each type and size.

F. No separate measurement or payment will be made for the following work required for work of this section. Such work will be considered subsidiary to the various bid items:

1. Ladders, steps, telescoping safety post, and other accessories.

2. Socket tools for access cover security bolts and fiberglass extension ladders.

3. Concrete work, including reinforcing steel.

4. Excavating, backfilling, jacking, boring, and tunneling, including concrete encasement, bedding material, and disposal of surplus material.

5. Support of excavation for depths not exceeding 5 feet.

6. Dewatering.

7. Removal and replacement of existing bases, pavements, sidewalks, curbs, and gutters.

8. Barricading and maintenance and control of traffic.

9. Maintenance and support of existing utility facilities, except as otherwise indicated in Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.

G. Trench Support System for trenches exceeding a depth of 5 feet will be measured and paid for as specified under Section 02221, “Utility Excavation and Backfill”.

END OF SECTION 02780
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing at-grade express troughs, for communications and signal systems.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A320/A320M - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service
   2. ASTM A563 – Standard Specification for Carbon and Alloy Steel Nuts
   3. ASTM D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
   5. ASTM C666/C666M Standard Test Method for Resistance of Concrete to Rapid Freezeing and Thawing

B. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)

C. Precast/Prestressed Concrete Institute (PCI):
   1. PCI/CONCRT MNL-128 - Recommended Practice for Glass Fiber Reinforced Concrete Panels

D. American Association of State Highway Transportation Officials, Inc. (AASHTO)
   1. AASHTO HB17 - Standard Specifications for Highway Bridges

1.3 DEFINITIONS

A. Express Trough Unit: A fabricated precast cable trough, including cover with a multiple open (cells) interior space for enclosing low voltage, medium voltage and fiber optics cables.

1.4 SUBMITTALS

A. Shop Drawings: Drawings for express trough and bend.

1. Scaled, detailed installation drawings corresponding to the proposed express trough system shall be submitted prior to trough installation, complete with offset distances and clearances from tracks, ties, switches, pushbuttons and OCS Foundations, showing allowed 5 foot standard minimum track to trough clearance maintained. Plan drawings are diagrammatic and shall be evaluated with other Systems equipment and Systems standard drawings to prepare the detailed installation drawing submittal.

2. Details of bends and multiple trough sizes connections, dimensions and location of each utilized type of trough for the proposed express trough system shall be submitted prior to trough installation. Work closely with trough manufacturer to design/draw bends and/or size transition pieces and submit for approval. Submit cutting means and methods if pre-formed factory pieces are not used.

B. Calculations: Submit calculations to demonstrate that the express trough design meets the required load-bearing capacity, and minimum and maximum dimensions shown on the standard details, certified by a Professional Engineer, registered in the State of Texas.

C. Certification: Submit certificates on furnished material properties and characteristics from manufacturers of materials, including composite material mix qualification.

D. Test results: Submit laboratory or “in-situ” test results on furnished materials and products showing mix qualifications and express trough units with covers meet strength and loading requirements, certified by a Professional Engineer, registered in the State of Texas.

E. Drawings, details and certifications of the specialty securing bolt system that demonstrates the specialty bolts comply with the fastening requirements indicated on the drawing and in these specifications. Drawing and details shall indicate the type, size, material and strength characteristics as well as the fastening mechanism(s) to the trough sidewalls and cover.

F. Samples: Submit a sample of the complete trough unit (body and cover), as directed by the Contracting Officer.
1.5 QUALITY ASSURANCE
A. Comply with:
1. AASHTO standards for H20 loading.
2. PCI/CONCRT MNL-128
3. Codes and regulations of the jurisdictional authority
4. NFPA 70

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Deliver precast express trough units and structures to the Worksite in such quantities and at such time to assure continuity of installation.
B. Store and handle units at the Worksite in such a manner to prevent cracking, chipping, distorting, warping, or other physical damage. Lift and support units only at designated lifting or supporting points as shown on approved shop drawings.

1.7 MAINTENANCE MATERIALS PROVIDED
A. Furnish and deliver to the Contracting Officer, ten sockets to fit specialty securing fasteners provided.

PART 2 - PRODUCTS
2.1 CONCRETE WORK
A. Trough material shall consist of either high-density polymer concrete (HDPC) consisting of aggregates bound together with polyester resin and/or reinforced with continuous woven glass strands or glass fiber, precast composite polymer/sheet molded compound trough section consisting of HDPC and glass reinforced polymer mortar (GRPM) consisting of fine sand and glass fiber found together with resin binder or a Portland cement type concrete with steel reinforcement. Precast HDPC, HDPC/GRPM concrete/mortar mix types shall be fire resistant and electrically non-conductive. Material type shall be specified on the Contract Drawings.
B. Precast HDPC and GRPM mortar concrete mix shall have the following certified, tested minimum characteristics:
1. Compressive strength (28-day): 10,300 psi
2. Tensile strength: 1,800 psi
3. Flexural strength: 3,600 psi
4. Modulus of elasticity: 1.83x10^6
5. Freeze/thaw resistance (2,500 cycles): Cycling between 0 degree and 40 degrees F.
6. Fire resistance (Maximum): 10 when tested in accordance with ASTM E84; or maximum burning rate of 0.3 inches per minute for each 0.1 inch of thickness when tested in accordance with ASTM D635
7. Shear (Minimum): 6,000 psi
C. Concrete formwork: As specified in Section 03100, "Concrete Formwork".
D. Quality assurance: As specified in Section 03300, "Cast-In-Place Concrete".
E. Concrete/cement: Portland cement type concrete in accordance with and as specified in Section 03305, "Portland Cement Concrete", mix S-3.

2.2 EXPRESS TROUGH
A. Express Trough: Shall meet the minimum dimensions shown on the plans for the installation of signal and communication cables. Express trough unit shall be designed to withstand AASHTO H20 traffic loading on a regular basis, including impact and live load surcharge forces, without any permanent deformation, deflection or failure as a result of applied loads. Actual structure dimensions shall be as designed by the manufacturer but must recognize the constraints of adjacent facilities. Actual structure dimensions shall be as designed by the manufacturer but must recognize the constraints of adjacent facilities. Include drainage holes, the number required per unit length to ensure adequate drainage.
B. Covers: Shall be provided with appropriate lifting devices for easy removal during cable installation and maintenance. Covers shall be designed to withstand AASHTO H20 traffic loading on a regular basis, including impact loads, without permanent deformation, sagging or failure as a result of applied loads. Each cover shall have non-slip, no skid surface and the DART logo permanently affixed thereto. Covers shall have recessed areas to house the security bolt heads. Each recessed area shall have a diameter that is large enough to accommodate the socket for the bolt heads.
C. Lifting Devices: Fabricated units shall be provided with appropriate lifting devices to facilitate construction operations without causing chipping, cracking, or other damage.

2.3 SECURITY BOLTS
A. Two specialty security fasteners shall be required to lock down an express trough cover in order to prevent unauthorized access to the express trough.
B. Specialty security fastener shall be fabricated to comply with the following physical specifications:

1. Bolt shall be Grade A307 zinc (galvanized) plated carbon steel conforming to ASTM A563; Nuts and Washers shall be Grade A563.

2. Bolt shall be made with a flat pentagonal 0.845 inch head (0.56 inch side), 0.3 inch minimum depth.

3. Bolt shall be torqued by means of a matching tool steel socket, which fits a 1/2 inch drive wrench.

4. Bolt lengths: As required to fully engage the threads and held to plus or minus 0.1 inch.

5. Bolt: 3/8 inch diameter, 16 threads per inch, class UNC-2A.

C. An electroplated metal washer shall be positioned under the bolt head to prevent stress and wear on the trough cover.

D. Apply marine grade anti-seize calcium sulfonate lubricant or equal to threads prior to final installation of security bolt.

PART 3 - EXECUTION

3.1 GENERAL

A. Express troughs installed in the ballast areas of ballasted track construction shall be installed with the covers one inch above final grade, per manufacturer’s recommendations.

B. Express troughs installed in the sub-ballast areas of track construction shall be installed with the covers one inch above final grade, per manufacturer’s recommendations.

C. Express troughs shall not be installed in the bottoms of storm water ditches, swales or other sump areas that collect water, thus causing controlled storm water drainage to enter the cable trough.

D. Express troughs shall be kept free of construction debris, rock, or earth. Foreign materials shall be removed from the outdoor express trough channels prior to installation of cables and covers.

E. Express troughs shall not be left uncovered. Contractor shall install the furnished express trough covers.

F. Express troughs shall be protected against deformation and damage during construction in work areas of track work installation and placing and tamping of ballast material associated with cranes, backhoes, front-end loaders, or other heavy equipment. Contractor shall avoid placing heavy construction loads immediately adjacent to express trough body sidewalls without providing appropriate protective measures to include trough cover installation. Trough cover removal and installation shall be maintained as designed.

3.2 EXCAVATING AND BACKFILLING

A. Where Express Trough is installed in the ballast areas of ballasted track construction, use AREMA Grade 4 ballast as backfill and base around the express trough units in accordance with Section 02460, "Ballasted Track Construction".

B. Where Express Trough is installed in the sub-ballast areas of construction, use sub-ballast as backfill and base around the express trough units in accordance with, Section 02451 “Sub-Ballast” and Section 02453 “Track Ballast”.

C. Where Express Trough installation extends below the level of sub-ballast, or into an area without ballast and sub-ballast, excavate and backfill in accordance with Section 02220, “Grading, Excavating and Backfilling”.

3.3 PLACING EXPRESS TROUGH SYSTEM

A. Where Express Trough is installed in the ballast areas of ballasted track construction, prepare the sub-ballast and the first 6 inches of ballast per Section 02460, “Ballasted Track Construction”.

B. Where Express Trough is installed in the sub-ballast areas of construction, prepare the sub-ballast per Section 02451, “Sub-Ballast” and Section 02453, “Track Ballast”.

C. Using mechanized equipment and lifting equipment recommended by the manufacturer, set express trough units in place on the ballast or sub-ballast to the line and grade required.

D. Adjacent proposed and existing units are to be butt-jointed to each other with appropriate accessories and features to prevent vertical and horizontal separations. Caution shall be exercised during construction to protect existing express trough and any other utilities and elements that are located in areas of work. If necessary the contractor is responsible for relocation of existing utilities as per project requirements and/or replacement of damaged utilities/elements as caused by installation of these systems elements.

E. Polyurethane based, one part elastomeric sealant meeting the requirements of Specification Section 07900, “Seals and Sealants”, shall be applied to trough connection to each bridge and manhole and to butt joint at abutments of each ballasted bridge.

F. Install horizontal and vertical bends at locations shown on approved layout drawings. Miter joints to the angle required providing uniform, tight butt joints to the tolerances indicated.
G. Where Civil plans and cross-sections indicate a changing vertical profile relative to ballast and sub-ballast final grading, the express trough profile shall follow final grading up to a maximum trough slope of 1:4. Additional ballast shall be installed, as needed, to ensure adequate trough sidewall burial indicated in Paragraph 3.1. A & 3.1.B above.

H. Ballast or sub-ballast backfill shall be placed against the sides of the express trough system simultaneously on both sides in successive layers of 4 inches and compacted.

I. Temporary covers shall be used during installation of the express trough system to prevent damage to the units from ballast or sub-ballast falling into the prefabricated units.

J. If a concrete shell is required by the manufacturer to ensure that the prefabricated units comply with H20 loading requirements, the Contractor shall form and construct this shell per approved shop drawings. This shell and prefabricated unit shall be constructed on the initial sub-ballast and/or 6-inch ballast construction prior to completing the ballast backfill to the finished grades.

K. Express cable troughs shall be inspected for any burrs or rough places that could damage cable insulation. Burrs or rough places will be removed or repaired. Cable troughs shall be thoroughly cleaned of debris, rocks, or other material. Permanent covers shall be placed on the trough units as specified in Paragraph 3.1.E above.

L. Butt joints shall be wrapped with geo-textile fabric prior to placement of ballast or subballast.

M. Where express trough is installed between cross ties, provide a minimum of 2 inch clearance from the top of the trough to the bottom of the rail. Ensure that express trough installed parallel to cross ties.

N. Interior corner guards shall be provided to prevent cables insulation from being damaged during the installation activities.

3.4 LENGTH ADJUSTMENTS

A. Polymer concrete express trough units shall be cut with special cutting equipment recommended by the manufacturer to adjust for lengths and angles. Cut ends shall be joined by a method recommended by the manufacturer to prevent vertical and lateral displacements and maintain the design H-20 loading.

3.5 CONSTRUCTION TOLERANCES

A. Construct Express Trough to the following tolerances:

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Elevation</th>
<th>Station</th>
<th>Offset</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Express Trough</td>
<td>+1/2&quot; / -1/2&quot;</td>
<td>N/A</td>
<td>+1&quot; / -1&quot;</td>
<td>N/A</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing express troughs on aerial structures for communications and signal systems.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A320/A320M - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low-Temperature Service
   2. ASTM D257 - Standard Test Methods for DC Resistance or Conductance of Insulating Materials

B. Precast/Prestressed Concrete Institute (PCI):
   1. PCI/CONCRT MNL-116: Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products
   2. PCI/CONCRT MNL-128: Recommended Practice for Glass Fiber Reinforced Concrete Panels

C. American Concrete Institute (ACI):
   1. ACI 548.1R - Guide for the Use of Polymers in Concrete

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

C. Texas Department of Licensing & Regulation:
   1. TAS - Texas Accessibility Standards

1.3 DEFINITIONS

A. Express Trough: A fabricated precast cable trough with a multiple open interior space for enclosing low voltage cables.

B. Security Bolt: A bolt assembly unit with specified material and geometric characteristics which prevent removal or damage due to normal use or attempted vandalism. The security bolt shall have pentagonal head and require a unique key to remove or tighten and be considered “tamper resistant”.

C. Plinth: A cast-in-place structure to establish the proper elevation for the express trough and for security bolt placement located on aerial structures per supplier’s details.

1.4 SUBMITTALS

A. Shop Drawings: Submit to the Contracting Officer’s Representative (COR) drawings for express trough and bends.

1. Scaled, detailed plan layout drawings for the proposed express trough system shall be submitted to the COR complete with offset distances and clearances from tracks, appurtenances, and all wayside structures including installation details.

2. Provide scaled, detailed drawings of the trough unit, covers, and plinths that include dimensions, inside area, extensions for security bolts, and any appurtenances required for this item.

3. Diagrams showing dimensioned tie-in for each type of manhole, junction box, and transition to ballasted trough at the abutments.

4. Lifting equipment for personnel and for mechanical equipment.

5. Provide installation schedule.

B. Documentation: Submit to the COR calculations to demonstrate that the express trough design meets the required load-bearing capacity, NFPA 130 requirements, and minimum and maximum dimensions shown on the standard details, certified by a Professional Engineer, licensed in the State of Texas.

C. Certification: Submit to the COR certificates on furnished materials from manufacturers of materials, including Certification of Compliance with NFPA 130 for the quantity of materials used on aerial structures.

D. Test results: Submit to the COR test results on furnished materials, including security bolts, showing that units meet requirements as specified in Part 2.

E. Mock-up: After submittals have been approved by the COR, a mock-up of the approved troughs including cover, security bolts, spacers, and expansion joints with all appurtenances required for a complete system shall be constructed to illustrate system is in compliance before installation may begin.

1.5 QUALITY ASSURANCE

A. Comply with:
   1. PCI/CONCRT MNL-116
EXPRESS TROUGH FOR AERIAL STRUCTURES

2. PCI/CONCRT MNL-128
3. ACI 548.1R
4. NFPA 70 (NEC)
5. NFPA 130, Chapters 1 - 3
6. TAS Section 4.5.2 Ground and Floor Surfaces.

B. Qualifications:
1. Precast work to be performed by a PCI certified plant regularly engaged in design and construction of structural precast, prestressed concrete members with a minimum of five years experience.
2. Submit name, qualifications and evidence of five years experience on work comparable to that specified.
3. Do not commence work until fabricator (precastor) has been approved.

C. Testing Laboratory and Quality Control: In accordance with Section 01450, “Quality Control”, Section 03300, “Cast-In-Place Concrete” and Section 03430, “Structural Precast Concrete”.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver precast express trough units and structures to the worksite in such quantities and at such time to assure continuity of installation.

B. Store and handle units at the worksite in such a manner to prevent cracking, chipping, distorting, warping, or other physical damage. Lift and support units only at designated lifting or supporting points as shown on approved shop drawings.

C. Supplier shall provide spacers for the express trough. Spacers shall be designed to prevent warping in the express trough and shall only be removed by the contractor immediately before cable installation.

D. Security bolt concrete inserts shall be provided with a plastic plug insert in the factory. Plug shall not be removed until it is ready to be replaced with a security bolt.

1.7 AUTHORITY TOOLS

A. Furnish and deliver to the Contracting Officer, ten sets of lifting equipment for the cover lifting devices provided. Five sets for personnel to lift covers and five sets for mechanical lifting.

PART 2 - PRODUCTS

2.1 CONCRETE WORK

A. Concrete Formwork: As specified in Section 03100, “Concrete Formwork”.

B. Reinforcing Steel: As specified in Section 03200, “Concrete Reinforcement”.

C. Concrete: As specified in Section 03300, “Cast-In-Place Concrete” and Section 03430, “Structural Precast Concrete”.

D. Grout: As specified in Section 04100, “Mortar, Grout, And Masonry Accessories”.

2.2 HIGH DENSITY POLYMER CONCRETE

A. Trough and cover material shall consist of high-density polymer concrete (HDPC) or aggregates bound together with polyester resin and/or reinforced with continuous woven glass strands or glass fiber. Precast polymer concrete shall be fire resistant and electrically non-conductive per ASTM D257.

B. The precast concrete mix shall have the following certified, tested minimum characteristics:
   1. Compressive strength (28 day): 10,300 psi
   2. Tensile strength: 1,800 psi
   3. Flexural strength: 3,600 psi
   4. Modulus of elasticity: $1.83 \times 10^6$
   5. Freeze/thaw resistance (2,500 cycles): No change
   6. Fire resistance (Maximum): 10

2.3 PORTLAND CEMENT CONCRETE

A. Design the express trough units to conform to Section 02781, “Precast Express Trough” and cover to be designed for a live load of 250 psf, and a concentrated live load of 500 pounds acting on an area measuring 1 foot square and placed in a position that will cause maximum stress. The loads need not be applied simultaneously.

B. Plinth concrete shall be Mix Design S-3 as specified in Section 03305, “Portland Cement Concrete”.

02782 - 2
2.4 EXPRESS TROUGH

A. Express Trough: Shall meet the minimum dimensions shown on the plans for the installation of signal and communication cables. Actual structure dimensions will be as designed by the manufacturer but must recognize the constraints of adjacent facilities and shall meet NFPA 130 specifications for use on aerial structures. Express trough for direct fixation bridges shall have weepholes located on low side or bottom of each cell with a maximum spacing of 5 feet. Weepholes shall be 1-1/2 inch in diameter with a galvanized metal screen mesh inside. The trough shall have some means to secure the trough to the plinths.

B. Covers: Shall be provided with appropriate lifting devices as approved on shop drawings for easy removal during cable installation and maintenance. Each cover shall have the DART logo and weight recessed so as not to create tripping hazard. Bridge trough covers shall have a width as shown in the plan details and shall meet NFPA 130 specifications. The trough covers shall have oversize longitudinally slotted holes to receive recessed bolts to prevent the security bolts from becoming a tripping hazard. Refer to the Texas Accessibility Standards criteria for maximum allowable surface tolerance. Covers shall have a non-slip surface with minimum static coefficient of friction (SCOF) of 0.5. Broom-finished concrete is acceptable. Covers shall not weigh in excess of 140 pounds each. Each cover shall be stamped with the actual weight, approved on the shop drawings, on top of the lid. Supplier shall design plinths to accommodate the cover locations.

C. Lifting Devices: The fabricated units shall be provided with lifting devices as approved on shop drawings to facilitate maintenance and construction operations without causing chipping, cracking, or other damage.

D. Plinth: The express trough will be affixed to the bridge deck utilizing plinths. The plinth shall be cast-in-place concrete as specified in Section 03300, “Cast-In-Place Concrete” and Section 03305, “Portland Cement Concrete”, Mix Design S-3. The plinth shall be designed by the supplier to accept their specific trough and coordinated with the covers and secured to the bridging slab. Plinths shall not be continuous.

2.5 SECURITY BOLTS

A. A minimum of two security bolts, depending upon the length of the trough unit as designed by the manufacturer, shall be required to lock down an express trough cover in order to prevent unauthorized access to the express trough.

B. The security bolt shall be fabricated to the following physical specifications:

3. Bolt shall be torqued by means of a matching 1/2 inch drive, tool steel socket wrench.

4. Bolt lengths shall be as required to fully engage threads and shall be held to plus or minus 0.1 inch.

5. Bolt shall be 3/8 inch diameter, 16 threads per inch, Class UNC-2A.

C. An electroplated metal washer and lock washer shall be positioned under the bolt head to prevent stress and wear on the trough cover.

D. Apply marine grade anti-seize calcium sulfonate lubricant or equal to threads prior to final installation of security bolt.

E. Security Bolt pentagonal heads shall match the security bolts provided in Section 02781, “Precast Express Trough”.

PART 3 - EXECUTION

3.1 GENERAL

A. Express troughs shall be installed on the structure and anchored in place as shown on the plans.

B. Joints in pre-cast cable troughs shall match the expansion joints in the aerial structure deck and parapet walls.

C. Express troughs installed on aerial structures shall be installed with the top of the covers 8 inches above the top-of-rail measured from the closest edge to the rail.

D. Express troughs shall be kept free of construction debris, rock, or earth. Foreign materials shall be removed from the outdoor express trough channels prior to installation of cables and covers.

E. Express troughs shall not be left uncovered. The Contractor shall install the furnished express trough covers.

F. Express troughs shall be protected against damage in areas of working cranes, backhoes, front-end loaders, or other equipment.

3.2 PLACING EXPRESS TROUGH SYSTEM

A. Set express trough units in place to the line and grade required using mechanized equipment and lifting equipment recommended by the manufacturer; shim and grout as needed.

B. Adjacent units are to be butt-jointed to each other with appropriate accessories and features to prevent vertical and horizontal separations.
EXPRESS TROUGH FOR AERIAL STRUCTURES

C. Polyurethane based, one part elastomeric sealant meeting the requirements of Specification Section 07900, “Seals and Sealants” shall be applied to trough connections at each bridge expansion joint.

D. Express cable troughs shall be inspected by the Contractor for any burrs or rough places that could damage cable insulation. Burrs or rough places shall be removed or repaired before payment is made. The cable troughs shall be thoroughly cleaned of any debris, rocks, or other material to the satisfaction of the COR. The permanent covers shall be placed on the troughs with the security bolts installed.

E. Any exposed metal used with the exception of the security bolts shall be grounded per Section 16450, “Grounding and Bonding”.

3.3 LENGTH ADJUSTMENTS

A. Polymer concrete express trough units and covers shall be cut with equipment recommended by the manufacturer to adjust for lengths and angles. The cut ends shall be joined by a method recommended by the manufacturer to prevent vertical and lateral displacements and maintain the design loading.

3.4 CONSTRUCTION TOLERANCES

A. Construct Express Trough to the following tolerances:

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Elevation</th>
<th>Station</th>
<th>Offset</th>
<th>Slope</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Express Trough</td>
<td>+/- 1/2”</td>
<td>N/A</td>
<td>+/- 1/8”</td>
<td>N/A</td>
<td>3/8”</td>
</tr>
</tbody>
</table>

B. The Contractor is responsible for making repairs per manufacturer’s prescribed repair procedures to cracks that are less than 1/16 inch wide, chips that are less than 1/4 inch deep and less than 12 square inches, and uneven saw cut edges. The COR may reject any units that are outside of these tolerances.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Precast express trough systems will be measured by the linear foot, complete-in-place, of each type specified. Measurement will be along the centerlines of the express trough system including troughs, covers, plinths, security bolts and all appurtenances, across aerial structures from front face of back wall of each abutment.

END OF SECTION 02782
SECTION 02830
CHAIN LINK FENCING

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing chain link fencing and gates.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A121 - Standard Specification for Zinc-Coated (Galvanized) Steel Barbed Wire
   2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   3. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
   4. ASTM A413/A413M - Standard Specification for Carbon Steel Chain
   5. ASTM A491 - Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
   7. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
   8. ASTM F567 - Standard Practice for Installation of Chain-Link Fence
   9. ASTM F626 - Standard Specification for Fence Fittings
   10. ASTM F668 - Standard Specification for Poly(Vinyl Chloride) (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric
   13. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code Steel

C. Military Specification (MIL):
   1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric)
   2. MIL-PRF-26915 - Primer Coating, for Steel Surfaces.

D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic").

1.3 SUBMITTALS
A. Shop Drawings:
   1. Site plan with fence showing physical breaks at intervals as directed, and locations of bracing, gates, ground rods, depression closures, and other special fence construction.
   2. Details of gates, gate post foundations, depression closures, and other special construction showing fabrication and installation.
   3. Details for installation of accessories.

B. Certification: Submit certification of all materials to be used.

1.4 JOB CONDITIONS
A. Right of Access to Adjacent Private Property: As indicated in the Contract Documents.
1.5 EXTRA MATERIALS

A. Deliver to Contracting Officer, extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. ABLOY locks and Knox padlocks: 10.0 percent of amount installed of each.

PART 2 - PRODUCTS

2.1 FENCE FABRIC

A. Steel: Hot-dip galvanized after weaving, ASTM A392; Class 2 coating, 2 inch mesh, No. 9 gauge wire, height shown, selvage twisted and barbed at top and bottom.

B. Aluminum: Aluminum alloy fabric woven from 9 gauge wire, conforming to ASTM A491. Minimum tensile strength after weaving 1560 pounds with 2 inch mesh, selvage twisted and barbed at top and bottom.

C. Poly (vinyl chloride) (PVC) coated steel fabric, ASTM F668, Class 2b, with 9 gauge wire, 2 inch mesh, selvage twisted and barbed at top and bottom. Color to be black.

2.2 POSTS, GATES, TOP RAIL, AND BRACES

A. Posts: Pipe used for posts shall conform to ASTM A123 or F1083. Line posts shall be fitted with watertight malleable iron caps. Provide standard weight 1-1/2 inch nominal diameter galvanized steel pipe weighing 2.72 pounds per foot. Provide 11 gauge minimum fabric tie wire spaced at 14 inch centers.

B. End, Comer, and Pull Posts: Provide 2-1/2 inch nominal diameter standard weight galvanized steel pipe weighing 5.80 pounds per foot.

C. Top Rail: Where shown, provide 1-1/4 inch nominal diameter galvanized steel pipe weighing 2.27 pounds per foot.

D. Provide standard weight ASTM A123 or F1083 galvanized steel pipe of the following size at each side of gate opening:

<table>
<thead>
<tr>
<th>Leaf Width, in Feet</th>
<th>Gate Post, in Inches</th>
<th>Weight per Linear Foot, in Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 6</td>
<td>2-1/2 NPS</td>
<td>5.80</td>
</tr>
<tr>
<td>Over 6 to 13</td>
<td>3-1/2 NPS</td>
<td>9.12</td>
</tr>
<tr>
<td>Over 13 to 18'</td>
<td>6 NPS</td>
<td>18.99</td>
</tr>
<tr>
<td>Over 18</td>
<td>8 NPS</td>
<td>28.58</td>
</tr>
</tbody>
</table>

E. Gates shall comply with ASTM F900 and ASTM F1184. Gate frame including top rail, bottom rail, braces, supports, and similar members shall be made of aluminum alloy 6063-T6 (in accordance with ASTM B221) or galvanized steel pipe, unless shown otherwise. Gate material to match fence in which installed.

1. Gate Hardware: Furnish a malleable iron ball and socket bottom hinge and a 180-degree wraparound-type top hinge to allow gate to swing 90 degrees or 180 degrees. Provide a padlocking device, center rests and semi-automatic catch to secure driveway gates in open position.

F. Galvanized Steel Gates:

1. Frames: Furnish 2 inch outside diameter galvanized pipe with pressed steel on malleable iron corner ells, securely riveted with four rivets per corner, or welded corners hot-dipped after fabrication.

2. Internal Bracing: Provide 1-5/8 inch outside diameter pipe brace and 2-3/8 inch adjustable truss rods.

G. Where vinyl (PVC) coated posts, rails, braces and accessories shall be PVC coated galvanized products in accordance with ASTM F668, Type 2b and ASTM F1043. Color to be black.

2.3 ACCESSORIES

A. Hot-dip galvanized, in accordance with ASTM A123 and F626, Class 40.

B. Wire ties: Fabric: No. 9 gauge or double strands of No. 13 gauge steel.

C. Tension wire: No. 7 gauge steel.

D. Turnbuckle: ASTM F1145, Type 1, Form 1, Class 8, Size 3/8 by six, hexagonal head, UNC threads, hot-dip galvanized.

E. Pipe sleeves for fence on retaining walls: 4 inch diameter standard weight pipe sleeve, hot-dip galvanized, 1 foot long, and centered in wall.

F. Fence fittings in accordance with ASTM F626.

G. Where vinyl (PVC) coated chain link fence is shown on the Contract Drawings, accessories shall be PVC coated galvanized products in accordance with ASTM F668, Type 2b and ASTM F1043. Color to be black.
2.4  **BARBED WIRE**

A. In accordance with ASTM A121, 12-1/2 gauge steel wire with 14 gauge four-point round barbs, 5 inches on center.

2.5  **CONCRETE AND GROUT**

A. Concrete: Minimum compressive strength at 28 days of 3,000 psi, using 1 inch maximum size aggregate and five sacks of cement minimum per cubic yard, with a maximum slump of 4 inches. Concrete materials shall conform to the applicable requirements of Section 03305, “Portland Cement Concrete”.

B. Grout: Structural Non-Shrink as specified in Section 03305, “Portland Cement Concrete”.

2.6  **MISCELLANEOUS MATERIALS**

A. Galvanizing Repair Paint:
   1. For Concealed or Top Coated Surfaces:
      a. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
         1) ASTM A780.
         2) SSPC-Paint 20.
   2. For Surfaces to be Left Exposed:
      a. In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
         1) MIL-P-21035.
         2) MIL-PRF-26915.
      b. Basis-of-Design: Brite Products “Brite Zinc”.

2.7  **CHAIN**

A. In accordance with ASTM A413, Class Grade 43, case-hardened carbon-steel security chain, 3/8-inch diameter by 24 inches long for all gates.

2.8  **LOCKING SYSTEM**

A. Latch: Fabricate gates as required to receive latching device.
   1. Provide fork latch at single swing gates.
   2. Double swing gates latch: Plunger bar or rod full height of gate, to engage stop at double gates, hot dip galvanized.
   3. Latch shall be approved gate lock box, to accept padlocks specified.

B. Each gate shall have ABLOY lock (no substitution) and Knox Padlock (no substitution). Coordinate with Contracting Officer on keying of ABLOY locks and obtaining of Knox locks.

2.9  **GROUNDING SYSTEM**

A. In accordance with Section 16450, “Grounding and Bonding”.

2.10  **FABRICATION**

A. Perform welding in accordance with requirements of AWS D1.1/D1.1M.

B. Gates: Materials to match fence in which installed.

**PART 3 - EXECUTION**

3.1  **FENCE INSTALLATION**

A. Installation shall be in accordance with ASTM F567 and as indicated herein.

B. Perform necessary clearing, grubbing, excavation, and filling to provide clear line-of-fence runs. Do not begin fence installation until final grading along fence line is complete.

C. Set posts in concrete footings, sized as shown.

D. Handling and placing of concrete shall conform to the applicable requirements of Section 03300, “Cast-In-Place Concrete”.

E. Extend concrete to 2 inches above ground line at posts, and slope to drain away from posts.

F. Space posts at 10 feet maximum and 8 feet minimum on centers. Place additional posts at each abrupt change in grade, and at breakpoints.

G. Where rock is encountered, drill holes 2 inches deeper than depth shown and 2 inches greater than outside diameter of post. After post is placed as shown and specified, and supported, fill remaining void with one-to-three grout mixture of cement and sand.

H. Where fence is located on concrete structure, embed 12-inch length of closed-bottom steel pipe sleeve having inside diameter 2 inches greater than outside diameter of fence posts, spaced as
shown on approved shop drawings. Fill void around fence posts with non-shrink grout.

I. Space pull posts at approximately 500-foot intervals for straight runs and at each vertical angle point. Install corner posts at each horizontal angle point. Provide corner, end and pull posts with horizontal braces and tie rods on each side of posts extending to and connecting to adjacent line posts.

J. After posts are installed, install top rail or tension wire and securely anchor at ends and to line posts before hanging fabric.

K. Secure ends of fabric by tension bars threaded through loops in fabric and secured to posts by bands with bolts and nuts or other approved devices.

L. Attach fabric outside framing system, away from Authority property. Stretch fabric by securing one end and applying sufficient tension by mechanical fence stretchers. Fasten fabric to line posts, tension wire and top railing with tie wires at spacing shown.

M. Hold bottom of fabric as uniformly as possible to, but in no case to exceed, 2 inches above finished grade.

N. Provide barbed wire where shown. Install support arms at 45 degrees upward and outward from Authority property; extend corner, gate and end posts as shown. Stretch barbed wire to remove kinks and sags and secure to bracket arms, using tension bands for attachment to posts.

O. Install gates and gate stops as shown.

P. Set gate stops in concrete accurately so that plunger can be fully engaged.

Q. Furnish one chain with one Abloy lock and one Knox padlock for each gate. Tack weld chain to gate to prevent loss or theft.

R. Grounding: For fences located fifty feet or closer to the center of any light rail track or high-voltage power line crossing (overhead or underground), fence and any appurtenances (including gate swings) shall be grounded and bonded in accordance with Section 16450, "Grounding and Bonding". For other fence locations, no grounding or bonding is necessary.

S. Install pipe sleeve and bottom eye bolt as shown on the Standard Drawings and in accordance with this section.

### 3.2 ADJUSTING AND CLEANING

A. Remove and replace fencing which is improperly located and is not true to line and grade or is defective and posts which are not plumb.

B. Galvanized Surfaces:
   1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.
   2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

### PART 4 - MEASUREMENT AND PAYMENT

#### 4.1 GENERAL

A. Chain link fencing and gates specified in this section will not be measured, but will be paid for at the lump sum price for "Chain Link Fencing", including excavation; backfill, disposal of surplus materials; concrete and grout; and gates, hardware; and incidentals.

B. Grounding system will be measured and paid for under Division 16, "ELECTRICAL".

C. Removal and disposal of and removal and relocation of existing chain link fence and gates will not be measured and paid for under this section. Removal and disposal of fencing and gates shall be subsidiary to Section 02050, "Demolition". Removal and relocation of chain link fences and chain link gates shall be subsidiary to Section 02072, "Removal and Restoration of Miscellaneous Existing Facilities".

END OF SECTION 02830
SECTION 02831
WOODEN SCREENING FENCE

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing a wooden screening fence with galvanized steel post and accessories, and includes wooden gates as required.

1.2 REFERENCED STANDARDS
A. American Welding Society (AWS):
1. AWS D1.1/D1.1M - Structural Welding Code - Steel
B. Army Corps of Engineer (COE):
C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2. ASTM A413/A413M - Standard Specification for Carbon Steel Chain
3. ASTM B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
5. ASTM F1145 - Standard Specification for Turnbuckles, Swaged, Welded, Forged
6. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

1.3 SUBMITTALS
A. Shop Drawings:
1. Site plan with fence showing physical breaks in accordance with the Contract Documents, and locations of bracing, gates, ground rods and other special fence construction.

B. Samples:
1. Painted wooden piece to illustrate the solid color stain to be used: Two 24 inch wooden boards with the solid color stain applied to sides.

C. Certifications: Submit for the following material:
1. Cedar, certify grade of cedar to be provided.

D. Certifications and Manufacturer's Product Data: Submit for the following products:
1. Solid color stain.
2. Sealant.
3. Flat caps, latches, hinges, mounting brackets, bolts, screws, turnbuckles, and other accessories.

1.4 JOB CONDITIONS
A. Right of access to adjacent private property: As shown

PART 2 - PRODUCTS

2.1 WOODEN FENCING
A. Red Cedar No. 2 without any holes which includes all stringers, fascia, boards, and caps for the sizes shown.

B. In accordance with WWPA and WRCLA standards and as shown on the Standard Drawing, "SCREENING FENCE DETAILS".

C. Product Pattern: Rough Sawn for the full length.

2.2 POSTS
A. Pipe used for posts shall conform to ASTM A53 or F1083.

B. Line posts shall be 2 inch outside diameter Schedule 80 galvanized steel posts.
C. Line posts shall be fitted with a watertight malleable flat iron cap.

2.3 ACCESSORIES
A. Accessories shall be hot-dip galvanized, in accordance with ASTM B695, Class 40 and corrosive resistant.
B. Turnbuckle: ASTM F1145. Type 1, Form 1, Class 8, Size 3/8 inches by 6 inches, hexagonal heads, UNC threads, hot dip galvanized.
C. Latch: Plunger bar full height of the gate, to engage stop at double gates, hot-dip galvanized. Latch shall accept an approved gate lock box.
D. Pipe sleeves for fence on retaining walls: 4 inch diameter standard weight pipe sleeve, hot-dip galvanized, 1 foot long, closed bottom and centered in the wall.
E. Hinges: Hot-dip galvanized per the fence manufacturer's recommendations.
F. Cap: Watertight malleable flat iron cap, hot-dip galvanized.
G. Mounting Brackets: Hot-dip galvanized, secured to stringer with 1/4-inch by 1-1/2 inch lag screws.
H. Lag Screws: Hot-dip galvanized; size 1/4-inch by 1-1/2 inch.
I. Fence screws: Hot-dip galvanized, size shall be based on the fence manufacturer's recommendations and corrosive resistant. Nails shall not be used on cedar fencing.

2.4 CONCRETE AND GROUT
A. Concrete: Minimum compressive strength at 28 days of 3,000 psi, using 1 inch maximum size aggregate and five sacks of cement minimum per cubic yard, with a maximum slump of 4 inches. Concrete materials shall conform to the applicable requirements of Section 03305, "Portland Cement Concrete".
B. Grout: Non-shrink in accordance to COE CRD-C 621 and Section 03305, "Portland Cement Concrete".

2.5 COATING
A. Cold galvanizing compound: Z.R.C. cold galvanizing compound, or Galvanox®-Subox Co. or approved equal.

2.6 LOCKING SYSTEM
A. At gates provide a latch, which will accept a cylinder lock.
B. Cylinder lock shall be in accordance with Section 08710, "Door Hardware".

2.7 CHAIN
A. In accordance with ASTM A413, Class Grade 43, case hardened carbon steel security chain, 3/8 inch diameter.

2.8 GROUNDING SYSTEM
A. If grounding is required, it shall be in accordance with Section 16450, "Grounding and Bonding" and shown on the Contract Documents.

2.9 FABRICATION
A. Gates: Materials shall match the fence material in which it is installed and comply with all material specified herein.
B. Perform welding in accordance with requirements of AWS D1.1.

2.10 SOLID COLOR STAIN
A. Based on WRCLA a solid color stain shall be used to provide 4 to 6 years of durability.
B. Solid-Color Acrylic Stain: Factory-formulated acrylic-resin-based solid-color stain applied at spreading rate recommended by manufacturer.
   7. Or approved equal.
C. Primer: As recommended by manufacturer.
WOODEN SCREENING FENCE

2.11 CAULKING

A. Caulking shall be in accordance with the fence manufacturer's recommendations and Section 07900, "Seals and Sealants".

PART 3 - EXECUTION

3.1 FENCE INSTALLATION

A. Perform necessary clearing, grubbing, excavation, and filling to provide clear line-of-fence runs. Do not begin installation until final grading along the fence line is complete.

B. Set posts in concrete footings to line, grade and plumb as shown on the Contract Documents. Temporary supports of posts may be required to maintain plumbness and line, which is the responsibility of the Contractor. Any post to be determined by the Contracting Officer not to be plumb will be replaced at no additional cost to the Authority.

C. Extend concrete to 2 inches above the finish ground line at posts, and slope to drain away from the post.

D. Space posts at 8 feet (maximum) intervals on center. Place additional posts at each abrupt change in grade and at breakpoints.

E. Where rock is encountered, drill holes 2 inches deeper than depth shown and 2 inches greater than outside diameter of the post. After post is placed as shown and specified, and supported, fill remaining void with one-to-three grout mixture of cement and sand.

F. Where fence is located on concrete structure, embed 12 inch long steel galvanized pipe sleeve with a closed bottom into the concrete structure at the spacing and location as shown on the approved shop drawings. The pipe sleeve shall be 2 inches greater in diameter than the outside diameter of the fence post. Fill voids around the fence post with non-shrink grout.

3.2 WOODEN CEDAR FENCE AND GATES

A. After posts are installed and concrete has reached 75 percent of its 28 day strength; install the stringers with mounting brackets as shown on the plans using 1/4 inch by 1-1/2 inch lag screws.

B. Attach cedar boards on the outside framing system, away from the Authority's property, using two screws at each stringer. The top of the screw head should be flush with the surface of the board.

C. Hold bottom of cedar boards as uniformly as possible to, but in no case to exceed, 2 inches above the finished grade.

D. Install cap and fascia as shown on the plans. Caulk all joints along the cap and fascia board with an approved sealant.

E. Install gates and gate stops as shown on the shop drawings.

F. Set gate stops in concrete accurately so that the plunger can be fully engaged.

G. Using a brush, apply a coat of primer and two coats of solid color stain to cedar. Once the primer has completely dried, notify and obtain the Contracting Officer inspection of the paint coverage. Any areas that appear to be covered inadequately shall be retouched to the satisfaction of the Contracting Officer. After completing the primer application, apply two coats of solid color stain. Allow first coat to dry thoroughly before applying second coat. The application of the primer and stain shall be in accordance to the stain manufacturer's recommendations.

H. Grounding of posts and gates shall be in accordance to Section 16450, "Grounding and Bonding", and as directed by the Contracting Officer.

3.3 DEFECTIVE WORK

A. Remove and replace fencing, which is improperly located and is not true to line and grade, and posts, which are not plumb.

B. Repair damaged galvanizing by thoroughly wire brushing damaged area to remove loose and cracked zinc coating and painting with two coats of cold galvanized compound. Allow first coat to dry thoroughly before applying second coat.

C. Repair damaged cedar boards by replacing them. Once they have been replaced to the Contracting Officer's satisfaction the primer and two coats of solid color stain shall be applied.

3.4 CLEANUP

A. The Contractor shall remove all debris, pieces of concrete, surplus lumber, hardware, accessories, etc. from the work site as directed by the Contracting Officer.

B. The ground surface along each side of the fence shall be regraded, as necessary, to conform to the finish grade as shown on the Contract Drawings.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Wooden cedar fencing and gates specified in this section will not be measured, but will be paid for at the lump sum price for “Wooden Cedar Fencing”, including excavation; backfill, and disposal of surplus materials; concrete and grout; and gates, hardware, and incidentals.

B. Grounding systems will be measured and paid for under Section 16450, “Grounding and Bonding”.

C. Private fencing and gates to be relocated, which are in salvageable condition, as determined by the Contracting Officer, will not be measured or paid for directly, but shall be subsidiary to Section 02072, “Removal and Restoration of Miscellaneous Existing Structures”.

D. Removal and disposal of existing fences and gates will not be measured or paid for separately, but will be considered as subsidiary to the work specified in Section 02050, “Demolition”.

E. No measurement or payment will be made for existing fences or gates, which are removed and relocated to temporary location or temporary or permanent rights-of-way. Any fence and gates, including private wooden fences or gates, and chain link fences and gates to be removed and relocated, shall be subsidiary to Section 02072, “Removal and Restoration of Miscellaneous Existing Structures”.

END OF SECTION 02831
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies procuring and installing permanent traffic control signs, other than those placed within the DART Light Rail Transit Station areas. Refer to Section 10441, “Specialty Post And Pole Mounted Signs”, for requirements for signs to be placed within LRT Station areas, and other parking areas being improved by DART.

B. Contractor shall furnish and install signs, sign posts, foundations, and hardware. Pathfinder sign panels shall be omitted as further described in Section 10441, “Specialty Post and Pole Mounted Signs”.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

B. Texas Department of Transportation (TxDOT)


1.3 SUBMITTALS

A. Samples: Submit shop drawings of signs, sign components, fittings, parts, and installation procedures showing layout, jointing, and complete anchoring and supporting systems for the various applications and mounting details for signs that are not standard TMUTCD regulatory warning, or temporary construction signs.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Signs shall be stored at the approved Contractor's staging area or at locations approved by the Contracting Officer.

1.5 JOB CONDITIONS

A. Location of Underground Facilities and Structures:

1. Prior to excavating for sign post foundations, Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.

2. Verify locations of existing utilities in accordance with Section 02760, “Maintenance, Support and Restoration of Existing Utility Facilities”.

PART 2 - PRODUCTS

2.1 PERMANENT TRAFFIC CONTROL SIGN PANELS AND DEVICES

A. Sign panels will be fabricated from 0.125 inch thick aluminum.

2.2 SUPPORT POSTS

A. Support posts for permanent signs located on City streets shall be 2 inch galvanized steel, Unistrut, ASTM A653/A653M, Grade A or Contracting Officer approved equivalent. Sign post shall be installed with Telespar breakaway anchor system or Contracting Officer approved equivalent.

B. Support posts for permanent signs located on streets under the jurisdiction of TxDOT shall be 3 inch round posts and shall be mounted on TxDOT approved triangular slip base systems as shown in the plans.

2.3 FASTENINGS

A. Steel hex-lag bolts, corner bolts, washers, and nuts as per post manufacturer specifications. Paint exposed fastenings to match adjacent areas.

2.4 CONCRETE

A. In accordance with Section 03305, “Portland Cement Concrete”, Mix S-7.

2.5 PATHFINDER SIGNS

A. Pathfinder sign panels are specified in Section 10441, “Specialty Post and Pole Mounted Signs”.

PART 3 - EXECUTION

3.1 ERECTION OF SIGNS

A. Excavate for concrete foundations in accordance with Section 02220, “Grading, Excavating, and Backfilling.” Install concrete foundations in accordance with Section 03300, “Cast-in-Place Concrete”.

B. Set posts at locations as specified on the Contract Drawings and such that vertical and lateral clearances of sign panel with respect to ground surface and curb face meet TMUTCD requirements.
C. Sign posts for permanent traffic control signs shall be set with breakaway anchors in accordance with the manufacturers installation instructions.

D. Sign posts shall be set plumb and centered in concrete footing of no less than 2 foot depth.

E. Dispose of surplus excavated material.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Permanent traffic control signs described in this section will be measured by and paid for at the unit price for “Traffic Control Signs” per each sign for each type and size. Inclusive of sign panels, sign posts, hardware, excavation, and foundations.

B. Pathfinder signs will be measured by and paid for under Section 10441, “Specialty Post and Pole Mounted Signs”. Inclusive of sign posts, hardware, excavation, and foundations. Sign panels are not included.

C. Temporary traffic control signs will not be measured for payment, but shall be considered subsidiary to the pay item in Section 01570, “Maintenance And Control of Traffic”.

END OF SECTION 02845
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing metal beam guard rail, supported on timber, steel, or concrete posts.

1.2 REFERENCED STANDARDS

A. American Association State Highway and Transportation Officials (AASHTO):
   1. AASHTO T68 - Standard Method of Test for Tension Testing of Metallic Materials

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   5. A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

C. American Wood-Preserver’s Association (AWPA):
   1. Unless otherwise indicated or specified, pressure treated in accordance with AWPA U1 (Use Category UC4A).

D. Texas Department of Transportation (TxDOT),
   1. Statewide Standard Details Sheet
      a. MBGF-03 Metal Beam Guard Fence

1.3 SUBMITTALS

A. Shop Drawings: Site Plans showing metal beam guard rail, materials, details of post connections and foundations.

B. Certification: Submit certification of all materials to be used.

PART 2 - PRODUCTS

2.1 GUARD RAIL POSTS

A. Steel posts and brackets: Structural steel: ASTM A36.

B. Wood posts and bracket blocks:
   1. Number 1, Dense SR southern pine, minimum stress grade 1400f.
   2. Well seasoned, sound and free from splits, cracks, and other defects.
   3. Unless otherwise indicated or specified, pressure treated in accordance with AWPA U1 (Use Category UC4A).

C. Concrete posts:
   1. Concrete reinforcement: In accordance with Section 03200, “Concrete Reinforcement”.
   2. Concrete: In accordance with Section 03305, “Portland Cement Concrete”, and Section 03430, “Structural Precast Concrete”.

2.2 GUARD RAIL ELEMENTS

A. Metal beam guard rail shall conform to TxDOT Standard Design Detail MBGF-03.

B. Rail elements fabricated from open-hearth or electric-furnace steel of thickness shown. Sheet shaped into beam with longitudinal corrugations forming section 12 inches minimum width and three inches minimum depth.

C. Fabrication:
   1. Edges of rail element straight and smooth.
   2. Steel sheet subject to standard mill tolerances for gauge.

D. For steel beam type guard rail installed on curves having radius of more than 20 feet and less than 150 feet: Rail elements convex or concave as shown.

E. Elongation of two inch specimen of sheet steel used for rail elements: 12 percent minimum when tested in tension in accordance with AASHTO T68.

F. Comply with the following:
   1. Tensile strength of specimen of full size of rail element, including a splice at center of specimen: 70,000 psi minimum.
2. Post connections to withstand 5,000 pounds side pull in both directions.

3. Section of rail with traffic face up, freely supported at both ends of 12 foot span, to support concentrated load of 2,000 pounds at center of span with maximum deflection of two inches.

2.3 HARDWARE

A. Bolts and nuts: Steel, ASTM A307, Grade A.

B. Post and splice bolts machined, button head, shoulder bolts with roll threads, Class 2A fit before galvanizing. Shoulder or neck shall have an oval shape as shown. Hexagon nuts for rail connections to be machined American Standard heavy type with recess to accommodate shoulder on bolts.

C. Bolts and nuts for offset steel brackets: American Standard heavy type.

D. Plate washers fabricated from steel conforming to requirements specified for rail elements and terminal connections.

2.4 GALVANIZING

A. Rail elements shall be galvanized in accordance with ASTM A653, Designation G210.

B. Steel posts, post anchors, brackets, and terminal sections hot-dip galvanized after fabrication in accordance with ASTM A123.

C. Hardware hot-dip galvanized after fabrication in accordance with ASTM A153. Zinc coating: Two ounces per square foot minimum.

D. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.

2.5 END SHOES

A. End shoes, where required, shall conform to the details shown in the plans and to the materials and galvanizing requirements for rail elements.

2.6 GROUNDING

A. In accordance with Section 16450, "Grounding and Bonding".

2.7 FABRICATION AND MANUFACTURE

A. Steel Posts, Brackets, and Post Anchors:

1. Cut ends square. Punch or drill posts and brackets as shown.

2. After being cut to length and punched or drilled, hot-dip galvanize posts and brackets separately before bolting.

3. On end steel posts and adjacent posts weld steel channel anchor, 15.3 pounds per linear foot and 1 foot 3 inches long, minimum.

   a. Weld anchors to posts and hot-dip galvanize.

   b. Welding: Section 05120, "Structural Steel - Bridges".

4. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.

B. Wood Posts and Bracket Blocks:

1. Cut ends square. Drill posts and bracket blocks as shown.

2. After cutting to length and drilling, saturate cut ends and holes with same preservative as that used for pressure treatment.

C. Concrete Posts:

1. Precast concrete, Mix S-3, in accordance with Section 03305, "Portland Cement Concrete", 8 inches square by 5 feet 9 inches long.

2. Reinforcement as shown and in accordance with Section 03200, "Concrete Reinforcement".

3. Cure in accordance with Sections 03300, "Cast-In-Place Concrete", and Section 03430, "Structural Precast Concrete".

4. Formwork shall be in accordance with Section 03100, "Concrete Formwork".

2.8 CONCRETE

A. Concrete for encasement of base: Section 03305, "Portland Cement Concrete", Mix S-7.

PART 3 - EXECUTION

3.1 POSTS IN DRILLED HOLES

A. Drill holes plumb, accurately positioned and of diameter and depth shown.

B. Position posts in hole to alignment shown; brace in position until remainder of hole has been backfilled with excavated material or concrete as shown.

C. Place backfill in layers 6 inches maximum and compact in accordance with Section 02220, "Grading, Excavating, and Backfilling".
D. Dispose of surplus excavated material in accordance with Section 02220, "Grading, Excavating, and Backfilling".

E. In unpaved areas, carry backfill to height of 2 inches above surface of ground and slope to drain away from post.

F. When holes in paved areas are shown to be backfilled with excavated material, place, and compact backfill to bottom of pavement. Where pavement is Portland cement concrete pavement, fill remainder of hole with concrete to surface of pavement. Where pavement surface is asphaltic concrete, stop fill 2 inches below final grade and fill remainder of hole with asphaltic concrete of same type as existing surface. Compact asphaltic concrete well by tamping and slope to drain away from post.

G. Where shown to be encased in concrete, place concrete to a height of 2 inches above natural ground and slope to drain. Trowel finish surface.

3.2 POST DRIVEN IN PLACE

A. Ensure that posts are plumb and located as shown. Remove and re-drive posts which are not in compliance.

B. Drive steel posts before offset bracket is attached.

C. After driving, top of posts to have substantially same cross-sectional dimensions as body of posts and be free of bends and damage to galvanizing coat. Remove posts not in compliance and drive new replacement post.

D. Drive posts carefully to prevent damage to utility facilities; if such facilities are encountered, relocate posts. Repair facilities damaged by construction operations.

3.3 POST SET ON CONCRETE PAVEMENTS AND DECK SLABS

A. Where steel beam guard rail is installed on existing Portland cement concrete pavement or deck slabs, fabricate steel post assembly as shown. Anchor assembly to pavement or deck slab with through-bolts or four unit expansion anchors as shown.

B. Clean pavement or deck surface area where base plate is to be installed. Set post with base plate over bolts; plumb and shim posts to proper grade and alignment with metal shims.

C. Work nonshrink grout under plate to ensure full contact of bearing area. Finish edges true and smooth.

3.4 INSTALLATION

A. Install brackets and blocks on roadway side of posts. Tighten bolts after rail elements have been attached and entire assembly adjusted to line and grade.

B. Erection of Rail Elements:

1. Erect rail elements and terminal sections on posts and post brackets previously set to produce smooth continuous rail to line and grade shown. Install rail with double-corrugation face toward traffic.

2. Bolt edges and center corrugation fully.

3. Make vertical adjustment at posts by use of oversize bolt holes in posts and brackets as shown. If oversize holes do not permit sufficient adjustment, reset post until guard rail is properly aligned.

4. After rail has been correctly aligned, tighten bolts. Check or burr threads projecting beyond nut to prevent removal.

5. Where steel beam type guard rail is shown anchored to bridge piers or terminating at concrete parapet walls, provide metal beam end shoes and make connections as shown.

6. Install grounding, if required, in accordance with Section 16450, "Grounding and Bonding".

C. Where approved, repair damaged zinc coating by wire brushing damaged area to remove loose or cracked zinc coating and applying two coats of primer.

D. Punching, drilling, reaming, cutting, or welding rail elements or terminal pieces in the field is prohibited except as approved.

E. Grounding: For steel beam guard rail located fifty feet or closer to the center of any light rail track or high-voltage power line crossing (overhead or underground), steel beam guard rail and any appurtenances shall be grounded and bonded in accordance with Section 16450, "Grounding and Bonding". For other steel beam guard rail locations, no grounding or bonding is necessary.

3.5 FIELD QUALITY CONTROL

A. Allowable Dimensional Tolerances:

1. Steel guard rail elements fabricated to width and depth tolerance of minus 1/8 inch.

2. Dimensions of concrete posts: plus or minus 1/8 inch of dimensions shown.
3. Dimensions of timber posts and bracket blocks: plus or minus 1/2 inch of dimensions shown.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work of this section will not be measured, but will be paid for at the lump sum price for "Metal Beam Guard Rail", including excavation, backfill, disposal of surplus materials, concrete, grout, hardware, and incidentals.

B. Grounding system will be measured and paid for under Division 16, "ELECTRICAL".

END OF SECTION 02846
SECTION 02847
RIGHT-OF-WAY SAFETY SIGNS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installation of Right-of-Way Safety Signs for the DART LRT system.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

B. DART Sign Standards Manual.

C. Federal Highway Administration (FHWA):
   1. FHWA - "Standard Highway Signs"
   2. FHWA - "Standard Alphabets for Highway Signs and Pavement Markings"

D. Texas Department of Transportation (TxDOT):
   1. TxDOT - "Standard Highway Sign Designs for Texas" manual

E. Texas Manual on Uniform Traffic Control Devices (TMUTCD).

1.3 SUBMITTALS

A. Manufacturer's Data: Submit the manufacturer's technical data for sign materials and signs. Include installation details and instructions for each type of sign and mounting required.

B. Samples: Submit full-size sample of complete sign panel and installation accessories for approval. The Contracting Officer's review of samples will be for color, texture, materials, and compliance with these specifications and noted standards only. Compliance with all other requirements is the exclusive responsibility of the Contractor.

C. Shop Drawings: Submit to the Contracting Officer, shop drawings and/or product data sheets of all sign panels, components, parts, fittings, and installation procedures showing layout, jointing, complete anchoring and support systems for the various applications and mounting details for the signs. Drawings shall clearly show provisions for all performance functions described herein. Submit shop drawings for approval of details, sections, sign panels and signs at full size scale.

1.4 QUALIFICATIONS

A. The sign manufacturer shall be an established firm which is regularly engaged in the fabrication of signs.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. A form of protective covering shall be placed on the signs and between the signs to prevent damage during shipment.

1.6 JOB CONDITIONS

A. Location of Underground Facilities and Structures:
   1. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.
   2. Verify locations of existing utilities in accordance with Section 02760, "Maintenance, Support and Restoration of Existing Utility Facilities".

1.7 WARRANTY

A. In addition to the General Provisions, Warranty of Construction, provide a 10 year warranty for the sign substrate against chipping, delaminating, and fading, and a 7 year warranty against retroreflectivity loss of not more than 50 percent for the reflective film. Both warranties shall start from the date when the Warranty of Construction commences.

1.8 SPARE SIGNS

A. Deliver spare signs to the location indicated by the Contracting Officer. Obtain receipt for delivered items.

B. Spares shall include sign panels complete with legends and symbols.

C. Package spare sign panels in a manner suitable for storage. Refer to Section 01600, "Product Requirements", for additional requirements.

PART 2 - PRODUCTS

2.1 POSTS AND FASTENERS

A. Sign Posts: Sign posts and anchors shall be square, 12 gauge galvanized steel Unistrut, or as approved by the Contracting Officer with 1/2 inch...
RIGHT-OF-WAY SAFETY SIGNS

perforation on 1 inch centers. Sign posts shall be 2 inch square.

B. Anchors: Two piece breakaway anchor consisting of a 2-1/4 inch square, 3 feet long base, and 2-1/2 inch square 1-1/2 feet long sleeve. Provide connecting bolts, fittings and hardware as shown on the Contract Drawings.

C. Concrete Grout: Fast setting, rapid strength gain 1000 plus psi in 8 hours, and 5000 plus psi in 24 hours. Grout shall be shrinkage compensating, contain no chloride, and comply with ASTM C 1107 Types B and C. Use TXI Zip Crete as provided by Texas Industries (TXI) or approved equal.

D. Framing and Bracing: Provide connecting bolts, fittings and hardware as shown on the Contract Drawings.

E. Sign Fastening: Provide pop-rivets to attach signs to Unistrut poles and tamper proof fasteners and other accessories as needed at other locations based on the Contract Drawings.

2.2 SIGN PANELS

A. Sign panels shall be fabricated from 0.125 inch thick aluminum and shall have retroreflective sheeting on the face side. Pieces shall be true, square, and free from warping, bending, blemishes and scratches. Exposed edges shall be true and smooth. All panel fabrication, including cutting, punching, and drilling of holes shall be completed prior to final surface preparation and application of retroreflective sheeting.

B. Sign panels shall be manufactured by a sole source.

C. Retroreflective Sign Sheeting: Copy and graphics shall be screen painted over 3M™ Scotchlite™ Reflective Sheeting Diamond Grade VIP (Visual Impact Performance) or equal.

D. Sign faces shall be capable of withstanding the following tests:

1. Sign face shall not be permanently defaced by steam, acids, aromatics, scratching, inks, or paints.

2. Sign face shall be readily wiped clean with paint remover or solvents without affecting the appearance or legibility of the sign finish or graphics.

3. Sign face shall retain legibility and finished appearance when sprayed with a 10 percent solution of hydrochloric, nitric, or sulfuric acid for one-half hour.

4. Sign face shall retain legibility and finished appearance when scrubbed by a brush of medium hardness using common commercial cleaning compounds such as ammonia, laundry soaps, detergents, or petroleum base solvents.

E. Fabrication: Fabricate all components in a uniform manner in compliance with the following requirements:

1. Joints and seams are not acceptable. Pieces shall be true, square, and free from warping, bending, blemishes, and scratches. Edges shall not be crazed or cracked, and the edge finish shall be smooth, clean, and neat.

2. The finished sign shall be absolutely flat.

3. Signs shall have the holes drilled and sealed per type of installation as noted in the Contract Drawings.

4. Signs shall have rounded corners with a 1-1/4 inch radius.

2.3 SIGN LEGENDS

A. Provide final camera-ready artwork.

B. Sign Legends: Sign legends shall be computer generated and machine cut. Neither hand-rendered nor hand-cut legends shall be acceptable.

C. Sign colors, lettering, symbols, and borders shall conform to the details shown in the Contract Drawings and as specified herein, and shall conform to MUTCD, DART Sign Standard Manual, Standard Highway Sign Design for Texas, and Standard Alphabets for Highway Signs and Pavement Markings.
2.4 **SIGN DESCRIPTION**

A. The Right-of-Way Safety Sign (Danger High Voltage No Trespassing) shall be fabricated with the graphics shown in the Contract Drawings.

1. Each sign comply with the following additional requirements:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphanumerics Colors:</td>
<td>Black</td>
</tr>
<tr>
<td>Icon Colors:</td>
<td>Black, Reflective Red</td>
</tr>
<tr>
<td>Icon Size:</td>
<td>4-1/2 inches (includes box surround)</td>
</tr>
<tr>
<td>Border Color:</td>
<td>Black</td>
</tr>
<tr>
<td>Background Color:</td>
<td>Reflective White, Reflective Red, Black</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>Rectangle</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>20 inches X 15 inches</td>
</tr>
<tr>
<td>Alphanumerics Type:</td>
<td>Series D, B, B, B</td>
</tr>
<tr>
<td>Alphanumerics Size:</td>
<td>2-1/2, 1-1/4, 1-1/4, 5/12 inches</td>
</tr>
<tr>
<td>Message Position</td>
<td>Centered top-to-bottom and left-to-right</td>
</tr>
<tr>
<td>Border Width:</td>
<td>1/2 inch or equal, but not to exceed stroke width of alphanumerics</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set 1/2 inch in from sign edge</td>
</tr>
</tbody>
</table>

2. The “ELECTRICAL HAZARD” Icon shall have a red lightening bolt with a black circle surrounding it. The “NO TRESPASSING” Icon shall have a black walking figure and a red circle with slash. Overall sign background shall be white. “DANGER” message shall be surrounded by a red oval with a white border and then surrounded by a black rectangle with rounded edges. The alphanumeric series specified herein shall be used as a proportional guideline. Compression may be utilized for lettering.

B. Prior to signage installation, mark each sign location with a flag, paint mark, tape, or survey stick. Obtain Contracting Officer’s approval for each sign location prior to installation of each sign.

C. Verify location of underground utilities prior to installing posts.

3.2 **INSTALLATION - GENERAL**

A. Mount signs along right-of-way at locations and by methods as shown in the Contract Documents. Vertical placement shall be within pedestrian normal field of view (approximately 4 to 6 feet above top of rail or ground elevation). Horizontal placement shall be at the edge of right-of-way on the fence or a pole, at grade crossings, wall mount adjacent to track, or in other areas as shown in the schedule in the Contract Documents.

B. Install signs as shown in the approved installation detail drawings, and according to the schedule in the Contract Documents. Installation types and methods include the following:

1. Post mount: Post installation shall be in ballast, concrete, asphalt, pavers, or soil.
2. Wall Mount: Where designated, attach signs on sound walls or retaining walls with appropriate fasteners and hardware as shown on Contract Drawings.
3. Fence Mount: Where designated, attach signs to fence with hardware as shown in the Contract Drawings.

3.3 **ERECTION OF POSTS**

A. Install sign posts plumb.

B. Set posts at locations and to elevations shown.

C. Anchor the posts into the ground using two piece breakaway anchor. For each post, first drive an anchor, and then a sleeve into the ground with a pneumatic post driver. Install anchor and sleeve plumb. Drive directly into ballast rock, gravel, asphalt, dirt, and similar substrates. On concrete paving and other concrete, core drill a 4 inch diameter hole through the concrete, drive in anchor and sleeve. Then grout in between anchor sleeve and concrete, making grout flush with existing concrete. All anchors and sleeves shall be exposed from one to two inches above grade (for bolt connections). Post shall extend into anchor between 6 and 8 inches. Secure post with 90 degree bend stainless steel anchor bolt.

D. Dispose of surplus excavated material.

**PART 3 - EXECUTION**

3.1 **INSPECTION**

A. Prior to submittal of procurement and shop drawings, examine the site locations and conditions under which the signs are to be installed.
3.4  INSTALLATION OF SIGN PANELS

A.  Install sign units and components at the locations shown, securely mounted, in accordance with the requirements specified herein.

B.  Install signs level, plumb and at the proper height. Coordinate, through the Contracting Officer, with other contractors for installation of sign units to finished surface. Repair or replace damaged units as directed by the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1  GENERAL

A.  Right-of-way safety signs shall be measured by and paid for as “Right-of-Way Safety Signs” per each sign installed, inclusive of hardware, posts, and anchors.

B.  Spare right-of-way safety sign panels shall be measured by and paid for as “Spare Right-of-Way Safety Sign Panels” per each sign delivered.

END OF SECTION 02847
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for furnishing and installing precast concrete parking bumpers (wheel stops) for vehicular parking stalls in parking structures and parking lots as indicated.

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1. ACI 503.2 - 503.4 - Three Epoxy Standards
   a. ACI 503.2 – Standard Specification for Bonding Plastic Concrete to Hardened Concrete with Multi-Component Epoxy Adhesive
   b. ACI 503.3 – Specification for Producing Skid-Resistant Surface on Concrete by the Use of Epoxy and Aggregate
   c. ACI 503.4 - Standard Specification for Repairing Concrete with Epoxy Mortar

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

1.3 QUALITY ASSURANCE

A. Precast parking bumpers shall be manufactured for the intended purpose by a company or firm specializing in the manufacture of precast concrete parking appurtenances.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Parking Bumpers:

1. Provide precast concrete parking bumpers of half octagonal configuration and dimensions indicated. Unless indicated otherwise, provide bumpers of 72 inch length.

2. Bumpers shall be manufactured of Mix S-3 or Authority approved equal reinforced concrete, as specified in Section 03305, “Portland Cement Concrete”, to withstand constant use and rough service. Each bumper shall be reinforced with two No. 4 deformed steel reinforcing bars, minimum.

3. Each bumper to be installed on at-grade asphalt pavement shall be manufactured with two holes to accommodate the installation rebar. Holes shall be positioned 6 inches in from each end.

4. Bumpers to be installed on concrete slabs of parking structures shall be manufactured without holes.

B. Adhesive: Adhesive for anchoring bumpers or wheel stops to pavement shall be an epoxy adhesive meeting ASTM C881, Type I, Grade 3.

C. Steel Bars for Installation: Epoxy-coated rebar, No. 5 size, conforming with applicable requirements of Section 03200, “Concrete Reinforcement”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Precast concrete bumpers shall be anchored and secured in position on at-grade asphalt pavements, as indicated, with two No. 5 epoxy-coated rebar.

B. Precast concrete bumpers shall be secured in position on at-grade concrete pavements, as indicated, with an appropriate epoxy adhesive as per ACI 503.2, ACI 503.2 and ACI 503.4.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Precast concrete parking bumpers will be measured for payment as an aggregate lump-sum unit, acceptably installed and completed.

END OF SECTION 02848
SECTION 02870
MODULAR RETAINING WALL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing modular block retaining wall units for landscape retaining walls. This system is not to be used to retain fills subject to automobile or rail traffic surcharge loading.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM C90 - Standard Specification for Loadbearing Concrete Masonry Units
   3. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

1.3 DEFINITIONS

A. Unit fill: Free draining granular material, used within the concrete units. See Paragraph 2.2C in this section.

1.4 SUBMITTALS

A. Shop Drawings: Submit shop drawings including details of curved walls, if applicable.

B. Product Data: Submit modular retaining wall unit product data including manufacturer’s installation instructions.

C. Samples: Submit manufacturer’s standard concrete color samples. Submit sample of each modular unit proposed for use.

D. Manufacturer’s Certificate of Conformance: Submit for modular retaining wall units and connecting pins.

E. Project Record Documents: Document on Project Record Drawings, submitted under Section 01785, “Project Record Documents”, location and top elevation of each wall at 25 foot intervals, and at break points along the top of wall.

F. Test data for backfill materials.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Contractor shall prevent mud, wet cement, epoxy, and like materials, which may affix themselves, from coming in contact with the materials.

PART 2 - PRODUCTS

2.1 CONCRETE UNITS

A. Modular retaining wall units shapes and sizes shall be as indicated in Contract Documents.

B. Modular retaining wall units shall be concrete with a minimum 28 day compressive strength of 3000 psi in accordance with ASTM C90. The concrete shall meet the following freeze/thaw criteria with a maximum moisture absorption rate of 7 percent.

1. Specific Freeze-Thaw Criteria: Demonstrate either by documented field performance or, if required by the Contracting Officer, by laboratory tests that the units have adequate resistance to freezing and thawing, suitable for the geographic region of Dallas, Texas. If a laboratory test is used, when tested in accordance with ASTM C67, specimens shall have no breakage and not greater than 3 percent loss in dry weight of any individual unit when subjected to 50 cycles of freezing and thawing. This test shall have been conducted not more than 24 months prior to delivery of units.

C. Retaining wall unit shall provide a minimum of 100 pounds of lateral resistance per square foot of wall face area. Any fill, which is contained within the dimensions of the units, may be considered as 80 percent effective weight.

D. Units shall have flat or angled sides and be capable of attaining concave and convex alignment curves with a minimum radius of 10 feet.

E. Units shall be interlocked as to provide a minimum of 1/4 inch of setback per each course of wall height. Units shall be formed to accommodate connecting pins.

F. Units shall have a facial color of gray, tan, or brown. Final color selection will be made by the Contracting Officer.

G. Overall dimension of units (width, height, or length) shall vary no more than 1/8 inch (3.2 mm) from the specified dimensions.

H. Units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction. Minor cracks incidental to the usual method of manufacture, or minor chipping resulting from customary methods of handling in shipment and delivery, are not grounds for rejection.

I. The face or faces of units that are to be exposed shall be free of chips, cracks, or other imperfections when viewed from a distance of 30 feet.
J. The units shall have a demonstrated mechanism to resist shear and/or sliding forces up to height of 3 foot without soil reinforcement. The units shall have geogrid reinforcement where noted on Contract Drawings as specified in Section 02275, "Geogrid Wall Reinforcement".

K. Finished retaining wall shall have an appearance similar to that of the Keystone or Versa-Lok, or approved equal retaining wall units with a rough rock surface finish. The Contracting Officer reserves the right to reject any systems, which in his judgment do not meet appearance criteria.

2.2 OTHER MATERIALS

A. Connecting Pins: Pins shall have a minimum shear strength of 13,000 psi and shall consist of a non-corrosive material.

B. Base Material: Material for footing shall consist of 6 inch thick crushed stone with a maximum nominal size of 1 inch or unreinforced concrete base footing in accordance with Mix S-7, as specified in Section 03305, “Portland Cement Concrete”, at the Contractor’s option unless otherwise indicated in the Contract Documents. Footing material for geogrid reinforced retaining walls shall be as specified under Section 02275, “Geogrid Wall Reinforcement”.

C. Unit Fill: Fill for units shall consist of free-draining, granular fill. Granular fill shall be graded within the following limits: 100 percent passing 3/8 inch sieve; 50 percent passing the No. 40 sieve, and 10 percent passing the No. 200 sieve.

D. Drainage Fill: Material for drainage fill layer behind unit shall be 3/4 inch minimum up to 2 inch maximum crushed stone.

E. Underdrain and Geotextile Filter Fabric: As specified in Section 02700, “Storm Sewer”, and indicated on the Contract Drawings. Type and size of underdrain pipe shall be indicated on the Contract Drawings.

PART 3 - EXECUTION

3.1 RETAINING WALL ERECTION

A. Place first course of concrete wall “units” on the footing. Check the units for level and alignment.

B. Ensure that the units are in full contact with base. Grout any units not in full contact.

C. Place units side by side for full length of wall alignment. Alignment may be done by means of a string line or laser offset from base line or straight wall construction. Layout units for curved walls in accordance with the approved shop drawings and manufacturer’s written instructions.

D. Install connecting pins in accordance with manufacturer’s written instructions.

E. Fill units with unit fill. Compact unit fill by running hand-operated compaction equipment just behind unit. Do not run mechanical vibrating plate compactors on top of units. See Section 02275, “Geogrid Wall Reinforcement”, compact to minimum 95 percent Standard Proctor density (ASTM D698).

F. Drainage Fill: Install a minimum of 12 inches of drainage fill extending behind the wall to within 6 inches of final grade.

1. Place drainage fill in lifts no greater than 8 inches thick.

2. Incorporate underdrain into drainage fill in accordance with the Contract Drawings and approved shop drawings.

3. Completely wrap drainage fill with filter fabric and over lapped at top of drainage fill, pinning the fabric together every 24 inches across top to ensure there is no sediment migration into the drainage fill, or, through the front of the units.

G. Fill behind drainage fill with reinforced fill material according to Section 02275, “Geogrid Wall Reinforcement”.

H. Sweep excess material from top of units and install next course. Ensure each course is completely filled prior to proceeding to next course.

I. Complete wall with cap units in accordance with manufacturer’s installations and approved shop drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Modular block retaining wall will be measured by and paid for at the unit price for “Modular Block Retaining Wall” per square foot of wall face projected on a straight plane surface for the full height above the foundation. No measurement will be made for surface irregularities of modular blocks. Payment will include unit fill, drainage fill, and the work specified under Section 02275, “Geogrid Wall Reinforcement”.

B. Excavation and earthwork, including backfill, soil reinforcing, and backfill material within the reinforced volume will not be measured separately for payment, but shall be considered subsidiary to the construction of the modular block retaining wall.

C. Subdrains or underdrains including filter fabric for the retaining wall will not be measured separately for payment, but shall be considered subsidiary to the construction of the modular retaining wall units.
PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies furnishing and installing prefabricated block retaining wall system for landscape retaining walls. This system is to be used to retain fills subject to automobile surcharge loading.

B. The system to be used to retain fills not subject to automobile surcharge loading is specified in Section 02870, “Modular Retaining Wall Units”.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C140 - Standard Test Methods of Sampling and Testing Concrete Masonry Units


3. ASTM C1262 - Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units

4. ASTM C1372 - Standard Specification for Segmental Retaining Wall Units

5. ASTM D448 - Standard Classification for Sizes of Aggregate for Road and Bridge Construction

6. ASTM D1556 - Standard Test Method for Density of Soil In Place by the Sand Cone Method


9. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)

1.3 DEFINITIONS

A. Geosynthetic reinforcement is a material specifically fabricated for use as a soil reinforcement.

B. Drainage aggregate is a material used around and directly behind the concrete wall units.

C. Backfill is the soil, which is used as fill behind the drainage aggregate and within the reinforced soil mass if applicable.

D. Foundation soil is the soil mass supporting the leveling pad and reinforced zone of the retaining wall system.

1.4 SUBMITTALS

A. Product Data: Manufacturer's literature, materials description.

B. Shop drawings: Retaining wall system design, including wall heights, geosynthetic reinforcement layout and drainage provisions. The shop drawings shall be signed by a registered professional engineer licensed in the State of Texas.

C. Samples:

1. Furnish one unit in the color and face pattern specified if requested by the Contracting Officer. If approved, unit may be used in the finished work.

2. 12 inches square or larger piece of the geosynthetic reinforcement specified.

D. Test reports from an independent laboratory stating moisture absorption and compressive strength properties of the concrete wall units meet the project specifications when tested in accordance with ASTM C140, Sections 6, 8 and 9.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. To prevent damage, store above ground on wood pallets or blocking. Remove damaged or otherwise unsuitable material, when so determined, from the site.

B. Faces of the concrete wall units shall be substantially free of chips, cracks and stains.

C. Prevent excessive mud, wet cement, epoxy, and like material, which may affix themselves, from coming in contact with the materials.
1. EXTRA MATERIALS
   A. Supply 3 replacement units identical to those installed on the Project.

PART 2 - PRODUCTS

2.1 MATERIALS
   A. Concrete Retaining Wall Unit: “Anchor Vertica Pro Retaining Wall Units” as manufactured under license from Anchor Retaining Wall Systems or approved equal.
      1. Concrete wall units shall meet requirements of ASTM C1372 except the maximum water absorption shall be limited to 7.0 percent and unit height dimensions shall not vary more than plus or minus 1/16 inch from that specified.
      2. Concrete wall units are required to have a minimum of 0.94 square foot face area.
      3. Color as selected by Contracting Officer from manufacturer's standard selections.
      4. Face pattern: Geometry: Beveled or Straight;
      5. Texture: Smooth or Split Rock Face.
      6. The concrete units shall include an integral concrete shear connection, flange/locator.
   B. Geosynthetic reinforcement: Polyester fiber geogrid, geotextile, or polypropylene woven geotextile for use as soil reinforcement.
   C. Base: Material shall consist of drainage aggregate, sand and gravel and/or concrete as shown on the construction drawings. A minimum of 6 inches of compacted base is required.
   D. Drainage aggregate: Fill between units shall consist of free-draining, crushed coarse aggregate that meets the gradation requirements of ASTM D448, Designation 57, 67, 6, 7 or 8.
   E. Backfill: Materials are suitable non-organic soils at a moisture content which enables compaction to the specified densities. Unsuitable soils are organic soils and those soils with the USCS classification symbol of CH, OH, MH, OL, or PT. CL soils with a Plasticity Index (PI) greater than 25 are also considered unsuitable soils.
   F. Drain tile: The drainage collection pipe shall be a perforated or slotted PVC or corrugated HDPE pipe. The pipe may be covered with a geotextile filter fabric to function as a filter.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine the areas and conditions under which the retaining wall is to be erected and notify the Contracting Officer in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected. Promptly notify the wall design engineer of any site conditions, which may affect wall performance or may require a reevaluation of the wall design.
   B. Foundation soil shall be examined by the project geotechnical engineer to ensure that the actual foundation soil strength, meets or exceeds that required on the Contract Documents.

3.2 EXCAVATION
   A. Excavate to the lines and grades shown on the construction drawings. Over-excavation not approved by the Contracting Officer shall not be paid for and replacement with compacted fill and/or wall system components will be required at the Contractor's expense. Do not disturb base beyond the lines shown. The Contractor shall be responsible for the stability of the excavation and it's influence on adjacent properties and structures.

3.3 FOUNDATION PREPARATION
   A. Foundation soil shall be excavated as required for footing or base dimension shown on the construction drawings, or as directed by the engineer.
   B. Soil not meeting the required strength shall be removed, sufficiently oversized from the front of the block and the back of the reinforcement and back-filled with suitable material.
   C. Over-excavated areas shall be filled with suitable compacted backfill.

3.4 BASE COURSE PREPARATION
   A. Base materials shall be placed as shown on the construction drawings with a minimum thickness of 6 inches.
   B. Base materials shall be installed upon undisturbed soils, or foundation soils prepared in accordance with Article 3.3.
   C. Material shall be compacted so as to provide a level, hard surface on which to place the first course of units.
   D. Base materials shall be prepared to ensure complete contact of retaining wall unit. Gaps shall not be allowed.
E. Base materials shall be to the depths and widths shown on the plans. Reduced the depth of sand and gravel and replace with a 1 to 2 inch concrete topping. Concrete shall be lean, unreinforced and a maximum of 2 inches thick. Where a reinforced footing is required, place below the frost line.

3.5 ERECTION

A. First course of concrete wall units shall be placed on the prepared base material. Units shall be checked for level and alignment. The top of all units in base course shall be at the same elevation.

B. Ensure that concrete wall units are in full contact with base.

C. Concrete wall units shall be placed side by side for full length of wall alignment. Alignment may be done, by using a string line or offset of wall line.

D. Fill all voids between and within concrete wall units with drainage aggregate.

E. Minimum of 12 inches of drainage aggregate shall be placed behind the concrete wall units.

F. Drain tile shall be installed at the lowest elevation possible to maintain gravity flow of water to outside of the reinforced zone. The drainage collection pipe shall be day-lighted to an appropriate location away from the wall system at not more than every 75 feet and at low points of the wall.

G. Remove excess fill from top of units and install next course. Ensure drainage aggregate and backfill are compacted before installation of next course.

H. Install each succeeding course. Backfill as each course is completed. Pull the units forward until the locating surface of the unit contacts the locating surface of the units in the preceding course. Pull the units forward as far as possible.

I. Install geosynthetic reinforcement in accordance with geosynthetic manufacturer's recommendations and the design drawings.

3.6 BACKFILL PLACEMENT

A. Reinforced backfill shall be placed, spread and compacted in a manner that will minimize slack in the reinforcement.

B. Fill in the reinforced zone shall be placed and compacted in lifts not to exceed 6 to 8 inches in loose thickness where hand operated compaction equipment is used and not exceeding 12 inches loose thickness where heavy, self-propelled compaction equipment is used.

C. Fill placed in the reinforced zone must be compacted to a minimum of 95 percent of the soil's standard Proctor density (ASTM D698) or as recommended by the project geotechnical engineer.

D. Only lightweight hand-operated equipment shall be allowed within 4 feet of the back of the retaining wall units.

3.7 CAP UNIT INSTALLATION

A. Apply construction adhesive to the top surface of the unit below and place the cap unit into desired position.

B. Cap units may need to be cut to obtain the proper fit.

C. Backfill and compact to finish grade.

3.8 ADJUSTING AND CLEANING

A. Damaged units shall be replaced with new units during construction.

B. Remove debris caused by this construction and leave adjacent paved areas broom clean.

3.9 QUALITY CONTROL

A. The wall installation contractor is responsible for quality control of installation of all materials. The contractor should enlist the assistance of a qualified independent third party to verify the correct installation of all materials according to these specifications and the construction drawings.

B. Work found to be deficient according to these specifications or the construction drawings must be corrected at the contractor's expense.

C. The retaining wall will not be considered complete until accepted by the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Prefabricated block retaining wall system will be measured by and paid for at the unit price for “Prefabricated Block Retaining Wall System” per square foot of wall face projected on a straight plane surface for the full height above the foundation. No measurement will be made for surface irregularities of blocks. Payment will include unit fill, drainage fill, and the work specified under Section 02275, “Geogrid Wall Reinforcement”.

B. Excavation and earthwork, including backfill, soil reinforcing, and backfill material within the
reinforced volume will not be measured separately for payment, but shall be considered subsidiary to the construction of the prefabricated block retaining wall system.

C. Subdrains or underdrains including filter fabric for the retaining wall will not be measured separately for payment, but shall be considered subsidiary to the construction of the modular retaining wall units.

END OF SECTION 02871
PART 1 - GENERAL

1.1 DESCRIPTION

A. This work shall consist of mechanically stabilized earth (MSE) retaining walls constructed in accordance with these Specifications and in conformity with the lines, grades, design, and dimensions shown on the Contract Drawings or established by the Contracting Officer. MSE wall design calculations, construction plans, and installation are the sole responsibility of the Contractor.

1.2 REFERENCED STANDARDS

A. American Association for State Highway and Transportation Officials (AASHTO):

1. AASHTO HB-17 - Standard Specification for Highway Bridges
2. AASHTO M85 - Standard Specification for Portland Cement
3. AASHTO T22 - Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens
4. AASHTO T23 - Standard Method of Test for Making and Curing Concrete Test Specimens in the Field
5. AASHTO T24 - Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
6. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
7. ASTM C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
9. ASTM D512 - Standard Test Methods for Chloride Ion In Water
10. ASTM D516 - Standard Test Method for Sulfate Ion in Water
11. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
13. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications
15. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
16. ASTM D4254 - Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
18. ASTM F436 - Standard Specification for Hardened Steel Washers
20. ASTM G57 - Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

1.3 SUBMITTALS

A. Shop Drawings: Submit shop drawings for walls and railings.

B. Product Data: Submit product data for retaining wall system and products including installation instructions: Include product data for fasteners, bearing pads, precast copings, and filter fabric.

C. Samples: Submit one sample of concrete face panels.

D. Manufacturer's Certificate of Compliance: Submit for concrete panels, embedded connectors, and soil reinforcement.

E. Concrete test results as specified in Paragraph 2.1.C herein.

1.4 DESIGN REQUIREMENTS

A. Design of retaining wall shall be performed by and shop drawings and computations shall be signed and sealed by the Contractor's engineer who shall be a Professional Engineer licensed in the State of Texas.

B. Shop drawings shall include all details, dimensions, and cross sections necessary to construct the wall.

C. Shop Drawings shall include plan and elevations of each wall. Plan and elevation drawings shall be developed in accordance with the lines and grades shown in the Contract Drawings.

D. Elevation view of the wall shall indicate the following information:
   1. Elevation at the top of the wall at the frequency shown in the Contract Documents;
   2. Elevations at the top of leveling pads;
   3. Distance along the face of the wall to all steps in the leveling pads;
   4. Designation as to the type of panel;
   5. Length, size, and number of soil reinforcements and the distance along the face of the wall to where changes in length of the soil reinforcements occur; and;
   6. Location final ground line at face of the wall.

E. Plan view of the wall which shall indicate the following information:
   1. Offset from the construction centerline to the face of the wall at all changes in horizontal alignment;
   2. Limit of the widest panel and strip, and;
   3. Centerline of any drainage structure or drainage pipe which is behind or passes under or through the wall.

   4. Identify obstructions or penetrations within the limits of the reinforced soil volume.

F. Shop Drawings shall also include, the following, as applicable.
   1. General notes required for design and construction of the wall.
   2. Cross section showing limits of construction and in fill sections, limits, and extent of backfill material placed above foundation soil.
   3. Limits and extent of reinforced soil volume.
   4. Limits and magnitude of applied bearing pressures.
   5. Details including any reinforcing bar bending details. Bar bending details shall be in accordance with Project drawings.
   6. Details for foundations and leveling pads, including details for steps in the leveling pads.
   7. Details of face panels. The details shall show all dimensions necessary to construct the element, all reinforcing in the element, and the location of reinforcement element attachment devices embedded in the facing.
   8. Details for construction of the wall around drainage facilities, overhead sign footings, catenary pole foundations, manholes, and similar items shall be clearly shown.
   9. Location of proposed internal drainage system in profile and its connections to drainage systems shown on the Contract Drawings beyond MSE wall.
   10. Details of the architectural treatment shall be shown.
   11. Details of elastomeric expansion joints, if required, shall be shown.

G. Design Computations: The method of analysis shall be a tie back wedge method as described in AASHTO HB-17. Designs shall be based on the design requirements indicated in the Contract Drawings.
   1. Submit design calculations for concrete face panels, anchor system, and concrete coping located at the top of the wall.
   2. Calculations shall include design of reinforcing around obstructions within the reinforced soil volume.
   3. Submit design computations on 8-1/2 inches by 11 inches sheets.
1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Contractor shall prevent mud, wet cement, epoxy, and like materials which may affix themselves from coming in contact with the materials.

B. Units shall be handled, stored, and shipped in such manner as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses. Damaged material shall not be incorporated into the mechanically stabilized earth wall. Panels in storage shall be supported on firm blocking located immediately adjacent to embedded connectors to avoid bending the soil reinforcement.

1.6 PROJECT RECORD DOCUMENTS

A. As part of preparation of project record drawings or “as-built” drawings specified in Section 01785, “Project Record Documents”, accurately record as built location and accurately record the top elevation of each wall at the frequency shown in the Contract Documents.

2.1 CONCRETE FACE PANELS

A. Concrete Strength: Cement shall conform to AASHTO M85. Cement shall have a minimum compressive strength of 4000 psi at 28 days. Air entrainment shall be 4 to 7 percent by volume. The distribution and steel reinforcement shall comply with the crack control provisions of AASHTO HB-17 for moderate exposure. Retarding agents, accelerating agents, or any additive containing chloride shall not be used without approval of the Contracting Officer.

B. Concrete Inserts: Tie strips, connecting pins, and PVC tubes and lifting and handling devices shall be set in place to the dimensions and tolerances shown on the plans prior to casting.

C. Testing and Inspection: Acceptability of the precast units will be determined on the basis of compressive strength and visual inspection. The Contractor or his supplier shall furnish facilities and an independent testing agency shall perform all necessary sampling and testing in an expeditious and satisfactory manner. Testing agency shall meet requirements of Section 01450, “Quality Control”. Panels, at the option of the Contracting Officer, may be acceptable for placement in the wall when 7-day strengths exceed 85 percent of 28-day requirements.

D. Casting: The panels shall be cast on a flat area, the front face of the form at the bottom, the back face at the upper part. Guides shall be set on the rear face to support the embedded connectors. The concrete in each unit shall be placed without interruption and shall be consolidated by the use of an approved vibrator, supplemented by such hand-tamping as may be necessary to force the concrete into the corners of the forms and prevent the formation of stone pocket or cleavage planes. Clear form oil of the same manufacture shall be used throughout the casting operation.

E. Curing: The units shall be cured for a sufficient length of time to ensure that the concrete will develop the specified compressive strength.

F. Removal of Forms: The forms shall remain in place until they can be removed without damage to the unit.

G. Concrete Finish: Unless otherwise indicated, the concrete surface of the front face shall have a bush hammered finish with penetrating acrylic stain. Bush hammered finish shall be formed by flexible form liner. Penetrating acrylic stain shall be as specified in Section 09980, “Coatings for Concrete and Masonry”. Color shall match Autumn Tan by United Coatings. The rear face of the panel shall have a uniform surface finish roughly screeded to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch.

H. Tolerances: Units shall be manufactured within the following tolerances:

1. Dimensions within 3/16 inch.

2. Angular distortion with regard to the height of the panel shall not exceed 0.2 inch in 5 feet.

I. Compressive Strength: Acceptance of the concrete face panels with respect to compressive strength will be determined on a lot basis. The lot shall consist of all production units (batches of concrete or panels) produced within a week’s or 7-day production operation. Production units shall be randomly selected in accordance with the production day sample sizes of Table A and tested for compressive strength. Compression tests shall be made on standard 6 inch by 12 inch test specimen prepared in accordance with AASHTO T23 or cores obtained and prepared in accordance with AASHTO T24. Compressive strength testing shall be conducted in accordance with AASHTO T22.

<table>
<thead>
<tr>
<th>Table A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Day Quantities</strong></td>
</tr>
<tr>
<td>0-35 cu.yds. (0-50 Panels)</td>
</tr>
<tr>
<td>36-70 cu.yds. (51-100 Panels)</td>
</tr>
<tr>
<td>71-106 cu.yds. (101-150 Panels)</td>
</tr>
<tr>
<td>Over 106 cu.yds. (+151 Panels)</td>
</tr>
</tbody>
</table>

1. When standard 6 inch by 12 inch test specimens are utilized, a minimum of four cylinders shall be cast for each production unit sampled. Two of these specimens shall be cured in the same manner as the panels and tested at 7 days. The remaining two cylinders...
shall be cured in accordance with AASHTO T23 and tested at 28 days. The test value of each two cylinder group will be their average compressive strength.

2. Lot will be acceptable if all acceptance tests in a lot are greater than 4,000 psi or provided no individual 28 day compressive strength test result falls below 3,600 psi and the average 28 day compressive strength of all test results for the lot equals or exceeds the acceptance limits set forth in Table B. The acceptance limits of Table B shall also apply to core compressive strength test results.

<table>
<thead>
<tr>
<th>Number of Lot Acceptance Tests</th>
<th>Average of All Lot Acceptance Tests Must Equal or Exceed These Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 7</td>
<td>4000 + 0.33R*</td>
</tr>
<tr>
<td>8 - 15</td>
<td>4000 + 0.44R*</td>
</tr>
<tr>
<td>16 +</td>
<td>4000 + 0.46R*</td>
</tr>
</tbody>
</table>

* (Range) The difference between the largest and smallest acceptance test result.

J. Rejection: Units shall be subject to rejection because of failure to meet any of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection:

1. Defects that indicate imperfect molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects such as chips, cracks, or fractures that cannot be repaired to restore structural integrity and appearance of panel.

K. Marking: The date of manufacture shall be clearly scribed on the rear face of each panel.

L. Concrete panels shall comply with Section 03450, “Architectural Precast Concrete”, as applicable.

2.2 SOIL REINFORCEMENT AND EMBEDDED CONNECTORS

A. Embedded connectors shall be shop fabricated of hot rolled steel conforming to the minimum requirements of ASTM A1011, Grade C or equivalent. They shall be hot dip galvanized to conform to minimum requirements of ASTM A123. Soil reinforcement shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall conform to ASTM A36 or equivalent. They shall be hot dipped galvanized to conform to the minimum requirements of ASTM A123.

B. Embedded connectors shall be cut to length and tolerances shown on the plans. Holes for bolts shall be punched in the locations shown. All soil reinforcement and embedded connectors shall be carefully inspected to ensure they are true to size and free from defects that may impair their strength and durability.

2.3 FASTENERS

A. Connections shall be positive, structural connections subject to the same metal loss rates and allowable stress requirements. For wire mesh systems using multiple-loop panel embeds and connector rods (or similar type connections), each longitudinal wire shall be securely engaged to its corresponding panel embed by the connector rod without the use of wedges.

B. Bolts and nuts shall be hexagonal cap screw, high strength conforming to ASTM A325, Type 1 for bolts. ASTM A563, Grade as recommended in Table X1.1, in ASTM A563, for nuts. ASTM F436, Type 1 for washers. Galvanized per ASTM A153/A153M. They shall be a minimum 1/2 inch in diameter, 1-1/4 inch in length with 3/4 inch thread length.

2.4 BEARING PADS

A. Bearing pads to be installed in horizontal joints between panels shall be preformed elastomeric pads conforming to ASTM D2000, M2AA 807, high density polyethylene pads with a minimum density of 0.946 g/cm² in accordance with ASTM D1505, or equal as approved by Contracting Officer.

2.5 MSE WALL REINFORCED VOLUME BACKFILL MATERIAL

A. MSE wall backfill material used in the reinforced volume shall be free from organic or otherwise deleterious materials and shall conform to the following specifications.

B. The backfill material shall consist of granular free-draining materials with a minimum effective angle of shearing resistance of 34 degrees. The granular material may include sand, crushed limestone, railroad ballast, sand-gravel mixture, and sand-crushed stone mixture.

C. The material shall have the following gradation for sections of the wall backfill that are not subject to flood water inundation and sections of the wall where the wall backfill is subject to flood water inundation:

<table>
<thead>
<tr>
<th>Percent Passing</th>
<th>Non-Inundated Condition</th>
<th>Inundated Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-inch</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>0.5-inch</td>
<td>50 - 100</td>
<td>0 - 10</td>
</tr>
<tr>
<td>No. 16</td>
<td>20 - 100</td>
<td></td>
</tr>
<tr>
<td>No. 40</td>
<td>10 - 60</td>
<td></td>
</tr>
<tr>
<td>No. 100</td>
<td>0 - 10</td>
<td></td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 6</td>
<td></td>
</tr>
</tbody>
</table>
Particles larger than 0.25 inches shall be angular or crushed. Rounded rock or gravel will not be allowed.

D. Material smaller than the No. 200 sieve size shall have a PI of 6 percent or less. A complete grain-size distribution shall be measured in accordance with ASTM C136. The coefficient of uniformity, Cu = D60/D10, shall be included with the grain size analysis. The liquid and plastic limits of the percent passing the No. 200 sieve shall be determined by ASTM D4318.

E. Granular material shall also conform to the following:
   1. Soundness: No soft, poor durability particles. Magnesium sulfate soundness loss of less than 30 percent after 4 cycles and sodium sulfate loss of less than 15 percent after 5 cycles, in accordance with ASTM C88 testing method.
   2. Resistivity: minimum 3,000 ohm-cm at 100 percent saturation; in accordance with ASTM G7 testing method.
   3. pH: 5 to 10, in accordance with ASTM G51 testing method.
   4. Chlorides: Maximum 100 ppm when resistivity is less than 5,000 ohm-cm; in accordance with ASTM D512 testing method
   5. Sulfates: Maximum 200 ppm when resistivity is less than 5,000 ohm-cm; in accordance with ASTM D516 testing method.

F. Angle of shearing resistance for portions of the granular material that passes a No. 10 sieve shall be determined by ASTM D3080, Consolidated Drained Direct Shear Test. Granular materials that have been crushed and that have 80 percent of the grain size greater than 0.75 inches do not need to be tested to confirm that these materials meet the 34 degree angle of shearing resistance provided the material meets the requirements listed above.

2.6 CONCRETE LEVELING PAD

A. Material for pad shall consist of a minimum 6 inch thick, concrete base leveling pad in accordance with Mix S-7 as per Section 03305, “Portland Cement Concrete”.

2.7 COPING

A. Concrete coping may be either precast or cast-in-place. Cast-in-place concrete shall comply with the requirements of Section 03300, “Cast-In-Place Concrete”.

2.8 GALVANIZED METAL RAILING

A. Galvanized metal railing shall be in accordance with the requirements of Section 05520, “Pipe and Tube Railings”.

2.9 FILTER FABRIC

A. Filter fabric placed along wall joints and at interface with other structure shall be in accordance with Section 02700, “Storm Sewer Systems” for Subsurface Drainage.

PART 3 - EXECUTION

3.1 WALL EXCAVATION

A. Excavation shall be in accordance with the requirements of Section 02220, “Grading, Excavating, and Backfilling”, and in conformity to the limits and construction stages shown on the Contract Drawings.

3.2 SUBGRADE PREPARATION

A. Subgrade for the structure shall be graded level for the width equal to or exceeding the length of the MSE soil reinforcement or as shown on the Contract Drawings.

B. Prior to construction the subgrade shall be proof rolled, except where rock is present at the base of the wall. Proof roll in accordance with Section 02220, “Grading, Excavating, and Backfilling”. Proof roll under the observation of the Contracting Officer.

C. Where it is not feasible to proof roll, the subgrade shall be checked using a dynamic cone penetration test. The test shall be performed in accordance with ASTM D6951. The cone shall be advanced to a depth of at least 3 feet or to hard layer, whichever is shallower. The number of blows to drive the cone shall be recorded. One cone test per 50 linear feet of wall subgrade or part thereof shall be performed. A minimum of three tests shall be performed.

D. If the Contracting Officer notes any soft, rutting, or shoving areas or dynamic cone results that indicate the presence of soft subgrade conditions, the soft subgrade conditions shall be removed and replaced with structural fill. Structural fill shall be placed in accordance with Section 02220, “Grading, Excavating, and Backfilling”, or as required by the Contracting Officer.

E. The subgrade shall then be compacted with a smooth wheel roller.

F. At each panel subgrade level, a concrete leveling pad shall be provided as shown on the approved plans.

G. The leveling pad shall cure for a minimum of 24 hours before placement of wall panels.

3.3 PANEL ERECTION

A. Precast concrete panels shall be initially placed at the batter necessary to achieve a vertical position following compaction of backfill.

B. Panels shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds. As fill material is placed behind a panel, the
panels shall be maintained in a vertical position by means of clamps placed at the junction of adjacent panels and temporary wooden wedges placed in the horizontal joint at the junction of the two adjacent panels on the external side of the wall. External bracing may also be required for each lift.

C. Bearing pads of the dimensions and thickness shown in the approved shop drawings shall be installed in the horizontal joints.

D. Filter fabric shall be placed behind all wall joints, and at the intersection of retaining walls with other structures. Filter fabric shall cover joints a minimum of 6 inches on each side and shall be positively held in place by an adhesive approved by the Contracting Officer. The adhesive shall be applied to the panels and not the filter fabric. The filter fabric shall be placed to prevent the loss of wall backfill soils through the panel joints. The minimum width and lap shall be 12 inches.

E. Vertical tolerances (plumbness) and horizontal alignment tolerance shall not exceed 3/4 inch when measured along a 10-foot straight edge. The maximum allowable offset in any panel joint shall be 3/4 inch. The overall vertical tolerance of the wall (plumbness from top to bottom) shall not exceed 1/2 inch per 10 feet of wall height. Panel joint gaps shall be a minimum width of 1/2 inch and a maximum width of 1 inch.

3.4 BACKFILL PLACEMENT

A. Backfill placement shall closely follow the erection of each lift of panels. At each soil reinforcement level, backfill shall be roughly leveled before placing and attaching soil reinforcement. Except as shown on the plans, soil reinforcement shall be placed normal to the face of the wall.

B. Field cutting or bending (deforming) of the soil reinforcements will only be permitted as specifically detailed on approved shop drawings and in accordance with the manufacturer’s recommendations. To avoid conflicts with piles or utility obstructions the following may be done:

1. Soil reinforcement may be skewed 15 degrees from normal position (provided no deformation occurs).

2. Soil reinforcements may be connected to a structural yoke which straddles or bypasses the obstruction.

C. The maximum lift thickness shall not exceed 10 inches (loose) and shall closely follow panel erection. The Contractor shall decrease the lift thickness if necessary to obtain the specified density.

D. Compaction of Wall Backfill Placed Three or More Feet from the Wall Face:

1. Wall backfill with a well-defined moisture-density relationship shall be compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698 with oversize corrections where warranted) between minus 2 and plus 3 percentage points of the optimum moisture content.

2. Coarse aggregate free-draining soils that do not have a well-defined moisture-density curve shall be compacted to a relative density of at least 70 percent as determined by test methods ASTM D4253 and D4254. Granular backfill shall be compacted at a moisture content that will allow the desired density to be achieved.

3. Where the backfill material consists of more than 30 percent retained on the 0.75 inch sieve and sand cone or nuclear density measurements can not be made, a method specification shall be used to control compaction. The method specification shall be based on a test compaction section to establish the number of passes required to where there is no visible change in the test lift thickness caused by the steel drum roller. The method specification shall define the lift thickness and fill moisture content requirements for the approved steel drum roller. The number of passes required for compaction shall not be less than four.

E. Compaction of Wall Backfill Within Three Feet of Wall Face.

1. Backfill soils shall be compacted using light mechanical tampers either single or double drum, walk-behind vibratory rollers or vibratory plate compactors.

2. Fill shall be compacted to at least 90 percent of the maximum dry density as determined by ASTM D698 and shall not receive less than three passes of the light compactor.

3. Except for the bottom course, placement of fill within three feet of the face shall not lag behind the remainder of the structural fill by more than one foot. The bottom course shall be placed after the first lift is placed and compacted above the lowest soil reinforcement level.

F. Only smooth drum compactors shall be used. Grid or sheepsfoot rollers are not permitted.

G. Flooding of the backfill to achieve compaction requirements is not permitted.

H. Backfill shall be placed in a manner as to avoid any damage or disturbance of the wall materials or misalignment of the facing panels or reinforcing elements. Any wall materials that become damaged during backfill placement shall be removed and replaced at the Contractor’s expense. Any misalignment or distortion of the wall facing panels due to placement of backfill outside the limits set forth in this specification shall be corrected at Contractor’s expense.
I. Backfill shall be placed and compacted parallel to the wall facing panels. Backfill placement shall work from a distance of no less than 3 feet from the wall panels and work towards the end of the soil reinforcement.

J. At the end of each workday, the Contractor shall shape the last level of backfill to permit runoff of rainwater away from the wall face or shall provide positive means of controlling runoff away from the wall.

3.5 DRAINAGE SYSTEM AND UNDERDRAINS

A. Install wall drainage systems and underdrains in accordance with approved shop drawings, the Contract Drawings, and Section 02700, “Storm Sewer Systems”.

3.6 FIELD QUALITY CONTROL

A. Backfill conformance testing frequency shall be as follows:

1. Gradation of Granular Backfill: One test per 5,000 tons, change in material source, or as required by Contacting Officer.

2. Soundness and Electrochemical Properties: One test per 10,000 tons, change in material source, or as required by Contacting Officer.

3. Angle of Shearing Resistance: One test per 10,000 tons, change in material source, or as required by Contacting Officer.

B. Compaction Test Frequency:

1. For each fill area less than 5,000 square-feet perform a minimum of three moisture and density tests for each layer of compacted fill.

2. For fill areas in excess of 5,000 square-feet, perform a minimum of one moisture and density test for every 5,000 square-feet. for each layer of compacted fill.

3. For wall subgrades, perform a minimum of one moisture and density test for every 5,000 square-feet or portion thereof.

C. Testing shall be at the expense of the Contractor.

D. Testing shall be accomplished by a testing laboratories complying with requirements of Section 01450, “Quality Control”.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Mechanically stabilized earth retaining wall will be measured by and paid for at the unit price for “Mechanically Stabilized Earth Retaining Wall” per square foot on the front surface area of the wall, from the top of the leveling pad to the top of the coping. The quantity measured and paid for will be that shown on the Contract Drawings. Should the actual area installed vary from the plans quantity shown on the Contract Drawings, no additional payment will be made for additional square footage.

B. Excavation and earthwork, including backfill, soil reinforcing, and backfill material within the reinforced volume will not be measured separately for payment, but shall be considered subsidiary to the construction of the mechanically stabilized earth retaining wall.

C. Subdrains or underdrains for the retaining wall will not be measured separately for payment, but shall be considered subsidiary to the construction of the mechanically stabilized earth retaining wall.

D. Reinforcing, formwork, concrete, joint filler, leveling pad and other pertinent items will not be measured separately for payment, but shall be considered incidental to the construction of the mechanically stabilized earth retaining wall.

E. Drainage systems not for the retaining wall shall be measured and paid for in accordance with Section 02700, “Storm Sewer System”.

F. Penetrating concrete stain shall be measured and paid for in accordance with Section 09980, “Coatings for Concrete and Masonry”.

G. Handrail will be measured and paid for under Section 05520 - Pipe and Tube Railings".

END OF SECTION 02872
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the procurement and installation of the station furnishings to be located on the station platforms. Such furnishings include trash receptacles, newspaper dispensers, bicycle lockers, seating and bus shelters, including their miscellaneous connections and attachments.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   3. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   5. ASTM D1044 - Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion

1.3 SUBMITTALS
A. Product data: Submit manufacturer's data for each type of station furnishings item specified, with installation instructions for each type that is connected or attached to other construction. Include methods of installation for each type of substrate.
B. Shop Drawings: Submit shop drawings showing installation, details of accessories permanently affixed to construction, including full scale installation details of special conditions.
C. Samples: Submit full-size samples for approval purposes of each station furnishings item consisting of manufacturer's standard size samples showing connection and attachment details. If approved, these samples can be incorporated in the finished installation.
D. Submit manufacturer's printed instructions for maintenance of station furnishings, including methods and frequency recommended for maintaining optimum condition under anticipated use conditions. Include precautions against materials and methods which may be detrimental to finishes and performance.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Transport furnishings to Worksite from the storage area in original factory wrappings and containers, clearly labeled with identification of manufacturer, brand name, and lot number.
B. Store materials in original undamaged packages and containers, inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity. Place materials on at least 4 inch high sills on floors in a manner that will prevent damage and rusting. Avoid the use of non-vented plastic or canvas shelters which could create a humidity chamber.
C. Comply with instructions and recommendations of manufacturer for special transportation, storage, and handling requirements.
D. Securely package furnishings items in crates, boxes, or containers to protect them from being scratched, dented, scraped, marked, or blemished in any way during shipping or storage.
E. Upon delivery of furnishings at the storage area in Dallas, examine all packages of furnishings for damage and repair any minor damage as directed by the Contracting Officer. Furnishings which are not repairable as determined by the Contracting Officer shall be removed and replaced with acceptable furnishings.
F. Do not install damaged furnishings, but furnishings damaged in transportation will be replaced.
G. Inspect all furnishings prior to transporting to determine if item is damaged. Do not transport damaged furnishings.

1.5 SEQUENCE AND SCHEDULING
A. Sequence accessory installation with other work to minimize possibility of damage and soiling during remainder of construction period.

PART 2 - PRODUCTS

2.1 TRASH RECEPTACLES
A. Trash receptacles shall be constructed with a wire grid panel of 5/16 inch frame and bars 2-1/2 inches on center with 1/8 inch cross wires 1/2 inch on center, set in 7/8 inch steel rings. As manufactured by Landscape Forms, Inc. or approved equal, the style shall be the Plexus Collection (LX5002-20-40), 20 inch receptacle, with tamper proof custom...
mounting brackets. Finish shall be powder coat, "Driftwood" color.

B. Trash receptacles shall be furnished with a clear polyethylene liner that accepts poly trash bags and a spun-metal hinged side-opening lid with locking device; finish shall be powder coat, "Dove" color.

C. Trash receptacles shall be provided and installed with custom wall mounted brackets from trash receptacle manufacturer, finish to be powder coat, "Driftwood" color.

2.2 NEWSPAPER DISPENSERS

Not used.

2.3 BICYCLE RACKS

A. Frame: Stainless steel.

1. ASTM A312, Schedule 40S, TP 304.

B. Style: Serpentine or ribbon.

C. Overall Height: Nominal 36 inches.

D. Overall Width: Nominal 62 to 64 inches.

E. Embed Depth: 12 inches minimum below top of concrete.

F. Capacity: Designed to accommodate not less than seven bicycles.

G. Installation Method: Embedded (E), cast in concrete.

H. Stainless-Steel Finish (S): Satin No. 4.

I. Manufacturer and Model:

1. AAA Ribbon Rack Co., Inc., Division of Brandir International, "Ribbon Rack" Model RB 07-S-E.
2. Columbia Cascade Company, "Original CycLoops", Model 2170-7-S-E.
4. Huntco, Model BR7-S-E.
5. Madrax, A T.L. Graber Co., "Heavy Duty Challenger", Model H36-7-IG-S.
6. Or approved equal.

2.4 BICYCLE LIDS

A. Molded composite bicycle lid enclosures shall be manufactured with fiberglass reinforced plastic with a solid color stipple texture finish, 2 bike model.

B. Color: As selected from manufacturer’s standard colors.

C. Manufacturer and Model:

3. Or approved equal.

2.5 SEATS

A. Seats shall be constructed with a wire grid panel of 5/8 inch frame and bars 2-1/2 inches on center, with 1/8 inch cross wires 1/2 inch on center inserted in 7/8 inch steel frame as manufactured by Landscape Forms, Inc. or approved equal. Style shall be Rialto flat rectangular seat, (RLFS02) finish to be powder coat finish, color as selected. Size of rectangular seat is 17-1/2 inches wide by 20 inches deep.

B. Seats shall include embedded support, finished with a powder coat finish, color to match seats.

2.6 BUS SHELTERS

A. Vertical Support Columns: 2-1/2 inch square and 2-1/2 inch by 5 inch rectangular steel tubing (ASTM A500, Grade B or better) with minimum 0.188 inch wall thickness.

B. Slipfitter Bases: For lowermost end of each vertical support column. Base plate of 0.25 hot rolled steel (ASTM A576). Base plate can be configured for either internal or exterior mounting.

C. Horizontal Framing System: 2-1/2 inch square steel tubing (ASTM A500, Grade B or better) with minimum 0.188 inch wall thickness. Framing system shall have cross members or be fabricated such that the wall glazing cannot be flexed or be kicked out.

D. Roof Framing Assembly: 2-1/2 inch square steel tubing (ASTM A500, Grade B or better) with minimum 0.188 inch wall thickness and 2-1/2 inch structural steel angle (ASTM A36/A36M) with minimum 0.25 inch thickness.

2. Glazing bars: 0.25 inch carbon steel flat stock (ASTM A36/A36M).
3. Roof end caps: 12 gauge cold rolled steel.

E. Benches: Steel benches at both ends of shelter.

F. Configuration: Center windscreen shall allow patrons to ingress and egress form both front and rear of shelter.


H. Color to match Benjamin Moore No. 1600.

I. Glazing:

1. Abrasion and UV-Resistant, Monolithic Polycarbonate Sheet: Sheet coated on both surfaces to produce an abrasion resistance of 0.8 to 2 percent maximum haze increase for 100 revolutions of CS-10F wheel per ASTM D1044.

2. Protected with adhesive backed protective paper until removal in the field.

3. Thickness:
   a. Wall glazing: 0.25 inch.
   b. Roof glazing: 0.188 inch.

4. Manufacturer and Product:
   b. GE Plastics, Structured Products, “LEXAN MR5”.
   c. Sheffield Plastics, Inc., “HYZOD AR”.
   d. Or approved equal.

J. Manufacturer and Model:

1. JWI, Inc., “Street Smart Designs” Model SV-56-3M-C-A.

2. Or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where installation is to be performed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Comply with manufacturer’s written installation instructions, unless more stringent requirements are indicated. Complete field assembly of site and street furnishings, where required.

B. Unless otherwise indicated, install site and street furnishings after landscaping and paving have been completed.

C. Install site and street furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.

D. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site and street furnishings and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout, mixed and placed to comply with anchoring material manufacturer’s written instructions, with top smoothed and shaped to shed water.

3.3 CLEANING

A. After completing site and street furnishing installation, inspect components. Remove spots, dirt, and debris. Repair damaged finishes to match original finish or replace component.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for station furnishings per location indicated wherein no measurement will be made.

END OF SECTION 02873
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for placing topsoil or site soil; soil preparation and fine grading; furnishing and installing trees, shrubs, and groundcovers; seeding; and staking and guying trees as indicated.

B. Plant-establishment time periods are in:
   1. Section 02950, "Landscape Planting"
   2. Section 02930, "Seeding and Sodding - Irrigated Areas"
   3. Section 02931, "Seeding and Sodding - Non-Irrigated Areas"

C. Slope protection and hydroseeding are specified in Section 02271, "Ditch Lining and Slope Protection".

D. Landscape irrigation is specified in Section 02810, Landscape Irrigation System.

1.2 SUBMITTALS

A. Plant Substitutions: Plant substitutions will not be permitted unless the Contractor furnishes the Contracting Officer with written evidence from no less than three nurseries that the plants specified are not obtainable. Such evidence shall be submitted within 30 calendar days after the effective date of the Notice to Proceed.

1.3 QUALITY ASSURANCE

A. Installer's Qualifications: Installer shall be a specialist in installing and planting landscape products, with documented experience in performing landscape work of comparable size, scope, and quality.

B. Supervision: Provide the services of at least one qualified person who shall be present during execution of the work of this Section. That individual, who shall direct the work, shall be thoroughly familiar with the types of materials being installed and the proper methods for their installation.

C. Contracting Officer's Observance:
   1. The work specified herein will be observed by the Contracting Officer. The Contractor shall request observance at least 24 hours in advance of the time such observance is required. Observance is required on the following portions of the work:
      a. During preliminary grading and soil preparation;
      b. When finish grading has been completed, and before the planting of grass, turf, and groundcover;
      c. When shrubs and trees are spotted for planting, before planting holes are excavated;
      d. When planting begins;
      e. When planting and other work has been completed;
      f. Before trenching; and
      g. Before any trenching is covered.

2. The Contractor shall require the supervisor of the landscape planting work to be on the site at the time of each such observance.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery:
   1. Deliver fertilizer and other chemicals to the site in original unopened containers bearing manufacturer's guarantied chemical analysis, weight, manufacturer's name, trademark, and conformance with state law.
   2. Deliver plant materials to the jobsite no earlier than three calendar days prior to planting.
   3. Protect plant material during delivery to prevent damage to root ball or desiccation of leaves.
   4. If trees and plants are transported in open trucks, trees and plants shall be wrapped to prevent damage and windburn. Adequate protection shall be placed between trees so that trunks are not scarred in transport and branches are not broken. Tree trunks shall be wrapped with protective covering prior to handling and loading. Covering shall be removed at the time of plant materials inspection at the job site.
   5. Notify the Contracting Officer in advance of delivery of plant materials, and submit an itemized list of the plants in each delivery.
B. Handling: Exercise care in handling, loading, unloading, and storing of plant materials. Plant materials damaged in any way shall be discarded and replaced with undamaged materials.

C. Storage:
1. Protect plant materials from wind, excessive sun, and drying out.
2. Fertilizer and lime shall not be stored with other landscape material. Herbicides and pesticides shall not be stored with other landscape material.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Planting shall not be performed during weather conditions which may adversely affect landscape materials, plants, and planting conditions.

1.6 SITE CONDITIONS AND SCHEDULING

A. Landscape work shall not begin until structures, utilities, paving, and other improvements, which require access to or through planting areas, have been installed and accepted unless approved by the Contracting Officer. Planting work shall not begin until the landscape irrigation system is installed in place, tested, and accepted by the Contracting Officer.

1.7 WARRANTY

A. Warrant that trees, shrubs, groundcovers, and other plant materials will take root and grow vigorously within one year after final acceptance of plantings, when such plants have received normal care and maintenance. Warranty commences at end of plant establishment period and final acceptance.

B. The warranty shall include replacement of trees and other plant materials that die back and lose the form and size as originally specified, even though they may have taken root and are growing after the die-back.

C. Corrective work shall include removal and replacement of warranted plant materials which, for any reason, fail to meet the requirements of the warranty. Replacements shall meet the same requirements as specified for the original materials. Replacements shall carry the same warranty period which shall start from the time the replacements are planted and accepted.

D. The maintenance period shall be for the entire one-year warranty period as specified in the General Conditions.

PART 2 - PRODUCTS

2.1 PLANT STOCK

A. Plant stock and materials are indicated in the Planting List or Schedule on the Contract Drawings. Provide trees and plants of the varieties, sizes, and quantities indicated. Provide nursery-grown stock only, which is free from insect pests and diseases.

B. Plants shall comply with Federal and State laws requiring inspection for plant diseases and infestations. Inspection certificates required by law shall accompany each shipment of plants, and the certificates shall be delivered to the Contracting Officer. Plants shall be true to species, varieties, and the sizes indicated, and shall be labeled in accordance with the recommended practice of the American Association of Nurserymen.

C. Label trees and bundles, containers or flats of the same shrub, ground cover and vine with durable waterproof labels and weather resistant ink. Labels shall state the correct plant name and size as specified in the Plant List on the Contract Drawings, and shall be legible for 60 days after delivery to the planting site. Plant material which is not labeled will be rejected.

D. Plants shall be healthy, shapely, and well-rooted. Roots shall show no evidence of having been root bound, restricted, or deformed. Plant material which has just been upgraded in container size will be rejected. Root condition of plants in containers will be inspected by the Contracting Officer by removal of earth from the roots of not less than two plants of each species or variety from each source. Plant materials requiring inspection by the Contracting Officer shall be assembled and available for such inspections. If the sample plants inspected are found to be defective, the Contracting Officer reserves the right to reject the entire lot or lots of plants represented by the defective samples.

E. Trees shall have straight trunks with the leader intact, undamaged, and uncut. Old abrasions and cuts shall be completely calloused over. Trees shall be measured when their branches are in their normal position. The height of a tree shall be measured from root crown to top of plant. The width of a tree shall be measured at branching at the widest point. Sizes shown on the Contract Drawings are before pruning. Trees shall not be pruned prior to delivery except upon approval of the Contracting Officer.

F. Trees shall be well tapered in the trunk so that when the nursery stake is removed, the tree supports itself upright without further staking. Trees shall have a main leader. The main branches shall be spaced vertically and alternately along the
trunk. Branching shall not be concentrated in one location and there shall be no severe crossing of branches. Branches shall be smaller in diameter than the trunk. Branch attachments shall be free of embedded bark. Branching along the lower two-thirds of the trunk shall have at least one half of the foliage of the tree.

G. Rejected plant materials shall be removed from the site and replaced with materials which conform to specified requirements.

H. Plant material shall be grown under similar climatic conditions to those found at the project site.

I. Ground cover and vines shall be rooted plants, grown in flats unless indicated otherwise on the Contract Drawings, or as approved by the Contracting Officer.

2.2 SOURCE QUALITY CONTROL

A. The Contracting Officer will inspect the source of supply (landscape nursery) of the proposed plant materials prior to shipment to the site.

B. Plant materials shall be properly labeled as herein before specified, before the Contracting Officer’s inspection of proposed plant materials. Plant materials which do not conform with specified requirements will be rejected, and shall be replaced with Contracting Officer-approved plants.

C. Notify the Contracting Officer at least ten days before shipment of plant materials from the source of supply.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate layout and installation of plant materials with installation of the irrigation system to ensure that there will be complete and full irrigation coverage of the planted areas.

3.2 EXCAVATION AND BACKFILL

A. Excavate and backfill areas to be landscaped as indicated and specified herein.

B. Excavations for soil removal shall be to within 6 inches of back of curb or edge of walk. The Contractor shall be responsible for protecting and maintaining the integrity of compacted base rock and subgrade materials under paving and curbs, and for protecting other structures in the excavated areas. Review with the Contracting Officer, the distance to remain away from other structures within the excavated areas. Do not undercut sides of excavation. Damage to base rock, subgrade, paving, curbs or structures shall be repaired or replaced. Remove and dispose of asphalt debris, concrete, base rock, and existing soil in landscaped areas from the site.

C. Refer to Section 02910 and drawings for depths of backfill.

D. Backfill excavated tree and shrub planting areas with topsoil. Prior to installing topsoil, scarify the bottom of the excavation to a 6 inch depth. Do not scarify or undercut sides of excavations. The Contractor shall be responsible for protecting base rock and subgrade compaction under adjacent paving and curbs. Provide topsoil backfill in 6 inch lifts. Incorporate the first 6 inch lift of topsoil into the existing soil at the bottom of the excavation.

E. Refer to Section 02220, “Grading, Excavating and Backfilling”, for requirements for disposal of surplus material from planting bed excavations.

3.3 ROUGH GRADING

A. Prior to planting, grade areas to be landscaped. Fill as needed or remove surplus dirt and float areas to a smooth uniform grade. Slope planting areas to drain. Roll, scarify, rake, and level as necessary to obtain true, even planting surfaces. Rough grading shall be inspected and approved by the Contracting Officer before amendments and fertilizers are added.

B. Planting areas shall be thoroughly wetted down. Allow soil to dry so as to be workable, after which thoroughly cultivate to a depth of 6 inches using a rotary hoe.

3.4 PLANTING OF TREES AND SHRUBS

A. Stake Plant Locations. Mark tree and shrub locations on site using stakes or similar means. Make adjustments to locations, where required by the Contracting Officer, and locations shall be approved by the Contracting Officer before plant holes are dug.

B. Planting Holes: Dig pits with vertical sides as indicated. After pits are dug, break the sides to open the wall of the pit for root penetration, and loosen the bottom of the pit to a depth of 3 inches. Perform a drainage test, as specified in Section
LANDSCAPING - GENERAL

02950, where required. Construct foot-tamped mound in the bottom of the pit to support the plant at the proper level.

C. Root Barriers: Install root barriers as indicated.

D. Watering Holes: Install watering holes as indicated.

E. Landscape Fabric: Install landscape filter fabric where indicated on the drawings. The fabric shall be tucked into the soil 2 inches along the perimeter of the landscaped areas. Provide 1 foot overlaps at sides and ends. Secure against movement with specified anchorage staples. Furnish cutouts in the fabric to accommodate irrigation items and at tree, shrub, and vine planting locations.

F. Placement of Plants:

1. Do not move or handle container plants by the tops, stems, or trunks. Lift plants so that the root ball is supported from the underside. Plants that do not have a satisfactory root system will be rejected.

2. Cut the root ball vertically in a few places to encourage new feeder root development along the perimeter of the root ball.

3. Plants shall be planted immediately after rootballs are cut.

4. Place each plant in an upright and plumb position. Plants, up to 15 gallon size, shall be typically set so that the top of the root ball will be 1 to 3 inches above the finish grade to allow for settling.

5. Ground cover shall be installed at spacings indicated on Contract Drawings, and shall be evenly spaced and staggered in rows. Place each plant in a pit so that the root system lies free without doubling and so that the roots are planted vertically. Firm the soil around each plant and water the area immediately to avoid drying out.

G. Backfilling:

1. Backfill holes and pits with amended topsoil. Ensure that proper irrigation will be maintained to the rootball. Taper backfill around sides and up to the top of the rootball so that sides of the rootball are not exposed.

2. Backfill for planting in areas where topsoil has been placed earlier shall be topsoil excavated from the planting hole. Backfill for plants in areas where existing site soil remains shall be the topsoil amended in accordance with the Soil Analysis Report (see Section 02930, "Seeding and Sodding - Irrigated Areas") and as specified on the drawings.

3. Construct a 4 inch high berm (watering basin) around plant holes and fill the watering basin with root stimulator solution. Mix and apply the solution in accordance with the manufacturer's written instructions.

4. Backfill shall be watered until the backfill material is moist to the full depth of the hole.

H. Pruning: Pruning shall not be performed unless specifically requested or approved by the Contracting Officer. Examine trees requiring pruning with the Contracting Officer. Trees that are damaged due to improper pruning or wind damage shall be replaced.

I. Bracing: Use tree bracing as shown on the drawings to set tree plumb.

J. Adjustment of Plants:

1. Plants that settle deeper than specified shall be raised to the correct level.

2. Plants that go out of plumb shall be straightened and stabilized.

K. Top Dressing: Install a 3 inch layer of mulch in landscaped areas. Mulch shall be kept away from stems and trunks of plants, and shall be kept off the foliage of ground cover.

3.5 DRAINAGE TEST AND AUGER HOLES

A. Requirements: After tree pits are dug and before planting operations, tree pits shall be water tested for drainage if requested by Contracting Officer.

B. Tests: Fill tree pits with water. Check holes after 24 hours to determine if water has drained out. If the water has not drained out, bring this to the attention of the Contracting Officer for remedial course of action. Adjustment of pit size, adjustment of pit location, or addition of auger holes will be required by the Contracting Officer if a drainage problem exists.
C. Auger Holes: Auger one 6 inch diameter hole through the bottom of each excavated plant hole that does not drain within the specified 24 hour period. Depth of the drill measured from the bottom of the excavation to the bottom of the drill hole shall be 4 feet. Backfill auger holes with 3/4 inch diameter, well-graded drain rock up to bottom of the plant hole. Cover drain rock in the auger hole with a 2 feet by 2 feet piece of landscape filter fabric.

3.6 CLEANUP
A. Comply with the requirements of Section 01740, Cleaning.
B. Neatly dress and finish landscaped areas.
C. Broom clean pavements.

3.7 PRELIMINARY TO FINAL INSPECTION
A. At completion of the work of this Section, the Contractor shall request a preliminary inspection to determine the condition theof landscaped areas.
B. Inspection shall be requested three working days in advance.
C. The Contractor and Contracting Officer shall be represented at the inspection.
D. Construction considered ready for inspection shall conform with the following requirements:
   1. Planting shall be healthy and free of infestations.
   2. Landscaped areas shall be free of weeds.
   3. Stakes and stabilizers shall be as specified.
   4. Mulch shall be raked to a uniform surface.
   5. Debris shall be removed from the landscaped area, pavements shall be broom clean, and foliage shall be washed clean.
   6. Plants shall be installed in place as indicated and specified.

3.8 FINAL INSPECTION AND ACCEPTANCE
A. Final inspection will be conducted at the end of the Plant Establishment Period. Notice requesting final inspection shall be submitted by the Contractor to the Contracting Officer at least 14 calendar days prior to the anticipated date.
B. Care shall be taken to prevent the deposit of fertilizer on stems or leaves. Fertilizer shall be spread with a mechanical spreader wherever possible. Fertilizer shall be applied only during favorable weather conditions to prevent dissipation by wind. Plants shall be thoroughly watered after fertilizer has been applied.
C. Mulch shall be raked away from around plant bases. Fertilizer shall be spread around each plant base and worked into the top 2 inches of soil. Mulch shall then be replaced.
D. Prior to final inspection, the Contractor shall also have performed weeding and a thorough cleaning of the landscaped areas.
E. The irrigation system shall be tested at the final inspection. Refer to Section 02975, “Landscape Irrigation System”, for additional information.
F. At the final inspection, the Contracting Officer will determine the condition of the plants and improvements. Acceptance of this work will be contingent upon proper maintenance and the establishment of vigorous plant materials. Plants which are dead, unhealthy, or missing, whether by disease, neglect, vandalism, or any other reason, shall be replaced with the same species and sizes originally specified and following these same specifications for installation.
G. Provide plant replacements within 30 days after final inspection, and extend the Plant Establishment Period for an additional 30 calendar days after replacement planting has been accepted by the Contracting Officer. The Contracting Officer will then repeat the final inspection for the replaced plants at the end of the extended Plant Establishment Period.

3.9 MAINTENANCE FOR PLANT ESTABLISHMENT
A. Maintain plant materials from the time of planting until end of plant establishment period.
B. Maintenance shall include watering, cultivating, weeding, remulching, repair of stakes, fertilizing, cultivation, spraying, and pruning as required to keep the plant material in a healthy growing condition and to keep the planted areas neat and attractive in appearance throughout the maintenance period. Maintenance shall also include treatment for fungus, diseases, rodents, insects, and repair of vandalism.
C. Plants in irrigated areas shall be watered not less than twice a week. Each watering shall be of such quantity as to provide optimum growing conditions. Rinse foliage of plant materials as often as necessary to keep foliage free of dust.
D. Rocks, clods, and debris which appear on the surface shall be removed. Heaved, settled, or eroded areas shall be restored by excavating, addition of topsoil, filling, finish grading, and rolling as required.

E. Gravel, surplus earth, papers, trash and debris, which accumulate in the landscaped areas and the areas directly adjacent to the paved areas, shall be removed and disposed of weekly. Such areas shall be cared for as required to present a neat and clean condition.

F. Provide weeding of areas, at intervals of not more than 14 days, as follows:

1. Weeds which appear in asphalt, concrete, or paved areas within Contract limits shall be killed before they exceed 2 inches in height or spread, by spraying with a contact herbicide which shall not stain the surfacing.

2. Weeds in ground cover shall be killed by spraying with a contact herbicide, approved by the Contracting Officer, before they exceed 2 inches in height or spread, or shall be removed by pulling with roots intact before they exceed 4 inches in height or spread.

3. Weeds between basins in areas planted with trees and shrubs shall be removed by pulling before they exceed 4 inches in height or spread. Weeds shall be removed from within basins, including basin walls, and from within planter boxes. Weed not killed by spraying shall be pulled with its roots intact.

4. Before using herbicide or pesticide, the Contractor shall obtain permits and approval from the jurisdictional authority for the proposed material and for the rate of application.

a. The Contractor shall submit material safety data sheets for herbicides and pesticides in accordance with the requirements of Section 01600, “Product Requirements”.

b. The Contractor shall be responsible for protecting plants, on or off the site, from damage by spraying operations. Weed control shall be performed as often as required to maintain the project in a neat and weed-free condition.

G. Watering shall be adequate to provide maintenance of healthy plant growth, and shall be controlled to prevent over saturation of soil leading to plant failure. Basins, where required, and basin walls shall be kept well formed.

H. Trees, shrubs, and ground cover shall be maintained by regular watering, cultivating, and weeding. Stakes and ties shall be repaired as needed. Plants shall be sprayed for insect pests and pruned as necessary or when requested by the Contracting Officer. Damaged, unhealthy or dead trees, shrubs and ground cover shall, upon discovery of loss or damage, be replaced immediately with new stock of a size to match the remaining healthy plants of the same variety.

I. Until the end of the Plant Establishment Period, plants which are damaged by herbicide, diseased, dead, or which are in an unhealthy condition exhibiting weakness and the probability of dying, shall be replaced within two weeks after notification from the Contracting Officer. Replacements of plants shall be made in the same manner as specified for the original planting.

J. On the last day of the Plant Establishment Period, complete the weeding and raking of planting areas. The site shall be cleared of debris and presented in a neat and orderly condition. Plants shall be in a healthy, thriving condition. Stakes shall be vertical. Paved areas shall be broom cleaned, and areas damaged by erosion shall be repaired, including the replacement of plants.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.1 GENERAL**

A. The work specified in this section will not be measured separately for payment, but all costs in connection therewith will be considered incidental to the work specified in other 02900 Series Sections such as Section 02910, “Topsoil and Finished Grading”.

END OF SECTION 02900
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes specifications for finished grading including addition of sandy loam and compost in preparation for planting.

1.2 REFERENCED STANDARDS

A. US Composting Council (USCC)
   1. Test Methods for Examination of Composting and Compost (TMECC)
      a. TMECC 02.02-B Sample Sieving for Aggregate Size Classification
      b. TMECC 04.06 Heavy Metals and Hazardous Elements
      c. TMECC 04.10-A 1:5Slurry Method, Mass Basis
      d. TMECC 04.11-A 1:5 Slurry pH
      e. TMECC 05.05-A Seedling Emergence and Relative Growth
      f. TMECC 05.07-A Loss on Ignition Organic Matter Method
      g. TMECC 05.08-B Carbon Dioxide Evolution Rate
      h. TMECC 07.01-B Fecal Coliforms

1.3 SUBMITTALS

A. Samples: Submit for testing two 1/2 cubic foot samples of the material proposed for sandy loam and compost.

B. Test Results: Submit certified test results for sandy loam and compost performed by an independent testing laboratory approved by the Authority certifying that the proposed material complies with the specifications. Contractor shall bear costs of the tests.

C. Documentation of permits for disposal of excavated material: (If required)
   1. Obtain written permits and releases from owners of property where material will be deposited in accordance with Section 02100, "Site Preparation".
   2. Submit copies of written permission and releases from owner of the property where excess materials and landscape waste shall be deposited. Submit copy of permission and releases to Contracting Officer seven calendar days prior to disposal of material.

1.4 QUALITY ASSURANCE

A. Notify the Contracting Officer and obtain Contracting Officer’s inspection and approval of product source prior to transporting materials.

1.5 JOB CONDITIONS

A. Existing Drainage:
   1. Refer to Section 01562, "Soil Erosion and Sediment Control", for related requirements.
   2. Preserve, protect, and maintain existing operable drains and sewers during grading operations.

B. Refer to Section 01500, "Temporary Facilities and Services" for requirements for barricades and other protective devices.

C. Location of Underground Facilities and Structures:
   1. Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.
   2. Verify locations of existing utilities in accordance with Section 02760, "Maintenance, Support and Restoration of Existing Utility Facilities".

D. Toxic, Hazardous, and Combustible Substances:
   1. Comply with the requirements of Section 01560 "Environmental Protection".
   2. During excavation, provide equipment and carry out such tests as necessary to detect presence of toxic, hazardous, and combustible substances.
   3. Take action to safeguard persons and property in accordance with rules and regulations of jurisdictional agencies and utility owners.
   4. Promptly notify utility owners when problems concerning their facilities become apparent.
1.6 WARRANTY

A. Warranty of Construction required under the General Provisions shall include correction of settled, eroded, or rutted areas.

PART 2 - PRODUCTS

2.1 SANDY LOAM

A. Sandy loam: Friable, fertile, dark, loamy soil, free of clay lumps, subsoil, stones and other extraneous material and reasonably free of weeds and foreign grasses. Loam containing Dallisgrass or Nutgrass will be rejected.

B. Physical properties as follows:

1. Clay: Between 7 to 27 percent.

2. Silt: between 15 to 35 percent.

3. Sand: less than 52 percent.

4. Organic matter: between 2 to 12 percent of total dry weight.

5. pH: between 6.0 and 8.7.

C. Obtain sandy loam from naturally well-drained areas a uniform loam, which is free from subsoil, slag, brush, objectionable weeds and other litter, and free from clay lumps, stones, stumps, roots, or other objects larger than 1 inch in diameter. Sandy loam shall also be free from toxic substances and other material or substances which might be harmful to plant growth or be a hindrance to grading, planting and maintenance operations.

2.2 COMPOST

A. Compost that has been produced by aerobic (biological) decomposition of organic matter and meets the requirements set forth by the United States Department of Agriculture and the United States Composting Council (USCC), “Test Methods for the Examination of Composting and Compost” (TMECC), shown in Table 02910 - 1. Compost feedstock may include, but is not limited to, leaves and yard trimmings, biosolids, food scraps, food-processing residuals, manure or other agricultural residuals, forest residues, bark, and paper. Ensure compost and wood chips do not contain any visible refuse, other physical contaminants, or any substance considered to be harmful to plant growth. Do not use mixed municipal solid waste compost. Provide compost meeting all applicable United States Code of Federal Regulations (CFR), Title 40, Part 503 standards for Class A biosolids and Texas Commission on Environmental Quality (TCEQ) health and safety regulations as defined in the Texas Administrative Code (TAC), Chapter 332, including the time and temperature standards in Subchapter B, Part 23. Meet the requirements of the USCC Seal of Testing Assurance (STA) program.

Table 02910 - 1

<table>
<thead>
<tr>
<th>Physical Requirements for Compost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size: 95 percent passing 5/8 inch, 70 percent passing 3/8 inch in accordance with TMECC 02.02-B</td>
</tr>
<tr>
<td>Heavy Metals: Pass in accordance with TMECC 04.06</td>
</tr>
<tr>
<td>04.06-As, Arsenic 04.06-Hg, Mercury</td>
</tr>
<tr>
<td>04.06-Be, Beryllium 04.06-Mo, Molybdenum</td>
</tr>
<tr>
<td>04.06-Cd, Cadmium 04.06-Ni, Nickel</td>
</tr>
<tr>
<td>04.06-Cu, Copper 04.06-Se, Selenium</td>
</tr>
<tr>
<td>04.06-Pb, Lead 04.06-Zn, Zinc</td>
</tr>
<tr>
<td>Soluble Salts: 5.0 max.* dS/m in accordance with TMECC 04.10-A</td>
</tr>
<tr>
<td>pH: 5.5 – 8.5 in accordance with TMECC 04.11-A</td>
</tr>
<tr>
<td>Maturity: greater than 80 percent in accordance with TMECC 05.05-A</td>
</tr>
<tr>
<td>Organic Matter Content: 25 to 65 percent (dry mass) in accordance with TMECC 05.07-A</td>
</tr>
<tr>
<td>Stability: 8 or below in accordance with TMECC 05.08-B</td>
</tr>
<tr>
<td>Fecal Coliform: Pass in accordance with TMECC 07.01-B</td>
</tr>
</tbody>
</table>

* A soluble salt content up to 10.0 dS/m for compost used in CMT will be acceptable.

B. Before delivery of the compost, provide Quality Control documentation that includes the following:

1. The feedstock by percentage in the final compost product,

2. Statement that the compost meets federal and state health and safety regulations,

3. Statement that the composting process has met time and temperature requirements,

4. Copy of the producer’s STA certification, and

5. Copy of the lab analysis, performed by an STA-certified lab, verifying that the compost meets the requirements of Table 02910 - 1.

6. When furnishing biosolids compost, also provide a copy of the current TCEQ Compliance Statement signed by the facility manager.

C. Provide a designated project stockpile of unblended compost for sampling and testing at the producer’s site. Samples from each stockpile will be taken by the Department for Quality Assurance. Make payment to the STA-certified lab chosen by the Owner’s Representative for the required Quality Assurance testing.

D. Maintain compost in designated stockpiles at the producer’s site until accepted by the Owner’s Representative. The Owner’s Representative reserves the right to sample compost at the job site.
TOPSOIL AND FINISHED GRADING

PART 3 - EXECUTION

3.1 FINISHED GRADING

A. Finished grading: Finished grading shall consist of preparation of areas designated to be planted and addition and incorporation of sufficient quantity of Sandy Loam and Compost to bring areas to required finish elevation in accordance with Section 02220, “Grading, Excavating and Backfilling”.

B. Areas to receive sandy loam and compost shall be ripped to depths shown in details over areas modified by work of this contract which are not covered by building, walk or paving.

C. Place sandy loam and compost in areas ripped to depth shown in detail of area to be modified and till into existing soils until sandy loam and compost are uniformly distributed. Areas to be modified are to be tilled and amendments thoroughly mixed with existing soils to depths as shown on drawings.

D. When weeding and soil conditioning have been completed and soil has been thoroughly water settled, landscaped areas shall be finish graded for placement of plant materials. Grading shall be performed when the soil is at an optimum moisture content for working.

E. Uniformly distribute soil mixture to required grades; feather back to where grades remain unchanged.

F. Finished grades shall be in accordance with the grading details for mounding in landscaped areas. Landscaped areas shall slope uniformly for positive drainage.

G. Grades not otherwise indicated shall be uniform levels or slopes between points where elevations are given, or between points established by walks, paving, curbs or catch basins. Finish grades shall be smooth, even, and on a uniform plane with no abrupt change of surface and no erosion scars.

H. Grading shall provide for natural runoff of water without low spots or pockets. Flow line grades shall be accurately set and shall be not less than two percent gradient unless otherwise indicated or approved by the Contracting Officer.

I. Finish grade of earth in landscaped areas shall be one inch below the top of adjacent pavement, curbs or headers, unless indicated otherwise on the Contract Drawings. Finish grade of earth shall be one inch below the top of pull and utility boxes or utility structures. Pull and utility boxes shall be adjusted by raising or lowering to conform with grading requirements in landscaped areas.

J. Tops and toes of slopes shall be rounded to produce a gradual and natural-appearing transition between relatively level areas and slopes.

K. Protect areas against compaction by construction equipment.

L. Use water to settle areas being modified and repair settled, eroded, or rutted areas through fine grading process to achieve finish grades. Add soil mix as needed after settling to maintain finish grades.

M. Remove rubbish, vegetation and rocks over one inch in diameter. Rake areas smooth and leave suitable for establishment of lawns and planting. Correct irregularities and areas where water will stand.

N. Place Soil Mix in the platform tree wells in 6 inch compacted lifts.

O. Non lime treated native soil from on–site stockpile may be used for parking lot island.

3.2 PROTECTION

A. Protect newly graded areas from traffic and erosion; keep free of trash and rubbish.

B. Repair settled, eroded or rutted areas.

3.3 FIELD QUALITY CONTROL

A. Allowable Tolerance:

1. Construct finished grade: 0.1 foot plus or minus the elevation shown, or top of curb.

2. Construct finished grades in landscape areas as follows:

   a. Sod areas: 0.2 foot below established finished grade.

   b. Seed areas: 0.1 foot below established finished grade.

3.4 FINISHING

A. On completion of work, clean ditches and channels.

B. Slope and shape areas to provide positive drainage. Crown parking lot islands for positive drainage.

C. Remove and dispose of unsuitable soil and surplus excavated materials in accordance with Section 02220, “Grading, Excavating, and Backfilling”.

D. Leave Site in neat, presentable condition.

E. Protect newly graded areas from traffic and erosion; keep free of trash and rubbish.

F. Continue repair of settled, eroded or rutted areas and maintain finish grade until such time that turf is established in lawn areas or plant materials have rooted in bedding areas.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be measured and paid for at the unit price per cubic yard (loose volume on truck) for "Sandy Loam" and "Compost".

B. Measurement will not include additional yardage caused by slips, slides, cave-ins, settling, or fill material due to the action of the elements or the carelessness of the Contractor.

END OF SECTION 02910
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing topsoil, fine grading, temporary and permanent seeding, and sodding at irrigated areas.

B. Temporary seeding is specified in Section 01562, “Soil Erosion and Sediment Control”.

C. Seeding and sodding at non-irrigated areas refer to Section 02931, “Seeding and Sodding - Non-Irrigated Areas”.

D. Facilities Contractor shall provide temporary seeding of station sites.

E. Landscape Contractor shall install permanent turf grass indicated on landscape drawings.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M140 - Standard Specification for Emulsified Asphalt
   2. AASHTO M208 - Standard Specification for Cationic Emulsified Asphalt

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C33 - Standard Specification for Concrete Aggregates
   2. ASTM C51 - Standard Terminology Relating to Lime and Limestone (as Used by the Industry)

C. Texas Department of Agriculture
   1. Texas Administrative Code (TAC) Title 4, Part 1, Chapter 9 – Seed Quality

1.3 SUBMITTALS

A. Samples and Certification: Submitted in accordance with Table 02930 - 2, at the end of this section, and as follows:
   1. Seed: Each seed bag bearing the following upon delivery:
      a. Analysis tag.
      b. Certification tag.
   2. Sod: Certified, each delivery bearing a certification tag and label as required by law.

3. Fertilizer: Labeled with manufacturer’s name and address, guaranteed analysis, including nutrient and its derived source, listing of potential acidity, and toxic materials.

4. Mulch: Labeled with manufacturer’s name and address, material components, trademark, chemical analysis, species, age and source.

5. Sandy Loam and Compost: Submit supplier’s name and address and source of topsoil. Submit certified report of soil laboratory test results listing textures, pH, P and K nutrients, soluble salt, organic matter and mechanical analysis as to percentage of sand, silt and clay. Do not deliver topsoil to site until approved. Approval does not constitute final acceptance. See Section 02910, “Topsoil and Finished Grading”.

6. Herbicide: Labeled with manufacturer’s name and address and chemical analysis.

1.4 SOIL ANALYSIS REPORT

A. Provide soil tests which include the following requirements:
   3. Particle Size/Appraisal: pH, salinity, organic percent, USDA Particle size.

1.5 PRODUCT INSPECTION, DELIVERY, STORAGE, AND HANDLING

A. Materials and supplies are subject to inspection and sampling for testing. Allow no seed, sod, fertilizer, straw, or other agronomic materials or supplies on Worksite other than those for the Project.

B. Seed: Deliver with labels and tags.

C. Sod:
   1. Deliver sod to job within 24 hours after being cut; place sod within 36 hours after being cut.
2. Prior to and after delivery during wet weather, allow sod to dry to the extent that will prevent tearing during handling and laying. During dry weather, water sod to ensure its vitality and prevent dropping of the soil in handling.

PART 2 - PRODUCTS

2.1 SEED

A. Provide seed free of quack grass, bent grass, clover, dock, cheat, chess, chickweed, dallisgrass, plantain, black medic, red fescue, and tall fescue.

B. Refer to plan for areas scheduled for sodding, drill seeding, broadcast seeding, hydroseeding or hydromulching.

C. Lawn Seed:
   1. Bermuda grass (Cynodon dactylon) or variety specified on drawings.
   2. Buffalo grass (Buchloe dactyloides) “Topgun” Primed KNO3 or variety specified on drawings.

D. Buffalo grass seed shall be pre-treated by soaking the seed for 24 hours in a 0.5 percent solution of potassium nitrate, then storing in moist environment at 41 degrees Fahrenheit for 4 to 6 weeks followed by drying rapidly at temperature not to exceed 110 degrees Fahrenheit.

E. Native Grass and Wildflower seed: Each wildflower species must meet minimum purity standard of 95 percent. Each species must be labeled and indicate percent germination, germination test date and quantity supplied. Submit seed vendor’s certification for required percentage of purity and germination
   1. Germination shall include hard seed and/or firm seed and/or dormant seed as determined by an approved certified seed testing laboratory.
   2. Seed must meet the requirement of the TAC Title 4, Part 1, Chapter 9, including testing and labeling for bulk seed.
   3. Seed shall be of the previous season’s crop and within 7 months prior to the planting date.
   4. Seed must be labeled and free of noxious weeds. Each seed container must have at least 1 approved Department of Agriculture seed tag on the inside of the container and one secured to the outside of the container. The seed tags shall indicate the botanical name, common name, purity and germination as specified the TAC Title 4, Part 1, Chapter 9. Wildflower seed must be delivered in a separate container for each species.

5. Seed shall be incorporated into the soil with a drill-type seeder, specifically calibrated for each size and type of seed used to guarantee uniform distribution of each species. Substitute application must guarantee uniform distribution, germination and full stand.

2.2 SOD

A. Well-rooted certified sod, at least 18 months old.
   Variety: Buffalo grass (Buchloe dactyloides) “Prairie”, or “Midiron” Bermuda grass (Cynodon dactylon) or variety specified on drawings. Refer to drawing for location.

B. Sod and attached soil free from noxious weeds such as quack grass, garlic, Johnson grass, Canada thistle, and other turf weeds.

C. Mowed in production field to height of not more than 2-1/2 inches within 5 days prior to lifting.

D. Machine cut in sections not less than 2-1/2 feet neither in length nor less than 12 inches in width and to a depth equal to growth of fibrous roots, uniform soil thickness of 3/4 inch, plus or minus 1/4 inch. Measurement for thickness to exclude top growth and thatch.

E. Cut in sections or strips strong enough to support its own weight and retain size and shape when suspended vertically from firm grasp on upper 10 percent of section. Small, irregular or broken pieces of sod are prohibited. Sod on Beck Roll is permitted.

2.3 OTHER MATERIALS

A. Fertilizer: For grass seeded and sodded areas: Approved commercial fertilizer 10-20-10.

B. Mulch:
   1. Wood cellulose fiber:
      a. Containing no growth or germination inhibiting factors and dyed green.
      b. Fibers furnished air-dry in packages not exceeding 50 pounds gross, with net weight shown on package.
   2. Straw: Wheat, barley, oat or rye straw, threshed, air-dried, and free from Canada thistle, dock, Johnson grass, and other foreign matter.
      a. 180-foot lengths or greater.
SEEDING AND SODDING - IRRIGATED AREAS

b. U-shaped staples: As standard with mulch blanket manufacturer.

C. Mulch with Tackifier:

1. Virgin wood fiber mulch with tackifier:
   a. Degradable, pure virgin wood fiber, made from whole wood chips with tackifier incorporated in the mulch from the mulch manufacturer. The mulch must be free from weeds, containing no growth or germination inhibiting factors or other foreign matter toxic to seed germination. Mulch must be suitable for hydromulching and dyed green.
   b. Acceptable product is available from Conwed, Weyerhaeuser and Camfor.

2. Apply mulch at minimum rate of 2000 pounds per acre (or 50 pounds per 1000 square feet). Cover seeded slopes where grade is 4 inches per foot or greater with tackifier at increased rate of 3000 pounds per acre (or 75 pounds per 1000 square feet).

D. Mulch Binder:


2. Synthetic binder for use with wood cellulose fiber or straw: Equal to Terra Tack 1, Grass Growers, Plainfield, New Jersey 07061; Soil Gard, Alco Chemical Company, Philadelphia, Pennsylvania 19013.

E. Fertilizer - For seeded and sodded areas: Approved commercial fertilizer applied at rate to distribute 2 pounds of nitrogen and 1 pound of phosphorous per 1000 square feet.

PART 3 - EXECUTION

3.1 APPROVAL OF AREAS

A. Delineate the areas scheduled for seeding and sodding on the site using the drawing to scale the shape and sizes of the planting areas for each mix.

B. The Contracting Officer shall approve the areas delineated to receive seed or sod prior to planting.

3.2 PREPARING SOIL AND FINE GRADING

A. Note: During hauling operations, keep walkway and roadway surfaces clean. Promptly remove sandy loam or other material.

B. After completion of construction work in the area, prepare surface of subsoil. Scalp areas that were planted with Avena oats or temporary seeding. Finish to lines shown and parallel to proposed finished grade as approved. Remove rocks and other foreign materials 1 inch or greater in any dimension.

3.3 SOIL PREPARATION

A. Soil shall be loosened and pulverized to prepare an acceptable bed for seed and sod. Pulverize soil with disc, chisel plow, tiller or other method approved by Contracting Officer, making minimum of one pass to break up clods. Do not till if soil is wet. Do not penetrate soil deeper than two inches so as not to encourage weed growth.

B. Soil Amendments, Fertilizers, and Cultivating:

1. Provide soil amendments, chemicals, and fertilizers herein before specified for both imported and approved on-site soils. These are minimum requirements. Provide such additional amendments and chemicals as are required by the Soil Reports.

2. Spread soil amendment and fertilizer evenly over ground cover areas at the following rates:
   a. Soil Amendment: As specified on the drawings
   b. Fertilizer: As specified above.

3. After approval of amendment and fertilizer applications by the Contracting Officer, incorporate soil amendments and fertilizers into the soil by repeated rotary-hoe cultivation at depth specified on drawings.

C. Watering: At completion of soil amendment and fertilizer installation, water the soil in landscaped areas for a period of 14 days. Maintain sufficient soil moisture to induce weed seed germination, but not to saturate the soil. Soil shall be moist to a minimum depth of 24 inches. In locations where irrigation is by drip or bubblers, the Contractor may, at its option and expense, install a temporary irrigation system to keep the soil moist.

D. Fine grade, level and scarify with a weighted spike harrow, spike float drag, or by hand raking. Leave no depressions, ruts, soft spots or humps. Finish to lines or elevations shown and parallel to proposed finished grade, as approved. Maintain positive drainage on site. Remove rocks, clods, weeds, trash or debris from area to be seeded or sodded. Legally dispose debris off site.
3.4 HERBICIDE APPLICATION

A. Herbicide Application:

1. At the end of the watering period, spray the area with an Contracting Officer-approved herbicide.

2. Apply herbicide according to the manufacturer's written application instructions. Alternate weeding methods may be used upon approval of the Contracting Officer.

3. Area scheduled for wildflowers, native grasses and buffalo grass: Totally remove grasses and weeds, unless directed otherwise by Contracting Officer. Apply a non-selective herbicide (e.g. “Roundup” or approved equal) to thoroughly exterminate existing grasses, weeds, or other vegetation (unless noted on the drawing for protection) in area scheduled to receive seeding or hydromulching for grasses or wildflowers.

4. Area scheduled for native grasses: Use a selective herbicide or post-emergent herbicide for spot application to remove dallisgrass, crabgrass, Johnson grass, nutsedge, dandelion and other noxious weeds identified in the field by the Contracting Officer. If native grasses exist on the site, verify with Contracting Officer if they are to remain or to be eliminated.

B. Pre-Emergent Herbicide Application:

1. Pre-emergent herbicide shall be applied to landscaped areas, including plant basins. Apply prior to mulching.

2. Pre-emergent herbicide shall be applied only when winds, if present, do not exceed 5 miles per hour.

3.5 LAWN SEEDING

A. After soil preparation and weed removal is approved by the Contracting Officer, commence with seeding for buffalo grass, Bermuda grass, or ryegrass.

B. Timing: If weeds should germinate prior to seeding, re-apply herbicide to eradicate weeds. The following lawn grasses should be seeded within these respective dates:

1. Bermuda grass and Buffalo grass: May 1 - August 1

C. Seeding: Clean seeders as approved prior to starting work. Apply seed mixture directly after fertilizing with Brillion seeder, drill seeder, or other approved mechanical seeder at rate specified for various areas.

D. Buffalo grass: Drill seeding with hydromulch cap: (Minimum 2 applications in lawn areas). Preferred method to be used in seeding unless written approval received for alternate method.

1. Drill seed or broadcast buffalograss seed in designated area using two pounds pure live seed per 1000 square feet for lawn area; one pound pure live seed per 1000 square feet for wildflower and native grass area. Incorporate seed into soil to a depth of 1/4 inch to 1/2 inch. Roll and wet seeded areas prior to mulching.

2. Finish as follows:

a. Lawn areas with slopes less than 3:1: Raked surface.

b. Roadside area with slopes less than 3:1: Scarified surface.

c. Slopes 3:1: or greater: Leave surface of topsoil in irregular condition with ridges running parallel to contour of slope to prevent erosion.

d. Rolling: Directly after seeding, roll lawn areas with slopes less than 3:1 using approved lawn roller, weighing 40 to 60 pounds, per foot of width, unless intervening precipitation would cause such rolling to be detrimental.

3. Apply a Hydromulch cap over seeded area at specified rate.

4. Reseed entire area scheduled for lawn (unless approved otherwise) within 30 to 45 days of first seeding at rate approved by the Contracting Officer based upon extent of establishment of first seeding. Do not reapply buffalo grass in areas to receive wildflowers or native grasses.

5. Spot seed bare spots in lawn area remaining every 2 weeks in order to establish healthy stand of buffalo grass with 100 per cent coverage of the area within 120 days.

6. Do not sow immediately following rain, when ground is too dry, or during windy periods.

7. Cover seeded slopes where grade is 4 inches per foot or greater with tackifier at increased rate of 3000 pounds per acre.

8. Replacement: Replant areas of lawn as needed in order to achieve 100 per cent coverage within the specified time frame to establish the lawn.

9. Reapply fertilizer at specified rate every 3 to 4 weeks for 3 months in lawn area.
E. Bermuda grass: Hydroseeding:

1. Spraying equipment: Use conventional hydromulch equipment as manufactured by Bowie Machine Works, or approved equal. Clean hydroseeders as approved prior to coming on site. Use water tank equipped with liquid-level gauge calibrated in increments no larger than 50 gallons over entire range of tank capacity with gauge visible to nozzle operator. Use tank equipped with agitation system capable of maintaining solids in complete suspension until used.

2. Fertilizing and seeding:
   a. Apply fertilizer at specified rate.
   b. Apply seed in designated area using 1.5 pounds pure live seed per 1000 square feet.
   c. Mix seed and fertilizer together in proportions specified, add mulch to seed and fertilizer mixture. Wood cellulose fiber at the rate of 50 pounds per 1,000 square feet.

3. Agitate mixtures constantly from time mixed until application. Use mixtures within eight hours after mixing.

4. Application method:
   a. Spray mixtures of seed and commercial fertilizer on previously prepared seed beds.
   b. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Directing nozzle of hand-held hose toward ground in manner that would produce erosion or runoff is prohibited.
   c. Make uniform application at specified rate to prevent misses.
   d. Utilize batter board against planting beds, walks, signs or structures.

5. Reseed bare area scheduled for lawn (unless approved otherwise) within 30 to 45 days of first seeding at rate approved by the Contracting Officer’s Technical Representative based upon extent of establishment of first seeding.

6. Spot seed bare spots remaining every 2 weeks in order to establish healthy stand of Bermuda grass with 100 percent coverage of the areas within 120 days.

7. Do not sow immediately following rain, when ground is too dry, or during windy periods.

8. Cover seeded slopes where grade is 4 inches per foot or greater with tackifier at increased rate of 3000 pounds per acre.

9. Replacement: Replant areas of lawn as needed in order to achieve 100 percent coverage within the specified time frame to establish the lawn.

10. Reapply fertilizer at specified rate every 3 to 4 weeks for 3 months.

3.6 WILDFLOWER AND NATIVE GRASS SEEDING

A. Weed removal: Use selective herbicide on entire area OR post-emergent herbicide for spot application to remove dallisgrass, crabgrass, Johnson grass, nutsedge, dandelion and other weeds listed in Section 02950, “Landscaping - Planting”. Do not injure buffalo grass seeded in area. Native grasses existing on the site, such as switchgrass, little bluestem, lovegrass or other grasses designated on the plan or identified in the field by the Landscape Architect, shall not be eliminated by herbicide treatment.

B. The areas designated as wildflower or native grass planting areas shall be “scalped”, i.e., mowed to a maximum height of one inch above the existing ground level and cut material removed and disposed of as directed by the Contracting Officer.

C. Do not disk, plow or disturb the soil greater than 1 inch in depth so as to not release dormant seed within the subsoil.

D. Drill seed or broadcast seed wildflowers and native grasses in designated areas.

E. Time of seeding:
   1. Wildflowers: September 15 - October 31.
   2. Native grasses: April 1 - May 31 or September 1 - October 31. (Some species may need to be planted no later than August 15)

F. The wildflower and grass seed shall be uniformly and evenly distributed over the areas shown on the plans. Broadcast only one species at a time. The planting method used shall insure that the seed make positive contact with the soil but shall not be planted deeper than the seed size of the species being planted. Apply 1 part wildflower seed with 4 parts damp, masonry sand and tamp into soil (except bluebonnet seed).

G. Apply hydromulch cap as specified for buffalo grass.
H. Do not sow immediately following rain, when ground is too dry, or during windy periods.

I. Seed Protection:
1. Identify seeded areas with stakes and string around area periphery. Set string at minimum height of 12 inches. Space stakes at maximum 20 feet o.c.
2. Cover seeded slopes where grade is 4 inches per foot or greater with tackifier at increased rate of 3000 pounds per acre.

J. Replacement: Replant areas of native grasses or wildflowers as needed in order to achieve 100 per cent coverage within one year of final acceptance.

3.7 SODDING

A. Sod bed preparation: Apply fertilizer at a per-acre rate determined by approved soil test and mix to depth of 4 inches minimum.

B. Laying Sod:
1. Time frame for laying sod is year round if needed, except under conditions noted below.
   a. Lawn areas: Sod varieties identical to Seed Mixture No.1, Table 02930-3, at the end of this section.
2. Extend or reduce specified period as approved and as necessitated by weather and soil conditions.
3. Final selection of sod: As approved.
4. Do not lay sod when sodding area is muddy or frozen or when sod is frozen. When soil surface is hot or dry, wet soil to a depth of 2 inches, 6 to 8 hours prior to sodding.
5. Lift sod from trucks or storage piles and place by hand with close joints and no overlapping. When Beck Roll of sod is used, lay as specified and in accordance with the supplier’s instructions.
6. Lay first row of sod in straight line. Place subsequent rows parallel to and tightly against each other. Stagger lateral joints to promote more uniform growth and strength. Do not stretch sod. On slopes, lay sod parallel to contours of slope.
7. Peg sod placed on slopes 3:1 or greater. Peg each strip or section of sod with at least two stakes not more than 2 feet apart. Use stakes 1/2 inch by 1 inch by 12 inches driven flush with top of sod so that roots are in contact with topsoil.
8. Water sod immediately to prevent excessive drying during progress of work. Sod which dries out will be rejected.
9. Roll entire area as sodding is completed in one section so that sod is without surface irregularities, such as depressions and high spots.
10. Irrigate immediately after rolling to wet underside of sod and 1 inch of soil immediately below.

3.8 ESTABLISHMENT PERIOD AND REPLACEMENT

A. The establishment period for seeding of grasses shall commence during installation and continue until final acceptance.

1. The establishment period for sodded areas shall commence at completion of sodding and continue for a minimum of 60 days.
2. The establishment period for seeded areas shall commence at completion of first seeding and continue for a minimum of 100 days.

B. Maintain seeding, sodding and incidental work by performing the following and other operations of care necessary for promotion of growth so that work is in an approved condition throughout maintenance period: uniform in color, quality, and coverage; and free of weeds, insects, diseases, surface damage, and other imperfections.

1. Watering: Provide labor and materials for establishment watering. A partial underground irrigation system will be in place in seeded areas.
   a. First 2 to 3 weeks: Perform watering daily to keep seed beds continuously moist and to maintain moist topsoil to a depth of at least 4 inches. Water during heat of day to help prevent wilting. Water with frequent, light watering and avoid runoff or puddling. Water may be needed more than once a day depending on weather conditions. Water to insure germination and root growth for reseeding work.
   b. Remaining weeks: Perform watering weekly, decreasing frequency and increasing amount per application to encourage deep root growth. Water more frequently as needed for germination of reseeding. Water during heat of day to help prevent wilting.
C. Eliminate weeds that emerge after seeding in a timely fashion mechanically and/or chemically. Use a herbicide that will not injure the newly seeded grass and apply according to manufacturer's recommendations. The Contractor should allow for a minimum of two herbicide applications of areas scheduled for grasses during the maintenance period. Weeds that are taller than Bermuda grass seedlings should be mowed to a 2 to 3 inch height.

D. Mowing: Lawn grass
   1. Mow Bermuda and Buffalo grass when it reaches a height of 4 inches. Do not mow until seed is firmly rooted and securely in place. Mow to height of 2 inches at first cutting. Thereafter, for Bermuda grass do not remove more than 1/3 of grass leaf at any cutting and mow only to enhance root growth. After Bermuda grass is established, mow every 10 days until final acceptance.
   2. Mow Buffalo grass after first mowing only as needed to help control weed growth.
   3. After the first mowing of the grasses, apply fertilizer at specified rate.

E. Edging: Edge walks during alternate mowings.

F. Rolling: Roll to maintain uniform surface.

G. Fertilizing:
   1. Bermuda and Buffalo grass: After performing initial fertilizing to establish grass, continue to apply fertilizer at specified rate once every three months until final acceptance. Contractor to allow for three fertilizations subsequent to initial fertilization.

H. Applying herbicides, fungicides or insecticides:
   1. Apply as needed to insure 100 percent coverage of turf grass that is weed, disease and pest free.
   2. Apply in spray form by certified applicator.
   3. Do not apply when temperature exceeds 80 degrees F or during periods of drought.
   4. Treat fire ant mounds as they appear.

I. Replacing seeding:
   1. During maintenance period, replace seeded areas that are dead or are in an unhealthy, unsightly, or badly impaired condition as soon as possible during specified planting seasons.
   2. Make such replacements in the same manner as specified for original seeding.

J. Coordinate watering schedules with other plantings during installation and until final the contract.

K. The establishment period for seeding and sodding shall commence during installation and continue until final acceptance.
   1. For seeded areas: Establishment period shall consist of 100 days minimum.
   2. For sodding 45 days.

L. Maintain seeding, sodding, and incidental work by performing the following and other operations of care necessary for promotion of growth so that work is in an approved condition throughout establishment period; uniform in color, quality, and coverage; and free of weeds, insects, diseases, surface damage, and other imperfections.

M. See Section 02981, “Landscape Maintenance - Irrigated Areas” for specific instructions.

N. Replacing seeding and sodding:
   1. During maintenance period, replace seeded and sodded areas that are dead or are in an unhealthy, unsightly, or badly impaired condition as soon as possible during specified planting seasons.
   2. Make such replacements in the same manner as specified for original seeding and sodding.

3.9 TEMPORARY LAWN SEEDING (ADD ALTERNATE TO BID)

A. Temporary Lawn Seeding: Depending on construction schedule, it may be necessary to establish temporary lawn to prevent erosion and provide an acceptable appearance of areas scheduled to receive lawn. A temporary lawn will be required in those areas designated for lawn grass for which installation must be delayed until the specified seeding dates. Lawns must be accepted after June 1 and prior to November 15, otherwise a temporary lawn must be installed. Perform seeding, fertilizing, watering, weeding and other maintenance to insure full coverage of temporary lawn.

   1. Eliminate weeds from areas to be seeded as specified in Article 3.4.

   2. Broadcast perennial rye grass seed over entire area at the rate of 10 pounds P.L.S. per 1,000 square feet.

   3. Broadcast or Pneumatic blow seed mixed with Compost Mix over areas to be seeded to a depth of 1-1/4 inch depth after natural settlement and will conform to minus 3/4 inch from finish lines, grades and elevations.
4. Water all seeded areas to establish full stand within 60 days. Do not allow areas to become dry, or water to the extent that seed will be lost by erosion.

5. When it is time to install the permanent turf grass or other planting in these areas, kill the temporary lawn with herbicide and scalp to height of 1/2 inch to receive new grass seed.

6. Broadcast spreading or Pneumatic blow permanent turf grass seed mixed with Compost Mix over areas to be seeded to depth which will produce a 3/4 inch depth after natural settlement and will bring soil to finish lines, grades and elevations.

3.10 CLEAN-UP

A. Daily removal of rubbish and debris caused by this work from the site.

B. Keep site clean during establishment period.

3.11 FINAL ACCEPTANCE

A. Due to seasonal requirements, final acceptance of this section may not coincide with that of the remaining contract work.

B. Request inspection for final acceptance at least 10 calendar days before the end of the maintenance period.

C. Final acceptance shall be considered the time at which sodding and seeding, cleanup, and maintenance period are 100 percent completed.

D. Replace rejected seeded and sodded areas as specified so that repair or replacement is rooted and established prior to approval.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Seeding and sodding described in this section will not be measured, but will be paid for at the lump sum prices for “Seeding for Irrigated Areas” and “Sodding - Irrigated Areas”, for each mixture, including fertilizer, mulch, and related items.

B. The lump sum prices for “Seeding” and “Sodding” will include any supplemental reseeding or resodding needed to achieve full coverage for Final Acceptance.

C. Temporary seeding will not be separately measured and shall be considered as incidental to the work of the Contract.

---

**TABLE 02930-3**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>MINIMUM GUARANTEED PURITY</th>
<th>MAXIMUM WEED SEED AND OTHER CROP</th>
<th>MINIMUM GUARANTEED GERMINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italian Annual Rye Lolium multi-florum</td>
<td>98%</td>
<td>0.2%</td>
<td>95%</td>
</tr>
<tr>
<td>Certified Kentucky 31 Tall Fescue Festuca elatior arundinacea</td>
<td>98%</td>
<td>0.2%</td>
<td>85%</td>
</tr>
<tr>
<td>Common Bermuda Cynodon dactylon</td>
<td>98%</td>
<td>0.2%</td>
<td>85%</td>
</tr>
<tr>
<td>Buffalo grass Buchloe dactyloides “Topgun KNO3”</td>
<td>98%</td>
<td>0.2%</td>
<td>85%</td>
</tr>
<tr>
<td>Oats Avena spp</td>
<td>98%</td>
<td>0.2%</td>
<td>85%</td>
</tr>
</tbody>
</table>

END OF SECTION 02930
SECTION 02931
SEEDING AND SODDING - NON-IRRIGATED AREAS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing temporary and permanent seeding and sodding for non-irrigated areas.
B. Temporary seeding is specified in Section 01562, "Soil Erosion and Sediment Control".

1.2 REFERENCE STANDARDS
A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M140 - Standard Specification for Emulsified Asphalt
   2. AASHTO M208 - Standard Specification for Cationic Emulsified Asphalt
B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C33 - Standard Specification for Concrete Aggregates
   2. ASTM C51 - Standard Terminology Relating to Lime and Limestone (as Used by the Industry)

1.3 SUBMITTALS
A. Samples and Certification: Submitted in accordance with Table 02931 - 1, at the end of this section, and as follows:
   1. Seed: Each seed bag bearing the following upon delivery:
      a. Analysis tag.
      b. Certification tag.
   2. Sod: Certified, each delivery bearing a certification tag and label as required by law.
   3. Fertilizer: Labeled with manufacturer's name and address, guaranteed analysis including nutrient and its derived source, listing of potential acidity, and any toxic materials.
   4. Mulch: Labeled with manufacturer's name and address, material components, trademark, chemical analysis, species, age and source.
   5. Herbicide: Labeled with manufacturer's name and address and chemical analysis.

1.4 PRODUCT INSPECTION, DELIVERY, STORAGE, AND HANDLING
A. Materials and supplies are subject to inspection and sampling for testing. Allow no seed, sod, fertilizer, straw, or other agronomic materials or supplies on Worksite other than those for the Project.
B. Seed: Deliver with labels and tags.
C. Sod:
   1. Deliver sod to job within 24 hours after being cut; place sod within 36 hours after being cut.
   2. Prior to and after delivery during wet weather, allow sod to dry to the extent that will prevent tearing during handling and laying. During dry weather, water sod to ensure its vitality and prevent dropping of the soil in handling.

PART 2 - PRODUCTS

2.1 SEED
A. Except where specified in Table 02931 - 2, at the end of this section, provide seed free of quack grass, bent grass, clover, dock, cheat, chess, chickweed, dallisgrass, plantain, black medic, red fescue, and tall fescue.
B. Grass Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing and as specified in Table 02931 - 2.

2.2 SOD
A. Well-rooted certified sod, at least 18 months old. Provide "Prairie" Buffalograss (Buchloe dactyloides), "Midiron" Bermudagrass (Cynodon dactylon), or as specified on the drawings or approved equal.
B. Sod and attached soil free from noxious weeds such as quack grass, garlic, Johnson grass, Canada thistle, and other turf weeds.
C. Mowed in production field to height of not more than 2-1/2 inches within five days prior to lifting.
D. Machine cut in sections not less than 2-1/2 feet neither in length nor less than 12 inches in width.
SEEDING AND SODDING - NON-IRRIGATED AREAS

and to a depth equal to growth of fibrous roots, uniform soil thickness of 3/4 inch, plus or minus 1/4 inch. Measurement for thickness to exclude top growth and thatch.

E. Cut in sections or strips strong enough to support its own weight and retain size and shape when suspended vertically from firm grasp on upper 10 percent of section. Small, irregular or broken pieces of sod are prohibited. Sod on Beck Roll is permitted.

2.3 OTHER MATERIALS

A. Fertilizer: Approved commercial fertilizer applied at rate to distribute 2 pounds of nitrogen and 1 pound of phosphorus per 1000 square feet.

B. Mulch:

1. Wood cellulose fiber:
   a. Containing no growth or germination inhibiting factors and dyed green.
   b. Fibers furnished air-dry in packages not exceeding 50 pounds gross, with net weight shown on package.

C. Mulch with Tackifier:

1. Wood cellulose fiber mulch with tackifier:
   a. Degradable, pure virgin wood fiber, made from whole wood chips with tackifier incorporated in the mulch from the mulch manufacturer. The mulch must be free from weeds, containing no growth or germination inhibiting factors or other foreign matter toxic to seed germination. Mulch must be suitable for hydromulching and dyed green.
   b. Acceptable product is available from Conwed, Weyerhauser and Camfor.
   c. Apply mulch at minimum rate of 2000 pounds per acre (or 50 pounds per 1000 square feet). Cover seeded slopes where grade is 4 inches per foot or greater with tackifier at increased rate of 3000 pounds per acre (or 75 pounds per 1000 square feet).

D. Mulch Binder:


2. Synthetic binder for use with wood cellulose fiber or straw: Equal to Terra Tack 1, Grass Growers, Plainfield, New Jersey 07061; Soil-Gard, Alco Chemical Company, Philadelphia, Pennsylvania 19013.

E. Mulch blanket: Knitted construction of biodegradable yarn with uniform openings.

   1. 180-foot lengths or greater.
   2. U-shaped staples: As standard with mulch blanket manufacturer.

PART 3 - EXECUTION

3.1 PREPARING SOIL AND FINE GRADING

A. After completion of construction work in the area, prepare surface of subsoil. Scalp areas that have been planted with Avena spp (oats) or temporary sodding. Finish to lines shown and parallel to proposed finished grade.

3.2 SEEDING

A. Seed areas that are 3:1 slope or less.

B. Dry seeding:

1. This method shall be used only upon written request and approval of the Contracting Officer if hydroseeding is not possible.

2. Seed bed preparation: After placing topsoil as specified, proceed as follows:
   a. Fertilizing: Within 24 hours before seeding, apply fertilizer at specified rate using machine spreader.
   b. Fertilizer shall be uniformly mixed into the top 4 inches of soil by harrows, rotary tillers or other equipment necessary to satisfactorily implement work.
3. Seeding: Clean seeders as approved prior to starting work. Apply seed mixture directly after fertilizing with Brillion seeder, drill seeder, or other approved mechanical seeder at rate specified for various areas.

   a. Grass seed mixtures for sowing is specified in Table 02931-3, at end of this section.

      1) Sow grass seed Mixture No. One at minimum rate of 1.25 pounds per 1000 square feet.
      2) Sow grass seed Mixture No. Two at minimum rate of 5.5 pounds per 1000 square feet.

   b. Incorporate seed into soil to a depth of 1/4 inch to 1/2 inch. Roll and wet seeded areas prior to mulching.

   c. Finish as follows:

      1) Roadside area with slopes less than 3:1: Scarified surface.
      2) Slopes 3:1: or greater: Leave surface of topsoil in irregular condition with ridges running parallel to contour of slope to prevent erosion.
      3) Rolling: Directly after seeding, roll lawn areas with slopes less than 3:1 using approved lawn roller, weighing 40 to 60 pounds, per foot of width, unless intervening precipitation would cause such rolling to be detrimental.

C. Hydroseeding:

   1. Preferred method used in seeding unless written approval received.

   2. Spraying equipment: Use conventional hydromulch equipment as manufactured by Bowie Machine Works, or approved equal. Clean hydroseeders as approved prior to coming on site. Use water tank equipped with liquid-level gauge calibrated in increments no larger than 50 gallons over entire range of tank capacity with gauge visible to nozzle operator. Use tank equipped with agitation system capable of maintaining solids in complete suspension until used.

3. Fertilizing and seeding:

   a. Apply fertilizer at specified rate.

   b. Apply seed mixtures as specified in Table 02931-3, at end of this Section.

      1) Sow grass seed Mixture No. One at minimum rate of 1.25 pounds per 1000 square feet.
      2) Sow grass seed Mixture No. Two at minimum rate of 5.5 pounds per 1000 square feet.

   c. Mix seed and fertilizer together in proportions specified, add mulch to seed and fertilizer mixture. Wood cellulose fiber at the rate of 50 pounds per 1,000 square feet.

4. Agitate mixtures constantly from time mixed until application. Use mixtures within eight hours after mixing.

5. Application method:

   a. Spray mixtures of seed and commercial fertilizer on previously prepared seed beds.

   b. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Directing nozzle of hand-held hose toward ground in manner that would produce erosion or runoff is prohibited.

   c. Make uniform application at specified rate to prevent misses.

   d. Utilize batter board against planting beds, walks, signs or structures.

3.3 SODDING

A. Sod areas that exceed 3:1 slope or areas designated on the drawings.

B. Sod bed preparation:

   1. Place topsoil as specified.

   2. Apply fertilizer at a per-acre rate of 1,500 pounds per acre and mix to depth of four inches minimum.

   3. Compact topsoil with lawn roller or tractor roller to 3 inches of final compacted thickness as approved.
C. Laying Sod:

1. Time frame for laying sod is year round if needed, except under conditions noted below.
   a. Lawn areas: Sod varieties identical to Seed Mixture No. One, Table 02931 - 3, at the end of this section.

2. Extend or reduce specified period as approved and as necessitated by weather and soil conditions.

3. Final selection of sod: As approved.

4. Do not lay sod when sodding area is muddy or frozen or when sod is frozen. When soil surface is hot or dry, wet soil to a depth of 2 inches, six to eight hours prior to sodding.

5. Lift sod from trucks or storage piles and place by hand with close joints and no overlapping. When Beck Roll of sod is used, lay as specified and in accordance with the supplier’s instructions.

6. Lay first row of sod in straight line. Place subsequent rows parallel to and tightly against each other. Stagger lateral joints to promote more uniform growth and strength. Do not stretch sod. On slopes, lay sod parallel to contours of slope.

7. Peg sod placed on slopes 2:1 or greater. Peg each strip or section of sod with at least two stakes not more than 2 feet apart. Use stakes 1/2 inch by one inch by 12 inches driven flush with top of sod so that roots are in contact with topsoil.

8. Water sod immediately to prevent excessive drying during progress of work. Sod which dries out will be rejected.

9. Roll entire area as sodding is completed in one section so that sod is without surface irregularities, such as depressions and high spots.

10. Irrigate immediately after rolling to wet underside of sod and 1 inch of soil immediately below.

B. Establishing seed and sodding and incidental work by performing the following and other operations of care necessary for promotion of growth so that work is in an approved condition throughout maintenance period; uniform in color, quality, and coverage; and free of weeds, insects, diseases, surface damage, and other imperfections.

1. Watering: Provide labor and materials for establishment watering.
   a. First week: Perform watering daily to keep soil on sod pads continuously moist and to maintain moist topsoil to a depth of at least 4 inches. Water to prevent wilting or as approved. Water may be needed more than once a day depending on weather conditions.
   b. Remaining weeks: Perform watering weekly or as needed to keep grass from wilting and to promote growth.

2. Mowing:
   a. Do not mow until seed is firmly rooted and securely in place and has grown to height of four inches.
   b. Mow to height of two inches at first cutting. Thereafter, do not remove more than 1/3 of grass leaf at any cutting.
   c. Maintain Common Bermuda between height of 1-1/2 and 2-1/2 inches, unless otherwise directed.

3. Applying herbicides:
   a. Apply in spray form by certified applicator.
   b. Do not apply when temperature exceeds 80 deg. F or during periods of drought.

4. Replacing seed and sodding:
   a. During establishment period, replace seeded and sodded areas that are dead or are in an unhealthy, unsightly, or badly impaired condition as soon as possible during specified planting seasons.
b. Make such replacements in the same manner as specified for original seeding or sodding.

5. Rolling: Roll to establish and maintain uniform surface.

3.5 CLEAN-UP

A. Daily removal of rubbish and debris caused by this work from the site.

B. Keep site clean during maintenance period.

3.6 FINAL ACCEPTANCE

A. Due to seasonal requirements, final acceptance of this section may not coincide with that of the remaining contract work.

B. Request inspection for final acceptance at least 10 calendar days before the end of the maintenance period.

C. Final acceptance shall be considered the time at which seeding and sodding, cleanup, and establishment period are 100 percent completed.

D. Replace rejected seeded and sodded areas as specified so that repair or replacement is rooted and established prior to approval.

TABLE 02931-1

This chart indicates minimum length of time by which material samples must be submitted for approval before intended use and minimum quantity of each. Usable samples will be returned.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TIME</th>
<th>QUANTITY</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEED</td>
<td>10 days</td>
<td>1 pound</td>
<td>Provide sample of each type of fertilizer used</td>
</tr>
<tr>
<td>FERTILIZER</td>
<td>14 days</td>
<td>3 pounds</td>
<td>Wood cellulose fiber mulch</td>
</tr>
<tr>
<td>MULCH</td>
<td>7 days</td>
<td>3 pounds</td>
<td>Synthetic binder</td>
</tr>
<tr>
<td>MULCH BINDER</td>
<td>14 days</td>
<td>1/2 pint</td>
<td>Unopened container</td>
</tr>
<tr>
<td>HERBICIDE</td>
<td>7 days</td>
<td>1/2 pint</td>
<td></td>
</tr>
<tr>
<td>OTHER MATERIAL</td>
<td>7 days</td>
<td>As directed or as approved.</td>
<td></td>
</tr>
<tr>
<td>Avena (oats)</td>
<td>10 days</td>
<td>1 pound</td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 02931-2

**GRASS SEED MATERIALS**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>MINIMUM GUARANTEED PURITY</th>
<th>MAXIMUM WEED SEED AND OTHER CROP</th>
<th>MINIMUM GUARANTEED GERMINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italian Annual Rye</td>
<td>98%</td>
<td>0.2%</td>
<td>95%</td>
</tr>
<tr>
<td>Lolium multi-florum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certified Kentucky 31 Tall Fescue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Festuca elatior arundinacea</td>
<td>98%</td>
<td>0.2%</td>
<td>85%</td>
</tr>
<tr>
<td>Common Bermuda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>98%</td>
<td>0.2%</td>
<td>85%</td>
</tr>
<tr>
<td>Avena spp</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 02931-3

**GRASS SEED MIXTURES**

For areas with slopes less than 2:1, unless otherwise shown.

**Seed Mixture No. One:** (April 15 - September 1)
- Roadside (Hulled Seed)
- 100% Common Bermuda.

**Seed Mixture No. Two:** (September 1 - April 15)
- 50% Italian Rye
- 25% Unhulled Common Bermuda
- 25% Kentucky 31 Tall Fescue

**Seed Mixture No. Three:** (All temporary seeding)
- 100% Avena (oats)

END OF SECTION 02931
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing complete landscape planting as shown on Drawings.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

B. Army Corps of Engineers (COE):
   1. COE CWGS 02378 - Geotextiles Used as Filters

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C33 - Standard Specification for Concrete Aggregates

D. American National Standards Institute, Inc. (ANSI):
   1. ANSI Z60.1 - Nursery Stock

1.3 DEFINITIONS

A. Contracting Officer’s Technical Representative (COTR): The landscape architect or other specialist who will be called upon by the Contracting Officer to represent the Contracting Officer in regard to specific tasks related to landscaping.

1.4 SUBMITTALS

A. Samples:
   1. Provide representative quantities (1 quart containers) of shredded hardwood mulch, filter fabric, crushed stone and decorative gravel.

2. Submit 1 representative sample of each variety of ornamental trees, shrubs, and groundcover plants.

3. After approval: Tag, install, and maintain as representative samples for final installed plant materials.

B. Confirmation of Plant Order:

1. Submit documentation within 150 days after award of contract that all trees and plants have been located and ordered. Include source for each. If required by the Contracting Officer, submit copies of plant material invoices.

2. Submit Tree Tagging Schedule in a form acceptable to the Contracting Officer. Include for each tree and plant material requiring tagging: Tree type, size, location (i.e. nursery), character as specified on the Contract Drawings, date of proposed tagging, and space for tag numbers. See Table 02950 - 1 for sample.

3. Submit a photograph of the finished product specimen with a human being for scale showing trunk form and branching pattern to use as an accepted example.

C. Submit written listing of source bed preparation materials required for the project. This data shall be furnished in addition to representative samples.

D. Submit results of percolation test, and when drainage system is required, submit Contractor’s proposed layout of drainage system.

1.5 QUALITY ASSURANCE

A. Observation at growing site does not preclude right of rejection at the Worksite. Plants damaged in transit or at the Worksite shall be rejected.

B. Personnel: Perform work only with qualified personnel familiar with required landscaping.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Balled and Burlapped (B&B) Plants: Dig and prepare shipment in a manner intended to protect roots and branches from damage and protect the shape, and future development.

B. Do not deliver plants until site conditions are ready for planting. If planting is delayed, heel-in bare rooted or freshly dug plants in a bed containing adequate shredded hardwood mulch to keep roots moist. Separate bundles and trim roots, if long or...
damaged, using sharp pruning shears. Place plants in flats, pots, or other containers in a sheltered spot protected from sun, wind and mechanical damage and keep roots moist. Storage is at Contractor’s own risk.

1.7 PROJECT CONDITIONS

A. Planting Restrictions: Perform actual planting only when weather and soil conditions are suitable in accordance with locally accepted practice. Commence landscaping work when the Site is free of rocks and debris.

B. Protection:

1. Do not move equipment over existing or newly placed structures without approval of Contracting Officer.
2. Provide board-roading as required to protect paving.
3. Protect other improvements from damage, with protection boards, ramps, and protective sheeting.

C. Utilities:

1. Protect and maintain existing utility services in accordance with Section 02760, “Maintenance, Support, and Restoration of Existing Utility Facilities”.
2. Determine locations of underground utilities and perform work in a manner, which is intended to avoid possible damage. Hand excavate, where required, to minimize possibility of damage to underground utilities.
3. Coordinate work with Contracting Officer to prevent damage to underground sprinkler system.

1.8 WARRANTY

A. Refer to the General Provisions, Warranty of Construction. The Warranty in regard to landscape planting shall include the following replacements:

- Replace dead materials and materials not in vigorous, thriving condition as soon as weather permits. Replace plants, including trees, which have partially died thereby damaging shape, size, or symmetry. The opinion of the Contracting Officer as to what constitutes a dead plant shall be final.

Warranty duration as follows:

1. One year from date of final acceptance
2. One year from any replacement date.

B. Replace plants and trees with same kind and size as originally planted. The Contractor’s warranty with respect to plants or trees replaced will run for 1 year from the date of replacement. Replace trees at start of next planting or digging season, unless the Contracting Officer approves earlier replacement in writing. In such cases, remove dead trees immediately. Protect irrigation system, other piping conduit, or other work during replacement. Repair any damage immediately.

C. Warranty excludes replacement of plants after final acceptance because of injury by storm, hail or vandalism.

D. At end of warranty period, remove vertical staking, and bracing materials. Below grade bracing material may be left in place unless the material is exposed and pose a safety threat.

PART 2 - PRODUCTS

2.1 PLANTS

A. General: Provide healthy, field-grown plants, well-formed No. 1 grade from a recognized nursery, and of the species and variety shown on the Contract Drawings, complying with the requirements of ANSI Z60.1. Listed plant heights are from tops of root balls to nominal tops of plants. Caliper inches is measured at 6 inches above the rootball for 4 inch caliper trees and less and 12 inches above the rootball for trees above 4 inch caliper unless noted on the plant listing.

B. Shrub and Ground Covers: Nursery grown, healthy, vigorous, of normal habit of growth for species, free from disease, insect eggs, and larvae. Specified sizes are before pruning and measured with branches in normal position. Plants to be well rooted and established in the container.

C. Ornamental and Shade Trees: No. 1 grade nursery stock healthy, vigorous, full-branched, well-shaped, trunk diameter, and height requirements as specified.

1. Ensure balls are firm, neat, slightly tapered, and well burlapped. Reject trees with loose or broken balls at time of planting.
2. Obtain the Contracting Officer’s approval of each tree, individually.
3. Root balls: 10 inches in diameter for each 1 inch caliper, measured 6 inches above root ball.

D. Container Stock: Verify that container stock has been grown in the containers in which delivered for at least 6 months, but not over 2 years. Samples must prove to be free of kinked, circling or girdling roots and with no evidence of a pot-bound
condition. Do not install container plants that have cracked or broken balls of earth when taken from container. Field grown plants recently transplanted into containers will not be accepted.

2.2 SOIL PREPARATION MATERIALS
A. Sandy Loam: See Section 02910, “Topsoil and Finished Grading”.
B. Compost: See Section 02910, “Topsoil and Finished Grading”.
C. Commercial Fertilizer: Complete fertilizer 10-20-10 (1:2:1 element ratio) with minimum 8 percent sulphur and 4 percent iron plus micronutrients.

2.3 MISCELLANEOUS MATERIALS
A. Steel Edging: 4 inches by 1/8 inch, painted green. Ryerson Steel, heavy gauge.
B. Tree Paint: Asphalitic based paint with antiseptic properties, manufactured for use on tree wounds.
C. Mulch: Shredded hardwood or cedar mulch.
D. Crushed Stone: Mill run 3/4 inch to 1-1/2 inch native crushed white limestone complying with ASTM C33.
E. Staking Materials for Trees:
   1. Braces: 2 inch by 2 inch untreated wood.
   2. Screws: 2-1/2 inch unfinished drywall screws.
   3. Stakes: 2 inch by 2 inch untreated wood.
F. Wood Retainer: Pressure treated 2 inches by 4 inches construction grade pine lumber.
G. Root Stimulator: Polystart 80.

2.4 JUTE MATTING (MESH)
A. Provide jute matting of a uniform, plain weave with warp, and wool yarns of approximately the same size.
B. The physical requirements shall be:
   1. Width: 45 inches to 48 inches, plus or minus 1 inch.
   2. 78 warp ends per width.
   3. 41 weft ends per yard.
   4. Weight: 1.80 lbs. (average) per running yard.

2.5 FILTER FABRIC (SOIL SEPARATOR FABRIC)
A. In accordance with AASHTO M288 and the following additional requirements:
   1. Woven or non-woven pervious filter fabric weighing approximately 5.6 oz. per square yard; free of defects.
   2. Fabric: Long chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, amide or vinyl-chloride, and with stabilizers or inhibitors to make fabric resistant to deterioration due to ultra violet and heat exposure.
   3. Fabric formed or treated so that filaments retain their positions relative to each other.
   4. Edges selvaged.
   5. Physical strength:
      a. Wide-Width Tensile strength: 1740-pound minimum in each direction, ASTM D4595.
      b. Elongation at failure: 15 percent, ASTM D4632.
   6. Flow Rate: 18 gallons per minute per square foot.
   7. Percent of open area: Not less than 4 percent or more than 6 percent.

2.6 BOULDERS
A. Provide boulders at sizes and location indicated on the Contract Drawings. Boulders to be supplied include "mossy boulders" and limestone boulders as described below:
   1. Mossy boulders - Gray to brown sandstone boulders with moss and/or lichens growing on the surface. Freestanding boulders shall be irregular in shape. Boulders used to form dry stack wall shall be more rectangular in shape. Mossy boulders shall meet appearance and material quality of those as supplied by Custom Stone Supply, Dallas, TX.
   2. Limestone boulders - Cream color limestone boulders with rust accents. Boulders shall be roughly half-spherical in shape.
LANDSCAPE PLANTING

Limestone boulders shall meet appearance and material quality of those as supplied by Custom Stone Supply, Dallas, TX.

B. Obtain the Contracting Officer’s approval and individually tag each boulder meeting the above criteria at the stone suppliers yard.

2.7 DECORATIVE GRAVEL

A. Provide decorative gravel where indicated on the Contract Drawings. Decorative gravel shall be New Mexico River Rock, medium size, as supplied by Custom Stone Supply, Dallas, TX, or approved equal. Gravel shall be rounded and vary in colors of gray, black, tan and red.

B. The gravel shall be graded in size from 2 to 4 inches.

2.8 PERFORATED AND NON-PERFORATED PIPE

A. Provide Schedule 40 perforated and non-perforated pipe for tree drainage system as detailed on the Contract Drawings. Use non-perforated pipe in sleeves.

2.9 DECOMPOSED GRANITE

A. Decomposed granite material consisting of material mix of decomposed granite gravel, ¾ inch down to 0 graduation.

B. Decomposed granite color shall be as indicated on the Contract Drawings.

C. Decomposed granite sources: Custom Stone Supply, Dallas, Texas or approved equal.

PART 3 - EXECUTION

3.1 SITE PREPARATION

A. Request the Contracting Officer’s inspection of the Worksite, and obtain the Contracting Officer’s written approval that the Worksite is ready.

B. Examine subgrade and verify conditions under which work is to be performed. Do not proceed with work until all grading and related work is completed in a satisfactory manner so that the landscape installation can proceed. Lumps, clods, and debris over 1 inch in diameter shall be removed from the Worksite.

3.2 BED PREPARATION

A. Refer to Section 02220, “Grading, Excavating, and Backfilling” for excavation and removal of soil, and Section 02260, “Topsoil and Finished Grading”, for addition of topsoil (sandy loam and soil conditioner) to site and bedding mix to platform tree wells.

B. Fertilize topsoil with 10-20-10 fertilizer at the rate of 30 pounds per 1000 square feet.

C. Place filter fabric or jute mesh, as shown on the Contract Drawings. Use filter fabric under crushed rock, decorative gravel and at weep holes. Use jute mesh on slopes 2:1 or greater in planted areas.

3.3 SHRUB AND GROUNDCOVER PLANTING

A. Place plants in position on bed areas before containers have been removed.

B. Obtain approval from Contracting Officer.

C. The Contracting Officer reserves right to interchange or shift locations of plants prior to planting.

D. Do not remove burlap from balled and burlapped plants.

E. Plant where shown, setting plants with tops of balls even with tops of beds, and compact soil carefully around each plant ball. Water thoroughly to eliminate air pockets.

F. Carefully prune plants to remove dead or broken branches and hand-rake bed areas to smooth even surfaces.

3.4 TREE PLANTING

A. Ornamental Trees:

1. Stake locations for approval.
2. Plant in pits at size indicated on drawings.
3. Backfill with topsoil and compost at ratio specified on drawings.
4. Backfill to be places in 6 inch layers and watered in thoroughly.

B. Shade Trees:

1. Stake locations for approval.
2. Plant in pits at size indicated on drawings.
3. Backfill with topsoil and compost at ratio specified on drawings
4. If rock is encountered:
   a. Contracting Officer may select alternative location if possible.
   b. Rock shall be removed to a minimum of 6 inches below the plant if an alternative location cannot be selected.
3.5 TOP DRESSING
A. After planting has been completed and approved, top dress bed areas with bark mulch, 3 inches deep.

3.6 PRUNING OF NEW TREES
A. Prune trees to preserve natural character of plant. When directed by the Contracting Officer, remove approximately 1/3 of wood by thinning. Do not cut back terminal branches. Remove sucker growth and broken or badly bruised branches. Thin native trees heavier than nursery grown plants.

3.7 TREE SAUCERS
A. Form a watering saucer around each new tree per planting detail. Contractor is responsible for deep watering throughout plant establishment period.

3.8 TREE STAKING
A. Stake and brace trees as detailed immediately following planting operation. Take precautions during staking operation to prevent damage or injury to branches and roots.

3.9 STEEL EDGING
A. Provide steel edging at interface of planted areas and lawn areas unless indicated otherwise on Drawings. Set edging as indicated in true lines as designed with top of edging a minimum of 1 inch above finish grade.

3.10 JUTE MESH
A. Install jute mesh per manufacturer's recommendations on slopes 2:1 or greater in planting beds and where indicated.

3.11 BOULDERS
A. Flag location of boulders for approval of COTR
B. Boulders which were damaged or broken during shipping will be rejected.
C. The COTR will number the boulders to specify the location of each boulder.
D. The Contractor shall move the boulders to the location for installation. If boulders are broken or damaged in transit, they will be rejected.
E. Excavate soil to set boulder below grade approximately 2 to 6 inches at the COTR's direction. Obtain the COTR's approval of each boulder installation in the field.

3.12 DECORATIVE GRAVEL
A. Obtain approval of finish grades prior to beginning work in this section. Excavate so that the top of gravel will meet finish grades, where required. Obtain the COTR's approval of the bed layout and excavated grade prior to commencing installation.
B. Cover area to receive gravel with filter fabric. Use u-shaped steel pins, approximately 2 inches in length, to secure filter fabric. Place pins approximately 24 inches on center. Apply 2 layers of filter fabric. Apply second layer at 90 degrees to first layer. Pin corners.
C. Obtain the Contracting Officer's approval of filter fabric application prior to installing gravel.
D. Pressure wash gravel prior to installation. Spread gravel to 2 inch depth and rake while washing to thoroughly clean gravel.
E. Spread remaining 2 inches of gravel and rake level while washing.
F. Spread gravel and trim filter fabric so none is visible.

3.13 DECOMPOSED GRANITE MULCH
A. The decomposed granite mulch shall be thoroughly blended with organic binder material at a rate of 10 pounds of binder material per ton of crushed granite screenings. Blending shall be done with a cement mixer, pug mill, or similar equipment prior to placing and spreading the blended decomposed granite mulch over the hand-compact backfill.
B. The mulch shall be placed in two 1-1/2 inch deep lifts compacted to a minimum 3 inch depth. Each lift shall be thoroughly moistened with water and then compacted to a minimum 85 percent relative density, with the finish surface of decomposed granite flush with surrounding curb and sidewalk.

3.14 TREE DRAINAGE SYSTEM
A. Obtain approval from COTR through the Contracting Officer for extent and layout of proposed tree drainage system. Install a tree drainage system as approved if tree pits fail percolation test described in this Section.
B. Provide 4 inch perforated pipe (Schedule 40) in gravel fill at low end of tree pit as shown on the Contract Drawings. Connect tree pits with pipe in gravel maintaining positive drainage of pipe. Extend pipe to approved low point on site and “daylight” pipe in approved manner. Use nonperforated pipe to connect perforated pipe sections.
3.15 REMOVING AND TRANSPLANTING TREES ON SITE

A. Flag trees for removal and transplanting with different color ribbon at 5 feet height on trunk. Obtain COTR’s approval for trees scheduled to be removed and trees to be transplanted. Obtain approval from COTR for location where trees will be transplanted. Stake each location and clearly label each stake for tree to be replanted at each location.


C. Trees scheduled for transplanting (Designated "Transplant" on the Contract Drawings):
   1. Prune and trim approximately 1/4 to 1/3 of tree canopy.
   2. Dig root ball providing 1 foot diameter of root ball per 1 inch of tree caliper measured twelve inches above grade.
   3. If Vemeer or other mechanical digger is not used, Contractor shall wrap root ball in burlap or other biodegradable material in order to hold the root ball intact during transport.
   4. Plant the tree as specified herein.
   5. Manually deep water tree roots as needed to promote growth. Apply root stimulant at transplanting per manufacturer’s recommendations.

3.16 PLANT ESTABLISHMENT PERIOD

A. Water: When irrigation system is not operational, provide necessary hoses and other watering equipment required to complete landscaping.

B. Establish plantings and trees by watering, cultivating, weeding, spraying, cleaning, and replacing as necessary to keep landscape in a vigorous, healthy condition, and rake bed areas as required until final acceptance.

C. Coordinate watering schedules during installation and until final acceptance. Provide deep root watering to newly installed trees at a minimum of once every 2 weeks during summer months or as weather conditions indicate.

D. Coordinate work of this Section with Sections 02980, “Landscape Maintenance - General”, 02981, “Landscape Maintenance - Irrigated Areas”, and 02982, “Landscape Maintenance - Non-Irrigated Areas”, as applicable.

3.17 CLEAN-UP

A. Keep premises neat and orderly including organization of storage areas. Remove trash and debris from excavated planting areas, preparing beds, or planting plants from Worksite daily as work progresses. Keep paved areas clean by sweeping or hosing.

3.18 FINAL ACCEPTANCE

A. Due to seasonal requirements, final acceptance of this section may not coincide with that of the remaining contract work.

B. Request inspection for final acceptance at least 10 calendar days before the end of the maintenance period.

C. Final acceptance will be considered the time at which planting and related work, as well as, clean-up are 100 percent completed, as determined by the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for “Landscaping” per location indicated wherein no measurement will be made.

B. Topsoil and compost installed as part of the work of this Section in backfill will be measured or paid for directly under Section 02910.

C. Performing and documenting percolation tests will not be measured or paid for directly, but will be considered subsidiary to the lump sum price for “Landscaping - Planting”. If tree drainage system is required, payment for tree drainage system will be covered under the General Provisions, “Changes”.

02950 - 6 DART Standard Specifications – July 2014
TABLE 02950 - 1  
TREE TAGGING SCHEDULE - SAMPLE

<table>
<thead>
<tr>
<th>Tag Number of Tree</th>
<th>Type</th>
<th>Size</th>
<th>Location</th>
<th>Character</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>101</td>
<td>Live Oak</td>
<td>4 inch caliper</td>
<td>ABC Tree Farm</td>
<td>Single Trunk</td>
<td>20 August, 2001</td>
</tr>
<tr>
<td>102</td>
<td>Red Oak</td>
<td>6 inch caliper</td>
<td>DEF Tree Farm</td>
<td>Multi-Trunk</td>
<td>28 August, 2001</td>
</tr>
<tr>
<td>103</td>
<td>Redbud</td>
<td>15 gallon</td>
<td>GHI Tree Farm</td>
<td>8' tall, 4' spread</td>
<td>29 August, 2001</td>
</tr>
<tr>
<td>104</td>
<td>Texas Sage</td>
<td>3 gallon</td>
<td>JKL Nursery</td>
<td>Sample-24&quot; wide</td>
<td>29 August, 2001</td>
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<td>Mondo</td>
<td>4 inch pot</td>
<td>MNO Nursery</td>
<td>Sample</td>
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</tbody>
</table>
SECTION 02975
LANDSCAPE IRRIGATION SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. Furnish work and materials, appliances, tools, equipment, facilities, transportation, and services necessary for and incidental to performing operations in connection with the installation of underground irrigation system complete, as shown on drawings and/or specified herein. When the term "Contractor" is used in this section, it shall refer to the Irrigation Subcontractor.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)


1.3 SUBMITTALS

A. The Contractor shall submit shop drawings or manufacturer's "cut sheet" for each type of sprinkler head, pipe, controller, valves, check valve assemblies, valve boxes, wire, conduit, fittings, and all other types of fixtures and equipment which he proposes to install. The submittal shall include the manufacturer's name, model number, equipment capacity, and manufacturer's installation recommendation, if applicable, for each proposed item.

B. No partial submittal will be accepted and submittals shall be neatly bound into a brochure and logically organized. After the submittal has been approved, substitutions will not be allowed except by written consent of the Contracting Officer.

C. Shop drawings shall include dimensions, elevations, construction, details, arrangements, and capacity of equipment, as well as manufacturer's installation recommendations.

D. Record Drawings:

1. Record dimensioned locations and depths for each of the following:

a. Point of connection, water meter, double check valve and backflow preventer.

b. Irrigation pressure pipe routing (provide dimensions for each 300 linear feet (maximum) along each routing, and for each change in directions).

c. Gate valves.

d. Irrigation control valves.

e. Control wire routing.

f. Other related items as may be directed by the Contracting Officer.

2. Locate all dimensions from two permanent points (buildings, monuments, sidewalks, curbs, or pavements).

3. Record all changes, which are made from the Contract drawings, including changes in the pressure and non-pressure pipes.

4. Record all required information on a set of blackline prints of the Contract drawings. Do not use these prints for any other purpose.

5. Maintain information daily. Keep Contract drawings at the Worksite at all times and available for review by the Contracting Officer.

6. When record drawings have been approved by the Contracting Officer, transfer all information to a set of reproducible mylars using permanent ink. Changes using ball-point pen are not acceptable. Make dimensions accurately at the same scale used on original Drawings, or larger. If photo reduction is required to facilitate controller chart housing, notes or dimension must be a minimum 1/4 inch in height.

7. Reproducible mylars will be furnished by the Contracting Officer at cost for printing and handling.
E. Controller Charts:

1. Do not prepare charts until record drawings have been approved by the Contracting Officer.

2. Provide one controller chart for each automatic controller installed.
   
   a. Chart may be a reproduction of the record drawing, if the scale permits fitting it into the controller door. If photo reduction prints are required, keep reduction to maximum size possible to retain full legibility.

   b. Chart shall be blackline print of the actual system, showing the area covered by that controller.

3. Identify the area of coverage of each remote control valve, using a distinctly different pastel color, drawn over the entire area of coverage.

4. Following approval of charts by the Contracting Officer, they shall be hemetically sealed between two layers of 20 mil. thick plastic sheet.

5. Charts must be completed and approved prior to final acceptance of the irrigation system.

F. Operating and Maintenance Manuals:

1. Provide five individual bound manuals detailing operating and maintenance requirements for irrigation systems.

2. Manuals shall be delivered to the Contracting Officer no later than 10 days prior to final acceptance of work.

3. Provide descriptions of installed materials and systems in sufficient detail to permit maintenance personnel to understand, operate, and maintain the equipment.

4. Provide the following in each manual:
   
   a. Index sheet, stating Irrigation Contractor's name, address, telephone number, and name of person to contact.

   b. Duration of guarantee period.

   c. Equipment list providing the following for each item:

   1) Manufacturer's name.

   2) Make and model number.

   3) Name and address of local manufacturer's representative.

   4) Spare parts list in detail.

   5) Detailed operating and maintenance instructions of major equipment.

G. Checklist:

1. Provide a signed and dated checklist, and deliver to the Contracting Officer prior to final acceptance of the work.

2. Use the following format:

   a. Plumbing permits: if none required, so note.

   b. Material approvals: approved by and date.

   c. Pressure pipe tests: by whom and date.

   d. Record Drawings: received by and date.

   e. Controller charts: received by and date.

   f. Materials furnished: received by and date.

   g. Operation and maintenance manuals: received by and date.

   h. System and equipment operation instructions: received by and date.

   i. Manufacturer's warranties if required: received by and date.

   j. Written guarantee: received by and date.

   k. Lowering of heads in lawn areas: if incomplete, so state.

1.4 CODES/PERMITS

A. Work under this section shall comply with the provisions of these Specifications, as illustrated on the accompanying drawings, as directed by the Contracting Officer and shall satisfy all applicable local codes, ordinances, or regulations of the
governing bodies and all authorities having jurisdiction over this Project.

B. Installation of equipment and materials shall be done in accordance with requirements of the National Electrical Code, Plumbing code of jurisdictional city, and standard plumbing procedures. The drawings and these Specifications are intended to comply with all the necessary rules and regulations; however, some discrepancies may occur, the Contractor shall immediately notify the Contracting Officer in writing of the discrepancies and apply for an interpretation. Should the discovery and notification occur after the execution of a contract, any additional work required for compliance with the regulations shall be paid for as covered by these Contract documents.

C. The Contractor shall give all necessary notices, obtain all permits, and pay costs in connection with his work; file with all governmental departments having jurisdiction; obtain all required certificates of inspection for his work and deliver these to the Contracting Officer.

D. The Contractor shall include in the work all labor, materials, services, apparatus, or drawings in order to comply with all applicable laws, ordinances, rules, and regulations whether or not shown on the drawings and/or specified.

E. The installation of the irrigation system shall be made by an individual or firm duly licensed under Article No. 8751 VTCS, Titled "Licensed Irrigators Act", S.B. No. 259 as passed by the 66th Texas Legislature.

F. Hard wiring 50 volt and above shall be performed by a licensed electrician.

1.5 EXISTING UTILITIES - LOCATION AND ELEVATIONS

A. Locations and elevations of various utilities included with the scope of this work have been obtained from the most reliable sources available and should serve as a general guide without guarantee to accuracy. The Contractor shall examine the site and verify to his own satisfaction the locations and elevation of utilities and availability of utilities and services required. The Contractor shall inform himself as to their relation to the work and the submission of bids shall be deemed as evidence thereof. The Contractor shall repair at his own expense, and to the satisfaction of the Contracting Officer, for damage to any utility shown or not shown on the plans.

B. Should utilities not shown on the plans be found during excavations, Contractor shall promptly notify the Contracting Officer for instructions as to further action.

C. Contractor shall make necessary adjustments in the layout as may be required to connect to existing stub-outs, should such stub-outs not be located exactly as shown and as may be required to work around existing work, this shall be done at no increase in cost to the Authority. All such work will be recorded on record drawings and turned over to the Contracting Officer prior to final acceptance.

1.6 ELECTRIC POWER

A. Electric power to operate the controller shall be furnished by the Facilities Contractor unless otherwise noted on the plans. Service wiring to the controller cabinet shall be furnished by the Landscape Contractor.

1.7 WATER FOR TESTING

A. Unless noted otherwise on the plans or elsewhere, furnish water necessary for testing, flushing, and jetting.

1.8 SLEEVES AND ELECTRICAL CONDUITS

A. Sleeves and electrical conduits have been installed as noted on the drawings. Contractor shall be responsible for locating sleeves and conduits at no additional cost to the Authority.

1.9 WARRANTY AND MAINTENANCE

A. The Contractor shall warranty material and workmanship for one year from final acceptance including repair and replacement of defective materials, workmanship, and repair of backfill settlement.

B. Maintenance during warranty shall include, but not necessarily be limited to, the following:

1. Adjustment of sprinkler height and plumb to compensate for settlement and/or plant growth.

2. Backfilling of trenches.

3. Adjustment of head coverage (arc of spray) as necessary.

4. Unstopping heads plugged by foreign material.

5. Adjustment of controller as necessary to insure proper sequence and watering time.

6. Maintenance necessary to keep the system in good operating order. Repair of damage caused by vandals, other contractors or
PART 2 - PRODUCTS

2.1 GENERAL

A. Unless otherwise noted on the plans, all materials shall be new and unused. The irrigation equipment catalog numbers used for reference in these Specifications are to establish minimum quality standards and may be substituted with an "approved equal" as outlined in Paragraph 1.5 of this section.

2.2 POLYVINYL CHLORIDE PIPE (PVC PIPE)

A. PVC pipe manufactured in accordance with ASIM Standards noted herein.

B. Marking and Identification: PVC pipe shall be continuously and permanently marked with following information: Manufacturer's name, size, type of pipe, and material, SDR number, Product Standard number, and the NSF (National Sanitation Foundation) Seal.

C. PVC pipe fittings: Same material as the PVC pipe specified and compatible with PVC pipe furnished. Solvent weld type shall be Schedule 40.

D. PVC Pipe: Class 200 solvent weld, SDR-21, PS 22-70 for all sizes 3/4 inch to 2 inches. 1/2 inch pipe shall be solvent weld SDR-13.5, Class 315.

E. Flexible Connectors: Flexible connections to rigid PVC shall be manufactured by F.P. Parker Mfg. Inc. under the name of Cobra Connector. Flexible nipples shall be factory assembled only.

F. Pipe sleeves: Class 200 solvent weld, SDR-21, PS 22-70.

2.3 SWING JOINTS

A. PVC swing joints shall be pressure rated at 315 PSI and be Sch. 80 PVC rated units. The unitized assembly shall have NPT threads on both the inlet and outlet fittings.

2.4 WIRE AND SPLICES

A. Wire: Single strand solid copper, minimum 14 gauge with type UF insulation which is Underwriters Laboratory approved for direct underground burial when used in a National Electrical Code Class II Circuit (30 volts AC or less) as per Articles 725 and 300. Voltage drop shall be taken into consideration.

B. Wire: Color coded so that the common wire shall have white insulation and the signal wires shall have red insulation.

C. Wire connectors: Scotch Brand DBY or DBR style connectors with the appropriately sized Scotchlok wire nut connecting the bare copper wires together.

D. Connectors: UL listed, rated 600 volt, for PVC insulated wire. No wire splices shall be buried.

2.5 QUICK COUPLING VALVES

A. Quick coupling valves shall be composed of a bronze cast body with a weighted metal cover and be a Weathermatic V075 unit.

B. The valve shall accept a single lug 3/4 inch bronze valve key for operation.

C. Provide one Weathermatic CO75 coupler and one No. 10 hose swivel ell for each quick coupling valve shown on the plans.

D. Valves are to be installed as shown in the details. Units to be isolated from main pressure pipe with a ball valve as noted in the detail.

2.6 MANUAL VALVES

A. Manual valves 2-1/2 inches and smaller shall be all brass, globe type with composition disc rated at 150 pounds W.O.G.

B. Valves shall have brass cross handles.

2.7 VALVE BOXES

A. Valve boxes shall be made of high-strength injection molded high density polypropylene or polyolefin plastic suitable for shrub bed irrigation purposes.

B. Boxes shall be suitable in size and configuration for the operability and adjustment of the valve.

C. Manufactured extension sections will be used as appropriate to the depth of piping.
D. Valve box covers shall bolt down or have locking mechanisms and shall be colored green or black as selected by the Contracting Officer.

2.8 POP-UP SPRAY HEADS

A. The sprinkler body and elated parts shall be plastic cycolac or polycarbonate. They shall have a spring retraction for positive return action of the pop-up nozzle. They shall have an internal check valve to prevent low head drainage of lateral piping.

B. The spring for retraction and the adjustable nozzle screw shall be made of corrosion resistant materials. A filter screen is required under each nozzle.

2.9 ROTARY HEADS

A. The sprinkler shall be gear driven, closed case rotary type unit having the following minimum characteristics. It shall have radius adjustment capabilities by means of a stainless steel nozzle retainer/radius adjustment screw or have the ability to be adjusted by a top-mounted single adjustment screw which changes the discharging nozzle and angle of throw.

B. The sprinkler shall be available in both full and part circle configurations. The adjustable part shall be adjustable from a minimum of 40 degrees to 330 degrees. The units shall have a minimum of a 4 inch rise and be equipped with an internal drain check valve to prevent low-head drainage and be capable of holding back water up to a 10 foot rise.

C. The unit shall have a rubber cover attached to the top of the riser. When specified, the unit shall have a cover molded in purple rubber to indicate the use of reclaimed water. Each unit shall have NPT female threads and be either 1 inch or 3/4 inch in diameter. The unit shall be serviceable after installation from the top and each unit shall have a filter screen installed. There must be a stainless steel spring from positive retraction of the riser upon completion of a cycle. Each unit shall be attached to a lateral pipe by means of a swing joint.

D. The unit shall carry a full 2 year exchange warranty from the date of installation.

2.10 ELECTRIC CONTROLLER

A. Electric irrigation controller shall be capable of operating the number of stations as indicated on the drawings. The system is designed to operate one solenoid valve at a time, unless otherwise noted.

B. Power source shall be standard 115 volt, 60 Cycle AC. Output for operation of companion solenoid actuated valves shall be 24 volts, 60 Cycle AC. A "back-up" battery shall hold the time of day and the day of the week in the event of a power loss.

C. Operation of the controller shall be full automatic, incorporating one 24 hour clock and 14 day calendar per controlled number of electric valves shown on the plan to start the irrigation cycle any hour or hours of the day or night of any day or days over a repeating 14 day period.

D. The controller shall be capable of repeating watering cycles as required with a maximum delay between the ending of one cycle and the beginning of the next not to exceed 2 hours. Control shall provide optional semi-automatic operation whereby the automatic cycle may be started independent of the clock and manual operation whereby any station may be operated by hand independent of all timing mechanism. The choice of automatic day or hour programming shall be available to the operator on the face of the control panel without the use of tools.

E. The automatic controller shall be equipped with rainproof housing.

2.11 ELECTRIC REMOTE CONTROL VALVES

A. Electric remote control valves shall have plastic bodies and covers and shall be globe-type diaphragm valves of normally closed design.

B. Operation shall be accomplished by means of integrally mounted heavy-duty, 24 VAC solenoid complying with National Electrical Code, Class II Circuit. Solenoid coil shall be potted in epoxy resin within a plastic coated stainless steel housing. Solenoids shall be completely waterproof, suitable for underground placement.

C. A flow stem adjustment handle shall be included on each valve.

2.12 BACKFLOW PREVENTER

A. A double ball valve isolated, double check valve assembly shall be located and sized as shown on the plans.

B. Construction shall be all brass for sizes 3/4 inch to 2 inches in diameter.

C. This assembly shall be installed in a vault with lid conforming to the City Plumbing Codes.
2.13 TEMPERATURE SENSOR & RAIN SENSOR

A. Temperature sensor shall be Freeze-Clik freeze sensor, manufactured by Hunter Industries or Rainguard freeze guard sensor, manufactured by WCS.

B. Rain Sensor shall be Mini-Clik I rain sensor, manufactured by Hunter Industries or Rainguard sensor, manufactured by WCS.

2.14 Drip Irrigation

A. Self-Cleaning, Pressure-Compensating Dripperline: The dripperline shall consist of nominal sized one half inch low density linear polyethylene tubing, housing internal pressure compensating, self cleaning, integral drip emitters. The tubing shall be brown in color and conform to an outside diameter (O.D.) of 0.67 inches and an inside diameter (I.D.) of 0.57 inches. The emitters shall have the ability to independently regulate discharge rates, with an input pressure of seven to seventy pounds per square inch (PSI), at a constant flow and with a coefficient of variation (Cv) of 0.03. The emitter discharge rate shall be either .61 gallons per hour (GPH) or 0.92 gallons per hour (GPH) utilizing a combination turbulent flow/reduced pressure compensation cell mechanism and a diaphragm to maintain uniform discharge rates. The emitters shall continuously clean themselves while in operation. The dripperline shall be installed at 12 inch spacings between emitters. Use Toro or approved equal.

B. Fittings: Techline connections shall be made with approved Techline 17mm (0.57") insert fittings. Use Toro or approved equal.

C. Accessories:

1. Flush Valve: Drip systems shall utilize Netafim Automatic Line Flush Valves at the end of each independent zone area or dripperline (maximum flow per valve: 15 GPM). This valve shall be capable of flushing one gallon at the beginning of each irrigation cycle. The valves to be used shall be Toro Model Numbers TLO50MFV - One Gallon Flush Valve with 1/2 inch Male Pipe Thread Connection or TLFV One Gallon Flush Valve with the Techline Connection for connecting directly to Techline Dripperline or approved equal. Use Toro (Netation) or approved equal.

2. Air/Relief Valve: Each independent irrigation zone shall utilize a TLAVRV Techline Air/Vacuum Relief Valve at its high point(s). The purpose of this valve is to evacuate air from the zone at start up and to relieve vacuum at system shut down. Use Toro or approved equal.

3. Pressure Regulation Valve: The pressure regulator shall be a Netafim piston type unit with an externally accessible regulation unit that can be serviced without removing the valve from the system. The regulator shall have a built in indicator that shows when the proper outlet pressure is reached. It shall be able to respond immediately to any inlet pressure variation. The regulator shall be capable of regulating from 15 PSI to 50 PSI using interchangeably color coded springs. Use Toro (Netation) or approved equal.

4. Disc Filter: The filter shall be a multiple disc filter with color coded filter elements indicating the mesh size of the element being used. The discs shall be constructed of chemical resistant thermoplastic for corrosion resistance. The filter shall be a Toro Model Number DFAP4C-100 or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Design Pressure: This irrigation system has been designed to operate with a minimum static inlet water pressure of 50 psi at the point of connection or as designated on the drawings. The Contractor shall take a pressure reading prior to beginning construction. If the pressure reading is less than above, the Contractor shall notify the Contracting Officer.

B. Contractor Responsibility: The Contractor shall not willfully install the irrigation system as shown on the drawings when it is obvious in the field that obstructions, grade differences or discrepancies in equipment usage, area dimensions or water pressure exist that might not have been considered in the engineering. Such obstructions or differences shall be brought to the attention of the Contracting Officer in writing. In the event this notification is not performed, the Contractor shall assume full responsibility for any revision necessary.

C. Staking: Before installation is started, place a stake or marking flag where each sprinkler is to be located, in accordance with drawing. Staking shall be approved by the Contracting Officer before proceeding.

D. Piping Layout: Piping layout is somewhat diagrammatic. Route piping around existing trees and shrubs in such a manner as to avoid damage to plantings. Cut roots with a sharp axe to provide
a clean cut. Do not dig within the ball of newly planted trees or shrubs.

E. In areas where trees are present, trenches are to be adjusted on site to provide a minimum clearance of four times the trunk diameter of the tree (at its base) between any tree and any trench.

F. Material and equipment shall be delivered to the Worksite in unbroken reels, cartons or other packaging to demonstrate that such material is new and of a quality and grade in keeping with the intent of these Specifications.

3.2 EXCAVATION AND TRENCHING

A. The Contractor shall perform excavation to the depth indicated in these Specifications and Contract drawings. The banks of trenches shall be kept as nearly vertical as practicable. Trenches shall be wide enough to allow a minimum of 4 inches between parallel pipes and/or electrical wiring. Where rock excavation is required, or where stones are encountered in the bottom of the trench that would create a concentrated pressure on the pipe, the rock or stones shall be removed to a depth of 6 inches (minimum) below the trench depth indicated. The over depth rock excavation and excess trench excavation shall be backfilled with loose, moist earth or sand, thoroughly tamped. Whenever wet or otherwise unstable soil that is incapable of properly supporting the pipe is encountered in the trench bottom, such shall be removed to a depth and length required, and the trench backfilled to trench bottom grade as hereinafter specified, with course sand, or other suitable material.

B. Bottom of trench grade shall be continued past ground surface deviations to avoid air pockets and low collection points in the line. The minimum cover specifications shall govern regardless of variations in ground surface profile and the occasional deeper excavation required at banks and other field conditions. Excavation shall be such that a uniform trench grade variation will occur in all cases where variations are necessary.

C. Trench excavation shall comprise the satisfactory removal and disposition of all materials, and shall include all shoring and sheeting required to protect the excavation and to safeguard employees as required by OSHA.

D. During excavation, material suitable for backfilling shall be stockpiled in an orderly manner a sufficient distance back from edge of trenches to avoid overloading and prevent slides or cave-ins. Material unsuitable for backfilling shall be wasted as directed by the Contracting Officer. When excavated material is of a rocky nature and the

topsoil or any other layer of excavated material is suitable for pipe bedding and backfill in the vicinity of the pipe, such material shall be separately stockpiled for use in such bedding and pipe backfill operations, unless satisfactory imported material is used.

E. Excavations and backfill shall be unclassified and covered in the basic bid. No additional compensation will be allowed for rock encountered.

F. Restore all surfaces, existing underground installations, etc., damaged or cut as a result of the excavations to their original conditions in a manner acceptable to the Contracting Officer.

G. Electrical conduit cut or broken is the responsibility of the contractor to correct unless the conduit is above 24 inches in depth or unmarked.

H. Trenching, pipe and wire installation shall be approved by Contracting Officer's Technical Representative before back-filling.

3.3 PIPE INSTALLATION

A. Irrigation Mains: Irrigation mains are that portion of piping from water source to solenoid valves. This portion of piping is subject to surges since it is a closed portion of the irrigation system. Irrigation mains shall be installed in a trench with a minimum of 18 inches of cover.

B. Lateral Piping: Lateral piping is that portion of piping from a solenoid valve out to an irrigation head. This portion of piping is not subject to constant pressure since it is an "open end" portion of the irrigation system. Lateral piping shall be installed in a trench with a minimum of 12 inches of cover.

C. Remove lumber, rubbish, and rocks from trenches. Provide firm, uniform bearing for entire length of each pipeline to prevent uneven settlement. Wedging or blocking of pipe will not be permitted. Remove foreign matter or dirt from inside of pipe before welding, and keep piping clean during and after laying pipe.

D. PVC pipe shall not be installed or welded where there is water in the trench, nor shall PVC pipe be laid when temperature is 32 deg. F or below or when rain is imminent. PVC pipe will expand and contract as the temperature changes. Therefore, pipe shall be snaked from side to side of trench bottom to allow for expansion and contraction.

E. Flush mainline piping prior to head installation.
3.4 PVC PIPE AND FITTING ASSEMBLY

A. Solvent: Use only solvent recommended by manufacturer to make solvent-welded joints following standards noted herein. Thoroughly clean pipe and fittings of dirt, dust, and moisture with an approved PVC purple tinted primer before applying solvent. Bevel male ends of pipe prior to making solvent welds.

B. PVC to Metal Connection: Work metal connections first. Use a non-hardening pipe dope such as Permatex No. 2 or "Teflon" tape on threaded PVC to metal joints. Use only light wrench pressure to tighten.

C. Threaded PVC Connections: Where required, use threaded Sch. 40 PVC adapters into which pipe may be welded.

3.5 HYDROSTATIC TESTS

A. Pressure Test: After the pipe is laid, the joints completed, and the trench partially backfilled, leaving the joints exposed for examination, the newly laid piping or anyvalved section of main pressure piping shall, unless otherwise specified, be subjected for four hours to a hydrostatic pressure test at normal city water pressure. Enclosed pipe, joints, fittings, and valves shall be carefully examined during the partially open trench test. Joints showing visible leakage shall be replaced or remade, as necessary. Cracked or defective pipe, joints, fittings, or valves leaking during this pressure test shall be replaced and retested until the test results are satisfactory. Replacement and repair shall be at Contractor’s cost.

3.6 CONTROL WIRE INSTALLATION

A. Control wire less than 500 feet in length shall be continuous without splices or joints from the controller to the valves. Connections to the solenoid valves shall be made at the valve using connectors specified in Paragraph 2.4 of this section, unless otherwise approved by the Contracting Officer in writing.

B. Control wires shall be installed at least 18 inches deep. Contractor shall obtain the Contracting Officer’s approval for wire routing when installed in a separate ditch. Control wires may be installed in a common ditch with piping; however, wires must be installed a minimum of 4 inches below or to one side of piping.

C. Wire passing under existing or future paving, sidewalk construction, etc., shall be encased in PVC Schedule 40 conduit extending at least 2 feet beyond the edges of paving, sidewalks, or construction.

D. Tape control wire bundles at 30 feet on center maximum.

3.7 POP-UP SPRAY AND ROTARY HEADS AND BUBBLERS

A. Provide heads and nozzles as specified and install in locations as shown on the Contract Drawings.

B. Pop-up spray heads shall be installed on a flexible connector directly to lateral piping as detailed on the Contract drawings.

C. Heads shall be installed with the top of the case and nozzle flush with the soil level in turf areas and the top of the mulch layer in shrub beds.

D. Contractor will be required to adjust heads as necessary after establishment of grass or other plant material.

E. Bubblers will be installed on flexible connectors and set to grade as noted and illustrated in the details.

F. Thoroughly flush lateral and main lines before installing heads.

3.8 QUICK COUPLING VALVES

A. Quick coupling valves shall be installed as illustrated in the details.

B. Quick coupling valves shall be installed on a swing-joint assembly as detailed on the drawings.

C. Under the warranty, the Contractor shall return after grass is established and adjust valves and valve boxes to proper grade.

3.9 MANUAL VALVES

A. Manual valves shall be sized and located where shown on the Contract drawings.

B. Valve boxes shall be adjusted to be flush with finished grade. The Contractor will be required to adjust after establishment of grass.

C. Valve boxes shall be properly supported and of sufficient construction that tractors and mowers crossing over the boxes will not push boxes down and crush the pipe, valve, or box.

3.10 VALVE AND VALVE BOX PLACEMENT

A. Manual, electric, and quick coupling valves shall be in boxes as specified in Paragraph 2.7 of this section, and shall be set with a minimum of 12 inches of space between their top surfaces. Boxes shall be in a straight line and evenly spaced off adjacent hardscape a minimum of three feet.
B. Valves shall be fully opened and fully closed to ensure that parts are in operating condition.

C. Valve boxes shall be set plumb, vertical, and concentric with the valve stem.

D. A valve box, which has moved from this required position so as to prevent the use of the operating wheel of the valve or the ball valve, shall be reset by the Contractor at his own expense.

3.11 **ELECTRIC CONTROLLER**

A. Electric controller shall be located as shown on the plans and shall be capable of operating the number of stations indicated.

B. The system is designed to operate one station at a time, unless otherwise noted on the plans. Install unit in strict accordance with the manufacturer’s published installation instructions.

3.12 **ELECTRIC SOLENOID CONTROL VALVES**

A. Solenoid valves shall be located and sized as shown on the plans. Electrical connections shall be made when the weather is dry with connection kits as specified in Paragraph 2.4 of this section in strict accordance with manufacturer’s recommended procedures. Remote control valves shall be installed in a horizontal position, in accordance to the manufacturer’s published installation instructions.

B. It shall be the responsibility of the Contractor to furnish and install the proper size wire on each of the low voltage circuits from the controller to the solenoid control valves.

C. Consideration shall be given to each circuit for allowance of voltage drop and economy consistent with accepted practices of electrical installation. Under no circumstances shall the voltage of any circuit be reduced more than proper due to length of run exceeding the maximum allowable for the wire size used.

3.13 **TEMPERATURE SENSORS & RAIN SENSORS**

A. The irrigation system shall have a temperature sensor and a rain sensor for each controller. Sensors shall not be installed in a location that will allow the irrigation spray to contact the sensors.

B. The freeze sensor shall be installed with a by-pass switch.

3.14 **DRIP IRRIGATION**

A. Install drip irrigation system as required by the manufacturer. Test lines for flow as recommended by manufacturer. Install dripperline at depth of 2 to 4 inches and spacing at 12 inches. Provide drippers at 12 inches on center with flow rate of 1.0 gallon per hour.

B. The drippers are designed to regulate for the specified output from 7 to 70 psi with a maximum recommended pressure of 45 psi when using insert fittings.

C. Use the dripline manufacturer’s Insert Fittings for connections to ensure the integrity of the connection. Improperly sized fittings will cause leaks.

D. Dripline can be installed by: Trenching, laying it out on a sub-grade lower than finished grade and back filling to the specified finished grade depth, or surface installation using Techline Staples to hold it in place with specified soil and mulch cover.

3.15 **BACKFILL AND COMPACTION**

A. After system is operating and required tests and inspections have been made, the trenches shall be carefully backfilled with the excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand, or other approved materials free from large clods of earth or stone. Rock, broken concrete, or pavement, shall not be used as backfill material. The backfill shall be thoroughly compacted and brought even with the adjacent undisturbed soil level.

B. Compact trenches by thoroughly flooding the backfill and compacting. The jetting process may be used in areas when flooding.

C. Compaction Densities:

1. In areas subjected to or influenced by vehicular traffic, backfill trenches to at least 95 percent of maximum density as determined by ASTM D698.

2. In areas not subjected to or influenced by vehicular traffic, backfill trenches to a density comparable with adjacent undisturbed material.

D. Trenches improperly backfilled, or where settlement occurs, shall be reopened to the depth required for compaction, then refilled and compacted with the surface restored to the required grade and left in a completed surface condition as described above.

E. Specifically tamp backfill under heads and around the flange of heads for one foot by a suitable means after trench backfill has dried from flooding to prevent movement of heads.
### 3.16 Final Adjustment

A. After installation has been completed, make final adjustment of irrigation system prior to Contracting Officer's final inspection.

B. Completely flush system to remove debris from pipes without forcing debris through nozzles. Remove nozzles from heads and turn on valves until clean water is being discharged. Replace nozzles.

C. Check nozzling for proper coverage. Prevailing wind conditions may indicate that an arc or angle of spray should be other than as shown on the drawings. In this case, change nozzles to provide correct coverage and furnish record data to Contracting Officer with each change.

D. Check and adjust each section for the proper operating pressure by use of the flow adjustment on each solenoid valve. Minimize any "misting" from sprinkler nozzles.

E. After system is thoroughly flushed and ready for operation, each section of sprinklers shall be adjusted to control pressure at heads.

F. Verify operation of each zone with wireless remote. Provide wireless remote during final inspection.

### 3.17 Clean-up

A. The Worksite shall be thoroughly cleaned of waste materials and unused or salvaged materials, equipment, tools, etc.

B. After completion of the work, areas disturbed shall be leveled and the Worksite shall be raked clean and left in an orderly condition.

### Part 4 - Measurement and Payment

#### 4.1 General

A. The work described in this section will be paid for on a lump sum basis for "landscape irrigation systems" per location indicated wherein no measurement will be made.

### Table 02975 - 1

**WATERING SCHEDULE FOR 1-YEAR WARRANTY - SUMMER**

<table>
<thead>
<tr>
<th>Line Section Code</th>
<th>Controller</th>
<th>Zone Type</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GI A 1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>GI A 2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>GI A 3</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>GI A 4</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>GI B 1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>GI B 2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

Note: The above schedule is to be used as a guide for format and is in no way directing the contractor to a particular frequency or duration.

### Table 02975 - 2

**WATERING SCHEDULE FOR 1-YEAR WARRANTY - WINTER**

<table>
<thead>
<tr>
<th>Line Section Code</th>
<th>Controller</th>
<th>Zone Type</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GI A 1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>GI A 2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>GI A 3</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>GI A 4</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>GI B 1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td>GI B 2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
</tbody>
</table>
### TABLE 02975 - 3
**WATERING SCHEDULE FOR AFTER 1-YEAR WARRANTY - SUMMER**

<table>
<thead>
<tr>
<th>Line</th>
<th>Controller Section</th>
<th>Zone Code</th>
<th>Zone Type</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>A</td>
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<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
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<td>2</td>
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<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td>G1</td>
<td>B</td>
<td>1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

Note: The above schedule is to be used as a guide for format and is in no way directing the contractor to a particular frequency or duration.

### TABLE 02975 - 4
**WATERING SCHEDULE FOR AFTER 1-YEAR WARRANTY - WINTER**

<table>
<thead>
<tr>
<th>Line</th>
<th>Controller Section</th>
<th>Zone Code</th>
<th>Zone Type</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>A</td>
<td>1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
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<tr>
<td></td>
<td></td>
<td>3</td>
<td>Tree Bubblers</td>
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<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
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<tr>
<td>G1</td>
<td>B</td>
<td>1</td>
<td>Shrub and G.</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>Tree Bubblers</td>
<td>Monday, Wednesday, Friday</td>
<td>20 minutes</td>
</tr>
</tbody>
</table>

Note: The above schedule is to be used as a guide for format and is in no way directing the contractor to a particular frequency or duration.

END OF SECTION 02975
SECTION 02976
IRRIGATION SLEEVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for underground irrigation sleeves and boring.

B. For irrigation system, see Section 02975, “Landscape Irrigation System”.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

1.3 DEFINITIONS

A. A sleeve is a pipe within which another pipe for carrying water will be installed.

B. A wire sleeve is a pipe used to carry low voltage irrigation wires for operation of electric solenoid valves.

1.4 COORDINATION

A. Contractor shall coordinate placement of sleeves with construction of platform, paving and track modifications or elements in timely manner.

PART 2 - MATERIALS

2.1 GENERAL

A. Polyvinyl Chloride Pipe (PVC): Provide PVC pipe and fittings manufactured in accordance with standards noted herein:
   1. Marking and Identification: PVC pipe shall be permanently marked with the following information: SDR number, ASTM standard number, and the NSF (National Sanitation Foundation) seal.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES

A. Borings: Direct bores are required to place sleeves under existing trackwork and pavement. Bores under trackwork shall meet DART standards. Bores under paving shall meet NCTCOG and TxDOT standards.

B. Coverage: Provide minimum of 18 inches cover over top of sleeve from finish grade of pavement or lawn/planting areas or 12 inches of cover from the bottom of the pavement subgrade. Provide minimum of 5 feet cover over top of sleeve from finish grade of rail track when sleeve cross under tracks.

C. Sleeve Extensions: Extend sleeves a minimum two feet past edge of pavement or concrete walls. Install a 90 degree elbow on each sleeve end and add additional length of same size pipe to extend 2 feet (minimum) above finish grade. Cap pipe ends using PVC caps to keep debris out. Clean pipe and fittings of dirt, dust and moisture before applying solvent.

D. Field verify location of sleeves with Contracting Officer prior to pouring concrete.

3.2 BACKFILL

A. Compaction: Place excavated soil over sleeves in 6" lifts. Tamp firmly into place taking care not to damage sleeve. Complete backfill and compaction to prevent future settlement.

B. Excavations are unclassified and include earth, loose rock, rock, or combination thereof in wet or dry state. Backfill trenches with material removed, provided the earth is free of rock, trash and debris. In event rock or other debris is found during trenching, pipe shall be installed in accordance with details on Drawings, utilizing sand cushion and for pipe.
C. Damage: Repair damage resulting from improper compaction including pavement repair and replacement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Irrigation Sleeves described in this section will not be measured, but will be paid for at the lump sum price for “Irrigation Sleeves”, for each size, including trenching, gluing, sleeves, sleeve extensions, capping and backfilling.

B. Bored Irrigation Sleeves described in this section will not be measured, but will be and paid for at the lump sum price for “Bored Irrigation Sleeves”, for each size, including boring, trenching, gluing, sleeves, sleeve extensions, capping, and backfilling.

END OF SECTION 02976
PART 1 - GENERAL

1.1 SCOPE

A. General requirements for Landscape Maintenance for the specified project.

B. Work under this Contract shall be performed in accordance with:
   1. Section 02981, "Landscape Maintenance - Irrigated Areas"
   2. Section 02982, "Landscape Maintenance - Non-Irrigated Areas"

1.2 SAFETY

A. The Construction Safety Orders of the State Division of Industrial Safety and the Department of Labor Occupational Safety and Health Administration.

1.3 SUBMITTALS

A. Material List.

B. The Contractor shall furnish the articles, equipment, or processes specified by name in the specifications. No substitution will be allowed without prior written approval by the Contracting Officer.

   1. A complete material list (fertilizer, chemical, etc.) shall be submitted prior to performing any work. Material list shall include the manufacturer, model number, and description of all materials and equipment to be used.

C. Equipment or materials (fertilizer, chemical, etc.) installed or furnished without prior approval of the Contracting Officer may be subject to rejection, and the Contractor required removing such materials from the site at his own expense.

D. Approval of any item, alternate, or substitute indicates only that the product or products apparently meet the requirements of the drawings and specifications on the basis of the information of samples submitted.

E. Manufacturer’s warranties shall not relieve the Contractor of his liability under the guarantee. Such warranties shall only supplement the guarantee.

1.4 QUALITY ASSURANCE

A. The governing Building Code(s), governing laws, ordinances, rules, permits, regulations, and directives from governing authorities having jurisdiction over this work.

1.5 GUARANTEE

A. Guarantees in accordance with requirements of the Contract Documents, with period of guarantees as stated herein; except that if the Contract neglects to correct or complete work in the inspection check list during periods of maintenance, the Contractor shall still be responsible and required to do so after expiration dates of the guarantee(s) or the life of the Contract, until the corrective work is complete and accepted by the Contracting Officer.

PART 2 - PRODUCTS

2.1 MANUFACTURER’S DIRECTIONS

A. Where specifications require work to be performed in accordance with manufacturer’s directions, the Contractor shall obtain and distribute copies of said direction to the Contracting Officer prior to starting affected portion of the work.

PART 3 - EXECUTION

3.1 SCHEDULE

A. Work under this Contract shall be performed in accordance with the Maintenance Matrix (Refer to Table 02981 - 1 in Section 02981, "Landscape Maintenance - Irrigated Areas" and Table 02982 - 1 in Section 02982, "Landscape Maintenance - Non-Irrigated Areas".

B. The Contractor shall outline in detail, acceptable to the Contracting Officer, the schedule for installation of each portion of maintenance. This shall be in the form of a “critical path” diagram, which identifies specific dates, submittals, etc. critical to the work.

3.2 UNKNOWN UNDERGROUND UTILITIES

A. The attention of the Contractor is called to the fact that utility lines may be present, the existence and location of which is not known. The Contractor shall exercise his best judgment in the course of excavation to avoid death or injury to all persons and damage to property caused by unexpected encounters with such lines, and he shall assume all liability arising there from. The responsibility for safely accomplishing the work rests solely with the Contractor.

B. In the event that such utility lines are encountered, the Contractor shall obtain the instruction from the
Contracting Officer as to the removal or relocation or protection thereof.

3.3 AIR POLLUTION

A. Throughout the duration of the Contract, the Contractor shall conform to the applicable Federal, State, and local regulations, laws and ordinances pertaining to air pollution.

3.4 PROTECTION OF WORK IN PLACE

A. Parts of the project shall be protected from damage from all causes until the Contracting Officer accepts the project. Parts, which are damaged, shall be repaired or replaced to the satisfaction of the Contracting Officer before the project will be accepted.

3.5 PROTECTION OF EXISTING ITEMS

A. Bench marks and other reference points shall be carefully maintained, and if disturbed or destroyed, shall be replaced as directed, at no cost to the Authority.

B. Do not interrupt existing utilities serving facilities occupied and used by the Authority or others, except when permitted in writing by the Contracting Officer and then only after acceptable temporary utility services have been provided.

C. Proper notification, approval, and coordination shall be given and obtained when working in an around utility facilities. The Contractor shall comply with any terms of any easements. Refer to the drawings for information regarding utility companies currently serving the project site.

3.6 PROTECTION OF EXISTING VEGETATION AND MATERIALS

A. Native plants and natural materials shall be protected during landscape maintenance, including topsoil, rock outcropping, boulders, and plant materials. Materials that cannot be temporarily relocated so as to avoid damage thereto shall be marked and protected by flagging, or barriers, at the direction of the Contracting Officer. Parts, which are damaged, shall be repaired or replaced to the satisfaction of the Contracting Officer, at no additional cost to the Authority, before the project will be accepted.

B. Existing, native trees shall be protected from landscape maintenance activities, unless otherwise directed by the Contracting Officer. The Contractor shall not drive or park any vehicle used for maintenance or the transport of labor personnel under the drip line of the existing tree canopy at any time or for any reason. Failure to comply with these specifications will result in the Contractor being penalized monetarily for each occurrence or being dismissed from the project.

3.7 CONTRACTOR’S PERFORMANCE

A. The Contractor shall perform work required as often as necessary, and provide the necessary labor force to fulfill the spirit and intent of the Contract. The Contractor’s labor personnel shall be neat in appearance, perform their work in a professional manner, keep noise to a minimum, and stage their work from an Contracting Officer approved location on the site, out of the way of the mainstream of the project residents and users. In general, the Contractor’s presence on the site shall be as inconspicuous as possible.

B. The Contractor shall perform work required in strict accordance to any national state, county, local, or other governing agency rules, regulations, and safety standards.

C. The Contracting Officer shall monitor the Contractor’s performance.

3.8 NEGLECT AND VANDALISM

A. The Contractor at no expense to the Authority shall replace shrubs, trees, or plants that are damaged or killed due to the Contractor’s operations, negligence, or chemical applications. If plant damage or death is caused by condition beyond the Contractor’s control, replacement shall be at the Authority’s expense upon receipt of written authorization to proceed.

B. The Contractor must replace drainage systems, irrigation components, tree drains, or structures that are damaged due to the Contractor’s operations promptly, at no expense to the Authority. Likewise, the Contractor, at the Authority’s expense upon written authorization to proceed, shall correct damages by other immediately.

C. Damage to the planting by others shall be repaired at the Authority’s expense. Upon written authorization to proceed, the Contractor shall correct thefts of exterior landscaping not caused or allowed by the Contractor.

D. Replace damaged materials caused by the Contractor’s negligence. Replacement shall be at the Contractor’s expense (example: mowing over shrubs, mowing and trimming cut on tree trunks, etc.).
3.9 **EMERGENCIES**

A. The Contractor shall answer emergency or complaint calls 24 hours a day, 365 days per year, regarding conditions in exterior landscape areas. The Contractor shall correct any problem or place warning signs and advise the Contracting Officer and Property Management Company of the need for major work to be performed at the Authority’s expense upon receipt of written authorization to proceed.

B. The Contractor shall answer emergency calls 24 hours a day, every day of the Contract, regarding the landscape irrigation systems failure or need for repair.

C. The Contractor shall provide an emergency telephone number that is answered 24 hours a day, every day of the Contract, and shall make that telephone number available to the Contracting Officer.

**PART 4 - MEASUREMENT AND PAYMENT**

4.1 **GENERAL**

A. The work specified in this section will not be measured separately for payment, but all costs in connection therewith will be considered incidental to the work specified under Section 02981, “Landscape Maintenance - Irrigated Areas” and Section 02982, “Landscape Maintenance - Non-Irrigated Areas”.

END OF SECTION 02980
SECTION 02981
LANDSCAPE MAINTENANCE - IRRIGATED AREAS

PART 1 - GENERAL

1.1 DESCRIPTION

A. It is the intent of this Contract to provide the Authority with a project site that is attractive in appearance. It is also the intent of this Contract to provide the Authority with existing plant material in a healthy, vigorous condition, and to have a maintained, neat appearance. The following specifications relate to the irrigated areas:

1. Section 02930, “Seeding and Sodding - Irrigated Areas”.
2. Section 02950, “Landscape Planting”.
3. Section 02975, “Landscape Irrigation System”.

B. See Section 02980, “Landscape Maintenance - General” for general requirements for landscape maintenance.

C. See Section 02982, “Landscape Maintenance - Non-Irrigated Areas” for tree, shrub and groundcover maintenance in non-irrigated areas.

D. The Contractor shall perform grounds maintenance work necessary for DART properties as shown, utilizing acceptable horticultural standards as adopted by the Texas Association of Landscape Contractors (TALC), Texas Nurseryman Association as interpreted by the Authority needs as further specified herein. Such work shall include, but is not limited to, the following:

1. General site clean up and trash removal and products of the landscape maintenance.
2. Irrigation checks, monitoring, and repairs.
3. Irrigation scheduling and programming.
4. In non-irrigated areas, hand watering of trees, turf, ground cover and shrubs. Supplemental hand watering in irrigated areas as needed. Contractor shall be responsible for manual operation of the irrigation system and/or setting the controller as needed. (Not all properties are equipped with sprinkler systems.)
5. Trees - pruning, trimming, guy-wire adjustments, fertilizing via deep root zone and flood application, insecticide and fungicide applications, disease control, and tree well mulching.
6. Shrub and groundcover beds - pruning, trimming, hedging, fertilizing, weeding, cultivation, pre-emergent and post-emergent applications.
8. Bermuda grass - mowing, clippings pick-up, edging, trimming, fertilizing, pre-emergent, post-emergent, aerating, scalping, insecticide and fungicide applications.
9. 609 Buffalo Grass - mowing, edging, trimming, fertilizing, pre-emergent, post-emergent, aerating, insecticide and fungicide applications.
10. Rye Grass - mowing, clippings pick-up, edging, trimming, fertilizing, aerating, scalping, insecticide, fungicide applications and eradication.
11. Drainage system cleaning, checking, and monitoring.
12. Draining stand pipes at trees and shrub beds.
13. Spraying and/or hand-removal of all grass and weeds growing in cracks and expansion joints of sidewalks, platforms, along building/s, and pavement areas throughout properties, including walkways around buildings.
14. Cleanup of Right-of-Way areas. Right-of-ways shall include alleys, adjacent areas that may be defined as a part of the property service requirement, and lots as shall be defined under the listing of properties.
15. Soil and/or plant testing shall be conducted as needed and in accordance with industry standards and/or as consistent with A&M data relative thereto.
16. Responsible for a monthly site inspection walk through with Contracting Officer.
17. Responsible for written notification to Contracting Office 48 hours prior to applying any herbicides, pesticide or fertilizer for on-site verification of materials and amounts to be applied.
18. Back-fill and adjustment of sprinkler head/bubblers in planter areas as defined in Section III, B6, of Scope of Work.

E. Extra Services:

1. All services not covered under this Contract shall be considered “extra services” and will be charged separately according to the nature of the item of Work. Written consent and authorization of the Contracting Officer must be obtained prior to the performance or installation of such “extra services” items and prior to the purchase of any reimbursable materials.

2. Such Work may occur by product of vandalism or other contractors, or other site related work.

3. Replanting of plant materials with the same species and size to match others in the mass, hedge or row, when plants die due to conditions not included under the Contractor’s guarantee will be placed at a negotiated price between this Contractor and the Contracting Officer.

4. Tree and Shrub pruning outside normal seasonal pruning.

5. The consent and authorization of the Contracting Officer must be obtained prior to the performance of such “additional services” prior to the purchase of any chargeable materials and/or services. Only the Contracting Officer may authorize any work beyond the provisions of the contract. The Contracting Officer will issue Work Orders for all work defined as “Additional Services.” The Contractor shall provide a unit cost, including labor, for each additional service item to be performed consistent with the pricing information set forth under in the Schedule as provided herein, but must not proceed with any work prior to receipt of a Work Order authorization from the Contracting Officer. A copy of the Work Order must accompany billing invoices for all “additional services” work performed, itemized services and costs thereof, by facility.

1.3 QUALITY ASSURANCE

A. The Contractor shall furnish the following personnel:

1. SUPERVISOR: The supervisor shall be qualified, knowledgeable, and experienced in north Texas horticultural practices and typical native plant maintenance procedures. The Supervisor shall have a minimum of ten (10) years of experience in the landscape maintenance industry, or an equivalent secondary education, counting as part of the ten years experience. The Supervisor shall be well versed in landscape maintenance, plant identification, and personnel management (including the ability to verbally communicate with all personnel). The Supervisor shall be able to verbally communicate with the Contractor Officer. Contractor Officer may chose to conduct a site inspection with the Supervisor once a week or as needed.

2. LEAD FOREMAN: The Lead Foreman shall be a “working” qualified foreman, knowledgeable, and experienced in north Texas horticultural practices and typical native plant maintenance procedures. The Lead Foreman shall be well versed in landscape maintenance, plant identification, and personnel management. The Lead Foreman shall be present on site at all times while the Irrigation Repair Technician, Chemical Applicator and Labor are on site.

3. IRRIGATION REPAIR TECHNICIAN: The Irrigation Repair Technician shall be Licensed Irrigation Designer by the State of Texas. The technician shall be knowledgeable and well versed in the landscape irrigation industry. The Technician shall also be knowledgeable of the landscape plant materials and be familiar with the water requirements of the landscape. The Technician shall be qualified in the repair and operation all types of irrigation systems. The Contractor shall furnish the same Technician for each of the inspections and routine repairs. The Technician shall thoroughly inspect, clean, repair and adjust the irrigation system every week.

4. LABOR PERSONNEL: The labor force shall be knowledgeable of the landscape maintenance industry and qualified to perform landscape maintenance tasks. The labor personnel shall be well versed in the proper operating procedures of landscape maintenance equipment.

1.2 SUBMITTALS

A. See Section 02980, “Landscape Maintenance - General”.
5. CHEMICAL APPLICATOR: The Chemical Applicator personnel shall be skilled and knowledgeable in the selection and application of all necessary chemicals required throughout the course of the Contract. The Chemical Applicator shall be legally licensed with the State of Texas to apply all necessary chemicals to the landscape. The Chemical Applicator's license shall be current, and kept so during the duration of the Contract. The Contractor shall provide a copy of the Chemical Applicator's current license to the Contracting Officer illustrating the applicator's name, license number and date of expiration. All Supervisors, Lead Foremen, Chemical Applicators, Irrigation Repair Technicians, and Labor personnel employed on the project shall be of legal status or citizenship, as defined by the United States Federal Government, State of Texas, Dallas County, and City of Dallas, Texas.

6. All of the Contractor's personnel shall be neat, professional, and well presented in appearance at all times. All personnel shall be uniformed at all times. All uniforms shall be the same. Failure to uniform personnel properly may result in the excuse of dismissal of the personnel from the Site and Project, at the discretion of the Contracting Officer.

7. The Contracting Officer reserves the right to reject the services, dismiss, or excuse any labor personnel from the Project at any time, with or without cause. In the case of the supervisor, Lead Foremen, Chemical Applicator, Irrigation Repair Technician, or Labor personnel's absence, the Contractor shall furnish the Project with another person of equal knowledge and experience.

8. Crew Working Hours and Time:
   a. The maintenance crew shall work Monday through Friday between the hours of 7:30 a.m. and 5:30. The Contracting Officer may grant extended hours if the Contractor proves that the extension would be beneficial to the Project.
   b. The maintenance crew shall be employed during a typical work week (Monday through Friday). With prior permission from the Contracting Officer, the Contractor may work on Saturdays and Sundays.

1.4 INSPECTION OF THE SITE
   A. The Contractor shall visit the site to inspect the conditions and review the Contract Documents to become familiar with the site and the scope of the Work.

1.5 SCHEDULING / REVIEW / COORDINATION
   A. For monitoring purposes, the Contractor will be provided with monthly work orders, which will indicate the properties to be maintained, and the work to be performed. The Contractor shall deliver (fax or hand) to the Contracting Officer on a daily basis an itemized work schedule of the work performed on the previous day.
   B. The Contractor shall be required to attend monthly meetings to be held at a time and location determined by the Authority. The purpose of the meetings will be to review the Contractor's invoices and proposed times and locations where work is to be performed, by the Contractor, for the month. Also, the Contractor and the Contracting Officer's Technical Representative will be given the opportunity to discuss problems or concerns, which may have arisen during the previous month.
   C. The Contractor's invoice submitted at the "Monthly Review" meeting will pertain to services, which were accomplished the previous month. No "hold back" or "delayed billings" will be allowed.

PART 2 - PRODUCTS

2.1 FERTILIZER
   A. Shall be based on current soil analysis. See Section 1.1.B.15.
   B. Trees:
      1. February - Complete Fertilizer 10-10-10 (1:1:1) slow release.
      2. July - Complete Fertilizer 10-10-10 (1:1:1) slow release.
   C. Shrubs, groundcover:
      1. March - Complete Fertilizer 24-6-6 (4:1:1) 50 percent sulfur coat.
      2. July - Complete Fertilizer 24-6-6 (4:1:1) 50 percent sulfur coat.
      3. September - Complete Fertilizer 24-6-6 (4:1:1) 50 percent sulfur coat.
E. **Daylilies:**

1. **Spring:** Complete Fertilizer 15-30-15 (1:2:1).
2. **Fall:** Complete Fertilizer 4-8-12 (1:2:3).

F. **Warm season grass areas:**

1. **March:** Complete Fertilizer 24-6-6 (4:1:1) quick release.
2. **May:** Complete Fertilizer 21-7-14 (3:1:2) with 3 percent iron and 50 percent sulfur coat.
3. **July:** Complete Fertilizer 21-7-14 (3:1:2) with 3 percent iron and 50 percent sulfur coat.
4. **September:** Complete Fertilizer 10-20-20 (1:2:2) with 3 percent iron.

G. **Buffalo Grass**

1. **March:** Complete Fertilizer 12-4-8 or 15-5-10 (3:1:2) slow release.
2. **May:** Complete Fertilizer 12-4-8 or 15-5-10 (3:1:2) slow release.
3. **September:** Complete Fertilizer 12-4-8 or 15-5-10 (3:1:2) slow release.

H. **Cool season grass areas:**

1. **November:** Complete Fertilizer 24-6-6 (4:1:1) quick release.
2. **January:** Complete Fertilizer 15-5-10 (3:1:2) quick release.

2.2 **HERBICIDES**

A. Contractor shall submit product description and MSDA.

B. General nonspecific weed control: Roundup, or equal glyphosate product.

C. Spring and summer broadleaf weed control: Threeway, Trimec or equal.

D. Grassy weed control: MSMA, DSMA, Trimec Plus, or equal.

E. Pre-emergent weed control: Simazine, or XL by Monsanto, or equal.

2.3 **ANTCONTROL**

A. In accordance with currently acceptable industry standards as established by Federal, State, and local authorities.

2.4 **WOUND PAINT**

A. Petroleum or latex base tree wound paint, dark gray, brown or black in color. Spray type paints are acceptable. For use on genus Quercus only.

2.5 **MACHINERY AND EQUIPMENT**

A. Machinery requirements listed under this Section are NOT intended to be restriction of specific manufacturers or models, unless so stated. Specific mention of the manufacturers in intended as a guide to illustrate the final product of the maintenance operations desired. All equipment used shall be and maintained in top working condition at all times.

B. Lawn mowers shall be of the rotary or reel type, in good working order, finely tuned to protect the grass from excessive exhaust fumes. Mower blades shall be sharp at all times to reduce the tearing of the turf and shedding of the cut grass blades. Mowers shall be kept in balance with no bent blades. Lawn mowers shall be in a safe working condition at all times.

C. Edgers shall be hard blade grass edgers. Edger’s shall be maintained in safe, working condition, cutting edges shall be sharp at all times.

D. String trimmers shall be maintained in safe and working condition.

E. Pruning tools shall be maintained in safe, working condition, cutting edges shall be sharp at all times.

F. Fertilizer and insecticide spreaders shall be of the hand-held or cyclone type. Vehicle-mounted or push cyclone spreaders shall be allowed. The Contractor shall be responsible for any grade, plant material (turf, trees, shrubs, etc.), or hardscape amenity (fence, pavement, arbor, steel edging, stone wall, etc.) damage caused by the spreader and the application process. Spreaders shall be in a safe working condition at all times.

G. Insecticide and fungicide sprayers shall be of the hand-held, backpack, or vehicle-mounted type. The contractor shall be responsible for any grade plant material (turf, trees, shrubs, etc.), or hardscape amenity (fence, pavement, arbor, steel edging, stone wall, etc.) damage caused by the sprayer and the application process. Sprayers shall be in a safe working condition at all times.
H. Deep root zone tree fertilizing shall be done with a hydraulic spray rig capable of producing 15 gallons of fertilizer solution per minute at 150 - 200 p.s.i.

I. Carts, trucks, wheelbarrows, and similar wheeled conveyances used in or on any portion of the existing landscape or amenities shall be equipped with pneumatic tires.

PART 3 - EXECUTION

3.1 WATERING

A. General:

1. Maintenance procedures should assure the operation of the irrigation system. The irrigation system components (valves, nozzles and controller) should be inspected, cleaned, repaired and adjusted weekly.

2. Adjust the system's timing in accordance with the general weather conditions. Improper watering procedures causing the decline of the permanent good health and appearance of the plant material shall be replaced with the same piece of equal size and form at the cost of the Contractor.

3. Promptly repair any damage to the irrigation system caused by the maintenance operations, vandalism, excavation by other result in broken heads, risers, pipe or other similar damage; replace with the same part and manufacture.

B. Deep root water newly planted trees once every week during the first summer and once a month during the first winter, if needed. This should be adjusted to the amount of rain. However, unless it has rained at least 1/2 inch since the last scheduled watering, continue to deep root water. Complete deep root watering by filling each tree saucer three times and letting it percolate dry.

C. Shrub, Ground Cover and Seasonal Color beds should be watered as necessary to keep uniform moisture in the bed. Adjust watering practices to match water requirements of species in planting beds. Maintain uniform moisture in all planting areas during the winter months - particularly when a freeze is predicted.

D. Containers will be hand watered as necessary.

E. Be alert to over watering and discontinue watering as required. If water stands in planting areas, consider fine grading revisions to eliminate water-holding pockets. In general, a drainage problem area can be identified when water consistently remains for 12-24 hours after either sprinkler system use or heavy rains. Be especially careful to avoid over-watering the following species: Red Yucca, Paleleaf Yucca, Twisted-Leaf Yucca, Greg Dalea, Sideoats Grama, Blue Grama, Little Bluestem, Buffalo grass, Cherry Sage.

F. Buffalo Grass Lawns: Buffalo grass requires only 25 percent of irrigation typically applied to Bermuda grass. It is anticipated that after establishment, normal seasonal rainfall will meet the water requirements of Buffalo grass lawns in fall, winter and spring, except for unusually dry periods. During the summer, and during unusual dry periods throughout the year, irrigate to provide the equivalent of 1 inch to 2 inches of Water per month. This is best applied as a monthly or semi-monthly soaking to wet the soil to the depth of 6 inches. Note: Over-watering of Buffalo grass will encourage invasion of difficult to control weeds, especially nut sedge and Bermuda grass.

G. Buffalo Grass, Native Grass and Wildflower Areas: Water as per Buffalo grass lawns. Take care to provide adequate moisture during the germination period of wildflower seeds in September and October.

H. Native Ornamental Grasses: Water short growing native ornamental grasses (Sideoats Grama, Blue Grama, Little Bluestem) as per Buffalo grass lawns. Water tall-growing native ornamental grasses (Big Bluestem, Inland Sea oats, Sugarcane Plume Grass, Switch Grass) to provide the equivalent of 1 inch water per week during the growing season.

3.2 FERTILIZATION

A. General: Fertilizing procedures should reflect the manufacturer's recommendations. Use caution in handling and spreading fertilizers - concentrated amounts may result in "burning" and damage to root systems. Carefully follow label instructions.

B. For Trees:

1. Introduced trees less than 3 years in place - 3 gallons of fertilizer solution per one inch of trunk caliper (measured 12 inches above finish grade).

2. Introduced trees more than 3 years in place - 5 gallons of fertilizer solution per one inch of trunk caliper (measured 12 inches above finish grade).

3. Native trees - 5 gallons of fertilizer solution per one inch of trunk caliper (measured 48 inches above finish grade).
C. Shrub Beds at rate of 1.25 pounds of nitrogen per 1,000 square feet of bed area. Cultivate and water beds thoroughly after application.

D. Shrubs, Vines, Groundcover, Ornamental Grasses and Perennials: Top dress with 2 inch layer of compost. Cultivate lightly and water thoroughly after application.

E. Seasonal Color Beds at rate of 1 pounds of nitrogen per 1,000 square feet of bed area. Cultivate and water beds thoroughly after application.

F. Lawns of Warm Season Grasses:
   1. March - 2 pounds of nitrogen per 1000 square feet.
   2. May - 2.5 pounds of nitrogen per 1000 square feet.
   3. July - 2.5 pounds of nitrogen per 1000 square feet.
   4. September - 1.25 pounds of nitrogen per 1000 square feet.

G. Lawns of Buffalo Grass and Buffalo Grass with Wildflowers:
   1. March - 1/3 pound of nitrogen per 1000 square feet.
   2. May - 1/3 pound of nitrogen per 1000 square feet.
   3. September - 1/3 pound of nitrogen per 1000 square feet.

H. Lawns of Cool Season Grasses:
   1. November - 1.5 pounds of nitrogen per 1000 square feet.
   2. January - 1.5 pounds of nitrogen per 1000 square feet.

I. Bog and Aquatic Plants - except Louisiana Iris:
   1. March - push 1 to 3 (5-10-5) slow release fertilizer pellets (depending on the size of the clump) into the soil in the root zone of each clump of plants. 2. May - push 1 to 3 (5-10-5) slow release fertilizer pellets (depending on the size of the clump) into the soil in the root zone of each clump of plants.
   2. July - push 1 to 3 (5-10-5) slow release fertilizer pellets (depending on the size of the clump) into the soil in the root zone of each clump of plants.
   3. Make sure each pellet is completely covered by soil and pea gravel to prevent release of fertilizer directly into the water.

J. Louisiana Iris:
   1. February - push 1 to 3 (5-10-5) slow release fertilizer pellets (depending on the size of the clump) into the soil in the root zone of each clump of plants.
   2. March - push 1 to 3 (5-10-5) slow release fertilizer pellets (depending on the size of the clump) into the soil in the root zone of each clump of plants.
   3. September - push 1 to 3 (5-10-5) slow release fertilizer pellets (depending on the size of the clump) into the soil in the root zone of each clump of plants.
   4. Take care not to damage roots or rhizomes of the plants.
   5. Make sure each pellet is completely covered by soil and pea gravel to prevent release of fertilizer directly into the water.

K. Daylilies: Fertilize at rate of one pound of nitrogen per 1,000 square feet of bed area. Water beds thoroughly after application. Keep fertilizer off the foliage.

3.3 TREES

A. Trees shall be continuously and routinely inspected for girdling caused by guying and lawn maintenance equipment. Girdled trees shall be replaced at the Contractor’s expense, as determined by the Contracting Officer.

B. Tree wells with mulch shall be monitored so that build-up of mulch does not occur. The tree root flare shall remain exposed.

C. Fire Ant mounds around or on top of a tree root zone shall be treated immediately and the mound removed physically. Do not allow the mound to build on the tree trunk as this will cover the tree root flare and possibly cause injury or death. Insure that any chemical application to the Fire Ant mound is safe for application atop tree root zones.
**D.** Trees: Prune annually in the correct season for the species; spring flowering trees will be pruned after bloom, summer, fall and non-flowering trees will be pruned in mid-winter. Experienced pruning personnel shall carry out pruning.

1. Prune to encourage positive growth; remove crossing branches; and maintain the natural shape of each species.

2. Sterilize pruning tools between individual plants, especially in the genus Quercus. Paint all wounds on plants of the genus Quercus with wound paint as soon as possible. Wounds shall be painted within 1 hour of pruning. Paint accidental wounds (storm or equipment damage or vandalism) as soon as they are observed.

3. Raising to an acceptable height as approved by Contracting Officer.

4. No weed-eaters or edger’s are to be used within 12 inches of any tree. Should the need for trimming be necessary within 12 feet of any tree, it shall be done so by hand trimming only.

**E.** Tree Maintenance in Shrub and Groundcover Areas: Groundcover growing around introduced or native trees shall be maintained by use of hand trimmers, within 30 inch” of the tree. Trimming of groundcover by weed-eaters and mowers is prohibited within the 30 inch zone of the tree. Tree drainage standpipes shall be checked on a weekly basis. Pipes found to be filled with water, debris, etc.; the Contractor shall clean and pump the pipes. Pipes shall be inspected and serviced on a weekly basis throughout the year.

3.4 **SHRUBS, VINES, AND GROUNDCOVER**

**A.** Thin to remove dead wood when necessary.

**B.** Remove dead wood and freeze damaged leaves in the spring.

**C.** In no case should any shrub be sheared. Shrubs shall be selectively pruned.

**D.** All water sprout and sucker type growth shall be pruned and trimmed continuously. Pruning and trimming of any shrub shall be done so in a manner as to retain the natural character and habit of the plant. All shrubs shall be pruned to create a uniformly dense plant. Selectively thin and tip back annually, or as needed. Do not change the natural shape of the shrub by pruning unless so directed by the Contracting Officer.

**E.** Shrub and groundcover beds shall be edged, weeded, and cultivated in accordance with the Schedule.

**F.** Always prune out dead, broken, and diseased wood. All cuts shall be flush cuts. Refer to the Schedule for pruning and trimming times. Guidelines for specific shrubs, vines, and groundcover shall be as follows:

1. Red Yucca, Paleleaf Yucca, Twisted-Leaf Yucca: Remove spent flower stalks throughout the year. Remove dead foliage from the vase of the plants throughout the year. Wear eye protection when working close to these shrubs.

2. Creek Plum, Smooth Sumac: Remove dead or declining trunks at ground level to encourage growth of young shoots from rhizomes.


4. Boston Ivy, Virginia Creeper, Carolina Jessamine, Wisteria: Prune and train to cover the fences and arbor on which they are growing. Keep them routinely trained and tied up. Remove unruly growth as needed. Always keep walks clear of hanging vines to a height of 78 inches. Prune the Carolina Jessamine and Wisteria after their individual blooming cycle.

5. Bar Harbor Juniper: Allow junipers to trail over walls. Pick prune unruly growth as needed. The bottom one-third of the stonewalls shall be visible. Selectively prune junipers to accomplish this intent. Do not shear or hedge.

6. Compact Pfizer Juniper, Sea Green Juniper: Do not shear or hedge. Pick prune unruly growth as needed.

7. Asian Jasmine: Trim Asian Jasmine to an even height. Maintain to a height of 6 to 9 inches.

8. Vinca: Maintain to a height of 10 to 12 inches.

9. Liriope: Trim the previous season’s growth off in the spring as new growth emerges (See Schedule).
10. Honeysuckle: Maintain shrub areas to a uniform height without hedging. DO NOT allow honeysuckle to climb on fences. Honeysuckle allowed to climb on fences shall be maintained as directed by the Contracting Officer. Honeysuckle allowed to climb tree trunks, or trail over walls.

G. As groundcover mature, discontinue cultivation.

H. Damaged, dead, or thin areas in groundcover beds shall be replanted at the direction of the Contracting Officer. Replacement of plant material not due to the Contractor's negligence will be at the Authority's expense, upon receipt of written authorization to proceed.

I. Shrub and groundcover beds with slopes of 2:1 or steeper shall not be cultivated due to the possible erosion nuisance, unless otherwise directed by the Contracting Officer.

J. Pruning debris and limbs shall be removed completely and immediately from site, or to an Contracting Officer approved location on-site.

K. Groundcover beds shall be sheared one time per year. This shall be done in the early spring, prior to the growing season. Groundcover beds bordering on paved surfaces must be edged as needed to retain a neat edge. Do not trim vertically so as to expose the stems.

L. Cultivate soil and re-mulch beds to give the planting soil a productive consistency.

3.5 PERENNIALS

A. Perennials will be continuously inspected for signs of pests and diseases. Identify pests and diseases and treat with appropriate methods. Refer to Appendix A for specific maintenance schedule.

B. Remove spent flowers, dead leaves and stems from plants as they appear. Take care not to damage or inadvertently remove dormant (but still living) plants.

C. Maintenance guidelines for specific perennials shall be as follows:

1. Texas gold columbine: Normally dormant during summer months and in active growth during the winter. Following spring flowering, allow the plants to set and scatter seed until the planting has reached desired density, as directed by Contracting Officer.

2. Wood fern: Dormant in winter. Remove dead foliage after it has been killed by frost in fall.

3. Pavonia: A semi-woody perennial shrub, dormant in winter. After the planting has reached the desired height (3 to 4 feet), prune the plants heavily in February to encourage flowering.

4. Blue phlox: A semi-evergreen herbaceous perennial. Watch for iron chlorosis due to high soil pH, and treat with soil acidifiers and chelated iron. Watch for fungal root diseases, and treat with appropriate fungicide.

5. Daylilies: Remove scapes soon after flowering.

3.6 BOG AND AQUATIC PLANTS

A. Bog and aquatic plants used in the project are herbaceous perennials adapted to grow in saturated, shallowly submerged soils. Planting areas for these plants are designed to be flooded with 2- to 3 inches of water during normal operation of water features. The planting areas are designed to hold water, allowing the water features to be drained for short periods of time for cleaning and maintenance. If the water features are to be drained for prolonged periods (greater than 3 days), provision must be made to keep these planting areas flooded.

B. It is normal for these plants to grow very rapidly, both in height and by horizontal spread. If the plants begin to creep beyond the planting areas, prune or trim at direction of Contracting Officer.

C. Maintenance guidelines for specific bog and aquatic plants are as follows:

1. Horsetail: Semi-evergreen. If severe cold kills foliage, remove by cutting at waterline.

2. Pickerelweed and Lizardtail: Dormant in winter. When frost kills the foliage, remove it by cutting at the water line.

3. Louisiana iris: Semi-evergreen with periods of slow growth in mid-summer and mid-winter. Selectively remove dead leaves throughout the year. Do not cut back the entire plant unless unusual cold kills all foliage. Remove any seedpods that form after flowers fade in late spring.
3.7 NATIVE ORNAMENTAL GRASSES

A. Ornamental grasses used in the project are herbaceous perennials, dormant in winter. The foliage, flowers and seed Plumes die with onset of freezing weather, but persist throughout the winter. The dead but standing foliage retains its form and is one of the main aesthetic values of these plants. Maintenance activities in or around these plants must be performed carefully during the fall and winter to avoid damage to the standing foliage. If damaged, the foliage will not completely regenerate until the following summer.

B. Species of ornamental grasses are sensitive to over-fertilization, and some species are sensitive to over-watering. Over-fertilization and over-watering causes the plants to become "top-heavy", resulting in foliage and flowers that do not stand upright, but fall over in wind or rain. This destroys the fall and winter value of the plants, and may cause decreased cold-hardiness.

C. Trim ornamental grasses only once each year, except for minor shaping at the direction of the Contracting Officer. Trimming shall be done in late winter or early spring just before spring growth starts. Trim by cutting dead foliage and flowers with hedge shears or other tools, leaving a neat, even mound of dead stalks. Take care not to damage the living crown of the plant. Trim ornamental grasses at the following heights.

1. Sideoats Grama, Blue Grama, inland Sea oats, Little Bluestem: 6 inches above finish grade.

2. Big Bluestem, sugar cane Plume Grass, Switch Grass: 12 inches above finish grade.

3.8 LAWN WEED CONTROL IN WARM SEASON GRASSES

A. Regard herbicides as hazardous to your health and dangerous to the environment; only experienced personnel should handle with extreme caution and chemicals. Read and follow label directions. Limit public access to area recently treated with herbicides. Wildflowers species used in the project are sensitive to pre-emergent and post-emergent broad leaf weed killers. Where Buffalo grass turf is adjacent to wildflower areas, use extreme caution in application of herbicides. Do not allow over spray or spillage of herbicide on wildflower areas. Observe run-off patterns and notify Contracting Officer if run-off from areas treated with herbicides can enter wildflower areas.

B. Cool season annual weeds: Apply pre-emergent herbicide to lawn area at the rate specified by the manufacturer. Identify weeds and use herbicide listed for those species. Do not contact with any other plants, including trees in lawns.

C. Broad-leaf weeds: Apply post-emergent herbicide to lawn area at the rate specified by the manufacturer. Identify weeds and use herbicide listed for those species. Do not contact with any other plants, including trees in lawns.

D. Grassy weeds: Apply Post Emergent to lawn area at the rate specified by the manufacturer. Identify weeds and use herbicide listed for those species. Do not contact with any other plants, including trees in lawns.

E. Persistent weeds: Extremely persistent or toxic weeds (such as Poison Ivy) may be controlled with a glyphosate herbicide, used as label directs. Avoid contact with any other plants.

3.9 LAWN WEED CONTROL IN BUFFALO GRASS

A. Regard all herbicides as hazardous to your health and dangerous to the environment; only experienced personnel should handle with extreme caution and chemicals. Read and follow label directions. Limit public access to area recently treated with herbicides. Wildflower species used in the project are sensitive to pre-emergent and post-emergent broad leaf weed killers. Where Buffalo grass turf is adjacent to wildflower areas, use extreme caution in application of herbicides. Do not allow over spray or spillage of herbicide on wildflower areas. Observe run-off patterns and notify Contracting Officer if run-off from areas treated with herbicides can enter wildflower areas.

B. Cool season annual weeds: Apply pre-emergent herbicide to lawn area at the rate specified by the manufacturer. Identify weeds and use herbicide listed for those species. Do not contact with any other plants, including trees in lawns.

C. Broad-leaf weeds: Apply post-emergent herbicide to lawn area at the rate specified by the manufacturer. Identify weeds and use herbicide listed for those species. Do not contact with any other plants, including trees in lawns.

D. Grassy weeds: Apply Post Emergent to lawn area at the rate specified by the manufacturer. Identify weeds and use herbicide listed for those species. Do not contact with any other plants, including trees in lawns.

E. Persistent weeds: Extremely persistent or toxic weeds (such as Poison Ivy) may be controlled with a glyphosate herbicide, used as label directs. Avoid contact with any other plants.

3.10 BUFFALO GRASS TURF AND WILDFLOWERS

A. Wildflowers used in this project are annual and perennial spring-blooming species. After the bloom period in spring they set seed, then become dormant or die. When cooler, moist weather starts in September, the dormant plants resume growth and the seed germinate. During the galls and winter, the plants are in a period of slow root growth, with short rosettes of green foliage on the surface of the soil. With warm temperatures and spring rains, growth becomes rapid in February and March. Some species may begin blooming in late March or early April.

B. Do not mow any portion of the wildflower planting during the spring bloom period. Do not edge any portion of the planting during the spring bloom
period, except at the direction of the Contracting Officer.

C. As the spring bloom period ends, allow the wildflowers to set seed. Observe the plants closely to determine that seed is maturing on all species, including the last to bloom. When seed is mature and has been released from the plants, the areas can be mown. If necessary, drag or rake the mature wildflowers to separate the seeds from the dead portion of the plant.

D. Mow the wildflower areas with rotary mowers set at height of 3 inches. It may be necessary to mow more than once at successively lower settings to achieve the final height of 3 inches. Do not use any method or equipment to mow or collect clippings that can remove the wildflower seeds from the area. Do not bag clippings, or allow clippings to be blown out of the wildflower area. Hand rake to remove clippings or use other methods that allow the seeds to fall out of the clippings onto the soil before the clippings are removed.

E. After the initial mowing after the spring bloom period, mow and edge the wildflower area as described for Buffalo grass, above.

F. When cooler weather and fall rains begin (usually mid-September), the annual wildflower seeds will germinate, and the perennial species will resume growth. Look closely for seedling rosettes. As soon as these are seen, cease mowing and notify Contracting Officer. If rainfall is inadequate during fall and winter, irrigate semi-monthly to provide moisture for developing seedlings.

G. When the Buffalo grass turf becomes dormant in the fall; consult with Contracting Officer to determine the need for a final clean-up mowing. This mowing may need to be at a greater height than the normal 3" mowing for Buffalo grass in order to avoid damage to the wildflowers.

3.11 MOWING AND EDGING

A. Mow and edge grass areas as shown on attached Table 02981 - 1. Bag clippings dispose legally.

B. Mow and edge Buffalo grass area as shown on attached Table 02981 - 1. Do not bag clippings.

C. Do not scalp the grass or cut more that one-third the existing top growth in one mowing. If more than that is cut, remove or catch the clippings. Clippings shall not remain on the turf surface for more than four hours.

D. When edging, use sharp blades to give a crisp appearance along walks, curbs, edge of pavement (street, walks), permanent structures, etc.

E. When trimming, use string trimmers around non-living structures and objects. Do not allow turf to be trimmed shorter with a string trimmer than other turf areas mowed by mowers the same day.

F. When trimming, do not allow the turf to be scalped around irrigations sprinkler heads and valve boxes creating a "doughnut" appearance.

G. When trimming, never use string trimmers around tree and shrub trunks where girdling trunk damage is possible.

H. The edge of road pavement and back of curbs shall be mechanically edged.

I. No weed-eaters or edger’s are to be used within 12 inches of any tree. Should the need for trimming be necessary within 12 inches of any tree, it shall be done so by hand trimming only.

J. Irrigation heads, signs, utility poles, fire hydrants, etc., shall be mechanically trimmed; chemical control not acceptable. Use extreme caution when trimming around new or existing trees to prevent damage.

K. Mulching mowers may be used if City Ordinance no longer permits bagging of clippings.

L. Turf Mowing:

1. During periods of cool weather: Mow Bermuda turf at 1-1/2 inch height.

2. During periods of warm and hot weather: Mow Bermuda turf at 2 inch height.


3.12 MOWING AND EDGING BUFFALO GRASS

A. Mow and edge Buffalo grass area as shown on attached Appendix "A". Do not bag clippings, unless heavy clumps remain on surface of turf.

B. Do not scalp the grass or cut more that one-third the existing top growth in one mowing. If more than that is cut, remove or catch the clippings. Clippings shall not remain on the turf surface for more than four hours.

C. When edging, use sharp blades to give a crisp appearance along walks, curbs, edge of pavement (street, walks), permanent structures, etc.
3.13 SCALPING

A. In late March, scalping shall be accomplished by lowering mower as low as possible. Mower height shall not exceed 3/4 inch in height. This procedure will help stimulate Bermuda to snap out of winter dormancy by helping the soil to warm up more rapidly.

B. Clippings shall not remain on the turf surface for more than four hours. Bag clippings.

3.14 RYE GRASS

A. On or about September 20th, the turf is to be scalped to a height of 1 inch and overseed with a perennial rye at a rate of 10 pounds per 1,000 square feet.

B. Water rye 3 times daily until germination is obtained.

3.15 ANT CONTROL

A. Install ant control as per manufacturer's recommendations.

3.16 PESTICIDES

A. As required for safe control of the particular diseases or insects.

B. Assess level of damage caused by insects and diseases regularly. Minor, visually unimportant damage does not need to be treated, as long as the long-term health of the planting is not affected.

C. Carefully identify any pest that causes significant damage. Do not attempt control until the pest organism has been identified.

D. After identification, choose the least hazardous control measure possible. Read and observe all label precautions. If the least hazardous control measure is not effective, use the next least hazardous measure. Preference will be given to biological and pest-specific control measures. In pest outbreaks, review cultural practices to determine the underlying cause, and correct.

E. Regard all pesticides as hazardous to your health and dangerous to the environment; only experienced personnel should handle with extreme caution and chemicals. Limit public access to any area recently treated with pesticides.

F. Specific directions are as follows:

1. Grubworms - Grubs feed on grass roots as much as two to four inches below the surface. Heavy infestations of grubworms will severely damage the root system, making it easy to roll up the sod and causing the turf to become spongy and eventually turn brown and die. Treat with Diazinon, Dursban, Oftanol, or Triumph granules in mid-July through mid-October if there are more than 4 grubworms per square foot present. Check first in July and continue checking through mid October. After the application of granular chemicals, operate the irrigation system for 20-30 minutes for spray heads and 45-60 minutes for oscillating heads to insure control.

2. Sod Webworms - Treat when present between June and September with Diazinon, bacillus thuringiensis or Dursban.

3. Armyworms - Treat when present between May and September with Diazinon, bacillus thuringiensis, Tempo or Mavrik.

4. Fire Ants - Broadcast spread Logic or Award, and spot treat with Diazinon, Dursban or Orthene granules when present.
5. Bermuda grass mites: Treat when present from July through September with Diazinon.

G. Disease: - When they first appear, spray for diseases with an approved commercial fungicide. Recommended fungicides for the control of disease found in Bermuda turf grasses are:

1. Pythium Blight - Treat when present during warm, wet weather with Fore.

2. Rust - Treat when present between July and August with Fore.

3. Helminthosporium - Treat during the summer months with Fore or Daconil 2787 when this disease is present.

4. All leaves and debris shall be removed from shrub and ground cover beds, be bagged, removed from, and transported off-sites at each service cycle. Never shall bags of trash, litter, clippings, brush, or debris of any type be left over-night at any DART property.

H. Insects: - Control insects with regular applications of commercial insecticides as needed. Recommended insecticides for infestations found in hedges, shrubs and ground covers are:

1. Asian Jasmine: Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene.

2. Crape Myrtle:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   b. Cucumber Beetles - Treat when present between April and September with Diazinon, Orthene or Tempo.
   c. Borets - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.

3. Dwarf Barbary:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   b. Scale - Treat when present with Orthene, oil or a combination of

4. Dwarf Burford Holly:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   b. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.
   c. Leaf Miners - Treat with Orthene or Tempo when first symptoms appear on leaves, usually in summer months.
   d. Grasshoppers - Treat when present between July and September with Sevin Tempo, or Orthene.

5. Dwarf Chinese Holly:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   b. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.

6. Honeysuckle:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.

7. Indian Hawthorn:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   b. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.

8. Liriope: No major insects.

9. Nandina:
   a. Cucumber Beetles - Treat when present between April and September with Diazinon or Tempo.
b. Aphids - Treat with Orthene, Tempo, or Mavrik when present.

c. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.

10. Photinia:

a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.

b. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.

11. Tam Juniper: Bagworms - Treat when present between April and September with Orthene or bacilli thuringiensis.

12. Yaupon Holly:

a. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.

b. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.

c. Leaf Miners - Treat with Orthene or Tempo when first symptoms appear on leaves, usually in summer months.

d. Grasshoppers - Treat when present between July and September with Sevin, Tempo, or Orthene.

e. Fire Ants: To control fire ants in all shrub and hedge beds, broadcast or spread, logic or Award in these areas in April or May and spot treat as needed with Diazinon.

f. Mites: For the control of mites, treat all shrubs and ground cover when present from March through October, with Dicofol, Pentac, Avid, Mavrik or Vendex at 7-day intervals for three applications. During winter months, apply dormant oil for the control of over wintering mites.

I. Biological Insect Control - In some instances of insect infestation, organic control may be desirable. Organic controls shall be:

1. Bacillus Thuringiensis - Bacillus thuringiensis ‘kurstaki’, Bacillus thuringiensis ‘israelensis’-- This bacterial insecticide provides effective control of the larvae of many moths, mosquitoes, fungus gnats larvae and butterflies. The spores are harmless to humans, animals and beneficial insects.

2. Trichogramma Wasp - The tiny wasps attack the eggs of more than 200 pest species, including cutworms, armyworms and many moth and butterfly eggs. Wasps should be released when moths are first seen, but a sequence of releases throughout the season is preferable to a single large release.

3. Green Lacewings (Chrysoperla rufilabris) - Egg masses are sometimes available. The larvae, known as aphid lions, prey on insects including aphids, spider mites, leafhoppers, thrips, moth eggs and small larvae. Lacewings introduced into the landscape must have a ready supply of food or they will leave.

4. Whitefly Parasite (Encarsia Formosa) - This tiny wasp is similar to the Trichogramma. It is attracted to its host by the actual smell of honeydew produced by the whitefly.

5. Whitefly Predatory Beetle (Delphastus pusillus) - This new, beneficial ladybug look-alike feeds on whitefly.

6. Praying Mantis - Egg cases containing about 200 individual eggs are available from a number of sources. The mantis is a voracious predator. Food preferences include ace bugs, grasshoppers, crickets, and many other harmful insects.

7. Lady Beetle - Aphids are the preferred hosts, but lady beetles will also eat mealy bugs, scale, spider mites, and many other soft-bodied pests and egg masses.

8. Insect Pathogenic Nematodes (Steinerema Feltiae, Neoplectana carpopcapse, Steinemema carpocapsae) - These mobile nematodes control a wide range of caterpillars and larvae.

9. Predatory Mites - (Phytoseiulus persimilis, Mesoseiulus longipilos, Neoseiulus californicus, Galendromus occidentalis) - These predators feed on the undersides of leaves where spider mites are prevalent.
Select the species that is best suited for the treatment area.

J. Diseases - Recommended fungicides for the control of diseases found in hedges, shrubs and ground covers are:

1. Asian Jasmine: No major diseases.

2. Crape Myrtle: Powdery mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.

3. Dwarf Burford Holly:
   a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Durosan, Clearys 3336, or Dithane M-45.
   b. Twig Blight - Treat when present with Daconil 2787, Clearys 3336, Durosan or Dithane M-45.
   c. Rust - Treat when present between July and September with Bayleton, Daconil 2787 or Dithane M-45.

4. Dwarf Chinese Holly:
   a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Durosan, Clearys 3336, or Dithane M-45.
   b. Blight - Treat when present with Daconil 2787, Clearys 3336, Durosan or Dithane M-45.
   c. Rust - Treat when present between July and September with Bayleton, Daconil 2787 or Dithane M-45.

5. Honeysuckle:
   a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Durosan, Clearys 3336, or Dithane M-45.
   b. Powdery Mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.

6. Indian Hawthorn:
   a. Fireblight - Treat when plants are flowering with Durosan, Clearys 3336 or streptomycin.
   b. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Durosan, Clearys 3336, or Dithane M-45.

7. Liriope: Fusarium Blight - Treat when present in the summer months with Bayleton Rubigan, Clearys 3336, or Durosan.

8. Nandina: Leaf Spot - Treat when present between May and September with Daconil 2787, Durosan, Clearys 336, or Dithane M-45.

9. Photinia:
   a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Durosan, Clearys 3336, or Dithane M-45.
   b. Twig Blight - Treat when present with Daconil 2787, Clearys 3336, Durosan or Dithane M-45.
   c. Powdery Mildew - Treat with present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.

10. Tam Juniper:
    a. Juniper Blight - Treat when present with Daconil 2787, Dithane M-45, Durosan or Clearys 3336.
    b. Juniper Rust - Treat when present with Bayleton, Dithane M-45 or Daconil 2787.

11. American Elm:
    a. Scale - Treat with present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.
    b. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
    c. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.
    d. Webworms - Treat when present between May and September with Diazinon, Mavrik, bacillus
thuringiensis, Tempo or Orthene and a spreader sticker.

e. Elm Leaf Beetle - Treat when present with Dursban, Diazinon, Mavrik, Orthene or Tempo.

12. Bald Cypress: Bagworms - Treat when present between April and September with Orthene, Tempo or bacillus thuringiensis.

13. Aristocrat Pear:
   a. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.
   b. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   c. Cankerworms - Treat April through June with Diazinon, Tempo, Mavrik, Orthene or Bacillus Thuringiensis when present.

14. Cedar Elm:
   a. Scale - Treat when present with Orthene, Oil, or a combination of Orthene and oil. Follow the temperature restriction for use of oil.
   b. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   c. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.
   d. Webworms - Treat when present between May and September with Diazinon, Mavrik, Tempo, bacillus thuringiensis, or Orthene and a spreader sticker.

15. Live Oak:
   a. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   b. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restriction for use of oil.
   c. Galls - Treat as leaves first start to appear in the early spring with Diazinon.
   d. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.
   e. Cankerworms - Treat April through June with Diazinon, Tempo, Mavrik, Orthene or bacillus thuringiensis when present.

16. Pine:
   a. Pine Tip Beetle - Treat when present with Tempo or Dursban between April and July.
   b. Pine Bark Beetle - Treat when present with Tempo or Dursban between April and July.

17. Redbud:
   a. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.
   b. Scale - Treat when present with Orthene, Oil, or a combination of Orthene and oil. Follow the temperature restrictions for use of oil.
   c. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   d. Leaf Rollers - Treat with Diazinon, Mavrik, Tempo, or Orthene and a spreader sticker between May and September when present.
   e. Leaf Miners - Treat with Orthene or Tempo when first symptoms appear on leaves, usually in summer months.
18. Red Oak:
   a. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restriction for use of oil.
   b. Borers - Treat once a month from April through September when borers are present. Spray the trunks and upper branches with Dursban. Open wounds are easily susceptible to borer attack.
   c. Aphids - Treat with Diazinon, Dursban, Mavrik, Tempo or Orthene when present.
   d. Galls - Treat as leaves first start to appear in the early spring with Diazinon.
   e. Cankerworms - Treat April through June with Diazinon, Tempo, Mavrik, Orthene or bacillus thuringiensis when present.
   f. Webworms - Treat when present between May and September with Diazinon, Mavrik, Tempo, Orthene, or bacillus thuringiensis and a spreader sticker.
   g. Twig Girdlers - Treat with Diazinon or Tempo in late July or early August if problem was present the year before.
   h. Grasshoppers - Treat when present between July and September with Sevin Tempo or Orthene.

d. Scale - Treat when present with Orthene, oil or a combination of Orthene and oil. Follow the temperature restriction for use of oil.
e. Webworms - Treat when present between May and September with Diazinon, Mavrik, Tempo, Orthene, or bacillus thuringiensis and a spreader sticker.
f. Tent Caterpillars - Treat when present between May and September with Diazinon, Mavrik, Tempo, Orthene, or bacillus thuringiensis and a spreader sticker.

K. Biological Insect Control - In some instances of insect’s infestation, organic control may be desirable. Organic controls shall be:

1. **Bacillus thuringiensis**, **Bacillus thuringiensis ‘kurstaki’**, and **Bacillus thuringiensis ‘israelensis’** - This bacterial insecticide provides effective control of the larvae of many moths, mosquitoes, fungus gnat larvae and butterflies. The spores are harmless to humans, animals and beneficial insects.

2. **Trichogramma wasp** - The tiny wasps attack the eggs of more than 200 pest species, including cutworms, armyworms and many moth and butterfly eggs. Wasps should be released when moths are first seen, but a sequence of releases throughout the season is preferable to a single large release.

3. **Green Lacewings (Chrysoperla rufilabris)** - Egg masses are sometimes available. The larvae, known as aphid lions, prey on many landscape pests including aphids, spider mites, leafhoppers, thrips, moth eggs and small larvae. Lacewings introduced into the landscape must have a ready supply of food or they will leave.

4. **Whitefly Parasite (Encarsia Formosa)** - This tiny wasp is similar to the Trichogramma. It is attracted to its host by the actual smell of honeydew produced by the whitefly.

5. **Whitefly Predatory Beetle (Delphastus pusillus)** - This new, beneficial ladybug look-alike feeds on whitefly and spider mites.

6. **Praying Mantis** - Egg cases containing about 200 individual eggs are available from a number of sources. The mantis is a voracious predator. Food preferences include lace bugs, grasshoppers, crickets, and many other harmful insects.
7. Lady Beetle - Aphids are the preferred hosts, but lady beetles will also eat mealy bugs, scale, spider mites, and many other soft-bodied pests and egg masses.

8. Insect Pathogenic Nematodes (Steinerema Feltiae, Neoplectana carpocapse, Steinemema carpocapsae) - These mobile nematodes control a wide range of caterpillars and larvae.

9. Predatory Mite - (Phytoseiulus persimilis, Mesoseiulus longipes, Neoseiulus californicus, Glaenromus occidentalis) - These predators feed on the undersides of leaves where spider mites are prevalent. Select the species that is best suited for the treatment area.

L. Mite Infestations - For the control of mites, treat all trees when present from March through October with Dicofol, Pentac, Avid, Mavrik or Vendex at 7-day intervals for three applications. During winter months, apply dormant oil for the control of overwintering mites.

M. Diseases - Recommended fungicides for the control of diseases found on trees are:

1. American Elm:
   a. Powdery Mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.
   b. Rust - Treat when present between July and September with Bayleton, Daconil 2787, Fore or Dithane M-45.
   c. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Fore, Durosan, Clearys 3336, or Dithane M-45.

2. Bald Cypress: Twig Blight - Treat when present with Mazat 200, Dithane M-45 or Durosan.

3. Aristocrat Pear:
   a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Fore, Durosan, Clearys 3336, or Dithane M-45.
   b. Fireblight - Treat when plants are flowering with bordeaux mixture, Durosan, Clearys 3336 or streptomycin.

4. Cedar Elm:
   a. Powdery Mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.
   b. Rust - Treat when present between July and September with Bayleton, Daconil 2787, Fore or Dithane M-45.
   c. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Fore, Durosan, Clearys 3336, or Dithane M-45.

5. Live Oak:
   a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Fore, Durosan, Clearys 3336, or Dithane M-45.
   b. Oak Leaf Blister - Treat with bordeaux mixture when leaves are appearing in the early spring, if there was a problem with this disease the year before.
   c. Powdery Mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.
   d. Oak Wilt - Inject Alamo into the root flares to prevent and control oak wilt for up to three years.

6. Pine:
   a. Pine Needle Rust - Treat when present with Bayleton.
   b. Pine Twig Blight - Treat when present with Dithane M-45, Durosan or Clearys 3336.
   c. Pine Needle Blight - Treat when present with Dithane M-45, Durosan or Clearys 3336.

7. Redbud: Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Fore, Durosan, Clearys 3336, or Dithane M-45.

8. Red Oak:
   a. Leaf Spot - Treat when present between May and September with
b. Oak Leaf Blisters - Treat with Bordeaux mixture when leaves are appearing in the early spring, if there was a problem with this disease the year before.

c. Powdery Mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.

d. Oak Wilt - Inject Alamo into the root flares to prevent and control oak wilt for up to three years.

9. Sweetgum:

a. Leaf Spot - Treat when present between May and September with Zybam, Daconil 2787, Durosan, Clearys 3336, or Dithane M-45.

b. Twig Blight - Treat when present with Daconil 2787, Fore, Clearys 3336, Durosan or Dithane M-45.

c. Powdery Mildew - Treat when present between May and September with Daconil 2787, Funginex, Bayleton or Rubigan.

N. Drenching Materials For Control Of Root Disease - Treat all root diseases on trees with Captan, Banrot or Subdue 2E.

3. IRRIGATION SYSTEM

A. Landscape Irrigation System: The Contractor shall be totally responsible for the operation of irrigation systems, both manual and automatic, as well as programming the automatic controlling devices to produce optimum moisture levels in all plant, vegetation and tree areas. Keys shall be provided to the Contractor for irrigation controllers. If the controllers do not have locks, the Contracting Officer will provide locks upon request. It shall be the Contractor's sole responsibility to keep plants watered properly (to the extent of supplemental watering when necessary to provide the need/s, beyond that provided by irrigation systems). If there are problems with the irrigation system that prevent proper watering procedures, Contractor shall effectuate repairs (except for trunk-line repairs). Contracting Officer shall be immediately notified of trunk-line breaks, so as to prevent any plant, vegetation and/or tree loss.

1. If possible, except as dictated by extenuating circumstances (when un usual circumstances occur as necessitated by special events, location, etc.) irrigation cycles shall be set to take place during night-time hours, but in instances prior to beginning of morning rush hours.

2. If there is more than one irrigation controller on a water meter, do not program controllers to water during the same time period, as an overdraft of water meter/s will result, resulting in diminished efficiency of system. Set controllers so that one finishes its watering cycle before then next starts its watering cycle. During periods of high rainfall, set controllers to the manual or rain mode, until irrigation is needed. Do not switch controllers to "off", as this will stop the time clock.

3. Operation of sprinklers shall be monitored by contractor on a weekly basis (in conjunction with service cycle); to insure proper coverage of areas, and/or operation, the setting of turf heads at the proper height, the straightening of heads, and cleaning/adjusting of nozzles and heads to prevent water spray on windows or buildings. When adjusting nozzles, the Contractor should remember to avoid the watering of tracks and hard surface areas (parking lots, platforms, walks, walkways and/or drive-ways); placing emphasis on this need, but particularly so during winter months.

4. During cold weather, the Contractor shall be responsible to monitor the weather
closely and to turn the irrigation system to manual or rain mode to prevent the icing of sidewalks, driveways, bus-lanes and grounds, and any associated damage to plants. When weather conditions dictate, the Contractor shall drain the irrigation system so that minimum freeze damage occurs to the system.

5. Many of the properties are equipped with freeze-stats and rain-stats, or a combination of both. In maintaining the irrigation system, the Contractor shall have the use of, and be responsible for the operation of these freeze-stats and rain-stats, keeping in mind the plus-variable factor in factory settings of freeze-stats.

6. Damage caused by the Contractor (heads, pop-up heads, stand-up heads, bubblers, valves, wiring etc.), during the mowing cycles and/or during the servicing of facilities, shall be repaired at no cost to the Authority. Replacement equipment shall be of the same type, model and manufacturer to keep the warranty coverage the same. No substitutions shall be accepted unless a particular replacement part is out of production.

7. After mowing, the Contractor or his licensed irrigation subcontractor shall perform minor maintenance on the water irrigation system at each facility listed, to ensure that the system is working properly. The Contractor shall be responsible for the supply and/or replacement of all sprinkler heads “blown-off,” (including parts) broken, missing, or otherwise damaged during routine scheduled service and/or vandalism of DART transit properties. Contractor should be prepared to respond immediately to reports of irrigation problems occurring between scheduled service visits.

B. Make adjustments and settings of automatic controllers to establish frequency and length of watering periods.

C. Check systems for continuous trouble free operation.

D. Adjust heads to maintain proper coverage. Reset heads as needed to proper height relative to adjacent grade.

E. Immediately repair and replace any equipment damaged as a result of maintenance operations, at the Contractor's expense.

F. Accidental damage not resulting from Contractor's negligence shall be reported promptly to Contracting Officer with estimate of cost for correction for Contracting Officer approval.

3.18 COMPOST TOPDRESSING

A. Add one inch of compost to planting beds and trees. Lightly cultivate compost into soil. Top with munch.

3.19 MULCHING

A. Re-mulch shrub and ground cover beds once a year with shredded hardwood or cedar bark, partially decomposed, minimum 1-1/2 inch depth. Apply after and over annual top dressing with compost.

3.20 LITTER REMOVAL

A. Maintain grass, shrub and paved areas as required to be free of litter and debris. The frequency is shown on the Table 02981 - 1.

3.21 STAKING AND BRACING

A. Maintain stakes and bracing as originally installed; and replace stakes and braces with equal material on existing trees until plant is capable of standing vertical and resisting normal winds. This is generally considered to be one full year after installation. At this point, stakes and braces are to be left in the ground to compost.

3.22 DRAINAGE DITCHES, CULVERTS, AND DRAIN INLETS

A. Drainage ditches, culverts, and drain inlets shall be kept clear, clean, and free of debris.

B. The Contractor shall make routine monthly inspection of all culverts AND after any form of precipitation (rain, snow, etc.) to insure that flow lines in and out of the culverts are free of obstructions.

C. Drainage ditches shall be kept clean and free of debris, trash, grass clippings, etc.

D. Drain inlets shall be kept clean and free of debris, trash, grass clippings, silt, leaves, etc.

3.23 CLEANUP

A. Clean up and haul off any debris resulting from the maintenance operation plus any debris and trash, which may have accumulated, in the plant beds and grass areas.
3.24 MAINTENANCE RECORD

A. Contractor shall maintain a log of site maintenance visits describing all maintenance activities performed as well as an itemized listing of costs for replacing dead plant materials and irrigation equipment due to conditions excluded from the Contractor’s guarantee. A copy of the monthly maintenance record shall be submitted at each request for payment.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be measured by and paid for at the unit price for “Landscape Maintenance” per month for each installation.
### TABLE 02981 - 1
**IRRIGATED AREAS MAINTENANCE SCHEDULE**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mow, trim and edge Buffalo</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>28</td>
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<tr>
<td>Mow, trim and edge Rye</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Scalp all turf</td>
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<td></td>
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<td></td>
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<td>1</td>
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<tr>
<td>Install Rye</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Pre-Emerge Turf</td>
<td>1</td>
<td></td>
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<td></td>
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<td>Post-Emerge Turf</td>
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<td></td>
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<td></td>
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<td></td>
<td>2</td>
</tr>
<tr>
<td>Pre-Emerge beds</td>
<td>1</td>
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<td></td>
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<td>Fertilize Buffalo</td>
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<td></td>
<td>1</td>
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</tr>
<tr>
<td>Fertilize Rye</td>
<td>1</td>
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<td></td>
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<td></td>
<td>2</td>
</tr>
<tr>
<td>Fert. shrubs, groundcover and vines</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Fertilize ornamental grasses &amp; perennials</td>
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<td></td>
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<td>Fertilize trees</td>
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<td>Prune shrubs</td>
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<tr>
<td>Trim perennials</td>
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<td>Attach vines</td>
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<td>Compost topdressing to trees, beds</td>
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<td>Mulch beds and trees</td>
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<td></td>
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<td>2</td>
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<tr>
<td>Litter removal</td>
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<td>Irrigation check</td>
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<td>1</td>
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<td>1</td>
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</tr>
<tr>
<td>Treewell and planter drainage ck.</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
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<td>12</td>
</tr>
<tr>
<td>Clean area drains and swales</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>Visit w/ Contracting Officer</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

* as needed

END OF SECTION 02981
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PART 1 - GENERAL

1.1 DESCRIPTION

A. It is the intent of this Contract to provide the Authority with a project site that is attractive in appearance. It is also the intent of this Contract to provide the Authority with existing plant material in a healthy, vigorous condition, and to have a maintained, neat appearance at all times. The following specifications relate to the non-irrigated areas:

1. Section 02931, "Seeding and Sodding - Non-Irrigated Areas".

B. See Section 02980, "Landscape Maintenance - General" for general requirements for landscape maintenance.

C. See Section 02981, "Landscape Maintenance - Irrigated Areas" for tree, shrub and groundcover maintenance at irrigated areas.

1.2 ADDITIONAL INFORMATION

A. The width of these tracts may vary considerably from railroad to railroad or from one end of the line to the other. The area to be maintained is from property line to property line of adjoining properties. It shall be the responsibility of the contractor to field-verify existing conditions at the various sites.

B. The degree of difficulty of access for maintenance varies from extremely difficult, (steep banks with heavy undergrowth, difficult access), to relatively easy access to flat-field terrain.

1.3 CONTRACTOR RESPONSIBILITY

A. The Contractor is to supply resources including supervision, labor, materials, equipment and transportation necessary to perform the services on the Authority's Railroad Right-of-Way.

B. The Contractor shall comply with Occupational Safety and Health Administration Standards while working on DART projects. The Contractor shall require employees to wear safety glasses with side shields when operating power mowers and trimmers. Employees shall wear safety toe shoes while operating power mowers. Employees shall protect their legs (i.e., wear thick long pants) while operating power trimmers.

C. The Contractor shall limit the use of operating gasoline-powered equipment prior to 10 a.m. on Ozone Action Days.

D. Personnel are required to wear a Authority-approved safety vest.

1.4 SCHEDULING / REVIEW / COORDINATION

A. For monitoring purposes, the Contractor will be provided with monthly work orders, which will indicate the properties to be maintained, and the work to be performed. The Contractor shall deliver (fax or hand) to the Contracting Officer on a daily basis an itemized work schedule of the work performed on the previous day.

B. The Contractor shall be required to attend monthly meetings to be held at a time and location determined by the Authority. The purpose of the meetings will be to review the Contractor's invoices and proposed times and locations where work is to be performed, by the Contractor, for the month. Also, the Contractor and the Contracting Officer's Technical Representative will be given the opportunity to discuss problems or concerns, which may have arisen during the previous month.

C. The Contractor's invoice submitted at the "Monthly Review" meeting will pertain to services, which were accomplished the previous month. No "hold back" or "delayed billings" will be allowed.

1.5 ADDITIONAL DEFINITIONS

A. The term "approved manner" means in complete compliance with federal, state, and local regulations and consistent with the requirements of this contract.

B. The term "monthly" shall mean once per calendar month, with each occurrence separated by at least 30 calendar days.

C. The term "Ozone Action Day" means that the weather conditions are high temperature, low wind and little or no cloud cover. When these conditions are predicted, the public is urged to take certain actions to minimize activities that cause emissions and therefore ozone.

1.6 SUBMITTALS

A. See Section 02980, "Landscape Maintenance - General".

PART 2 - PRODUCTS

2.1 MATERIALS

A. See Section 02981, "Landscape Maintenance - Irrigated Areas".
PART 3 - EXECUTION

3.1 CONTRACTOR PERFORMANCE CRITERIA

A. The Contractor shall perform the activities specified herein according to the following performance criteria:

1. Mowing: The Contractor will maintain grass and/or weeds below a height of six inches. With each mowing, the Contractor will remove (off site) trash; litter and all cut or dead tree vegetation from the properties. The Contractor will not be required to remove grass and weed clippings.


3. Litter Control: The Contractor shall inspect, remove and dispose of (off site) litter and trash, which may include sizeable objects such as tires, furniture, and appliances. Dumping must be at the Contractor’s own expense and at an appropriate State of Texas approved landfill. Frequency of litter control shall be as needed and directed by the Contracting Officer.

4. Weed Control: The Contractor shall control all weed and grass growth, within the site limits, utilizing mowing and other non-chemical methods as approved by the Contracting Officer.

5. Tree Trimming and Removal of Underbrush: The Contractor shall trim all trees and remove all underbrush and downed treesto assure that no vegetation or other growth or downed trees are within 12 feet of the railroad tracks. No other tree removal work shall be performed without prior approval of the Contracting Officer.

B. Refer to Table 02982 - 1 for frequency of work activity under this Section.

3.2 INSPECTION AND MONITORING

A. The Contractor shall report to the Contracting Officer any evidence of onsite vandalism, theft, apparent unauthorized use of DART property, or property damage.

B. If what is observed does not present a threat to the public safety, or the security of the site, the Contractor shall make a verbal report, followed up by a written report, to the Contracting Officer of such evidences no later than the next work day.

C. Where such evidences present a clear and present danger to either the public or the security of the site, the Contractor shall immediately report such evidences to the Contracting Officer, verbally and in writing, and immediately to the appropriate governmental authority (fire department, police, etc.).

D. The Contractor shall make a verbal report of adverse land conditions such as erosion, track washouts, debris lodged in culverts or drainage problems encountered during vegetation maintenance operations. The Contractor shall submit a written report, to the Contracting Officer, no later than the next workday.

3.3 MAINTENANCE RECORD

A. Contractor shall maintain a log of site maintenance visits describing all maintenance activities performed as well as an itemized listing of costs for replacing dead plant materials and irrigation equipment due to conditions excluded from the Contractor’s guarantee. A copy of the monthly maintenance record shall be submitted at each request for payment.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be measured by and paid for at the unit price for each person hours and each equipment hour of the classifications of personnel and equipment listed in the Bid Schedule.
**TABLE 02982 - 1**  
NON-IRRIGATED AREAS MAINTENANCE SCHEDULE

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
<th>Total Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mow, trim and edge Bermuda</td>
<td>Jan: 1, Feb: 2, Mar: 2, Apr: 1, May: 1, Jun: 1, Jul: 1, Aug: 1, Sep: 1, Oct: 1, Nov: 1, Dec: 1</td>
<td>10</td>
</tr>
<tr>
<td>Clean area drains and swales</td>
<td>Jan: 1, Feb: 1, Mar: 1, Apr: 1, May: 1, Jun: 1, Jul: 1, Aug: 1, Sep: 1, Oct: 1, Nov: 1, Dec: 1</td>
<td>12</td>
</tr>
<tr>
<td>Visit w/ Contracting Officer</td>
<td>Jan: 1, Feb: 1, Mar: 1, Apr: 1, May: 1, Jun: 1, Jul: 1, Aug: 1, Sep: 1, Oct: 1, Nov: 1, Dec: 1</td>
<td>12</td>
</tr>
</tbody>
</table>

*This schedule reflects the frequency of work efforts and the hours shown on the bid form. Hours may vary at the direction of the Contracting Officer.*

END OF SECTION 02982
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SECTION 03100
CONCRETE FORMWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies formwork for cast-in-place concrete construction except for construction associated with Section 02525, “Combined Curbs and Gutters, Curb Ramps, and Walks”, and Section 02550, “Concrete Pavement”.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO HB-17 - Standard Specification for Highway Bridges
   2. AASHTO M33 - Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
   3. AASHTO M153 - Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
   4. AASHTO M220 - Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

B. American Concrete Institute (ACI):
   1. ACI 117 - Standard Specification for Tolerances for Concrete Construction and Materials
   2. ACI 303.1 - Standard Specification for Cast-In-Place Architectural Concrete
   3. ACI 347 - Guide to Formwork for Concrete

C. American Hardboard Association (AHA):
   1. AHA/BOARD A135.4 - Basic Hardboard

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   2. ASTM E154 - Standard Test Methods for Water Vapor Retarders Used in Contact with Earth under Concrete Slabs, on Walls, or as Ground Cover
   3. ASTM E1643 - Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs

E. California Redwood Association (CRA):
   1. CRA Standards

F. Corps of Engineers (COE):
   1. COE CRD-C 572 - Handbook for Concrete and Cement Corps of Engineers Specifications for Polyvinylchloride Waterstop

G. Federal Construction Regulations (FED):
   1. FED PS1-83 - Construction and Industrial Plywood

1.3 SUBMITTALS

A. Product Data: For each type of product specified.
   1. Material data for waterstops including material, size, preparation requirements and installation instructions.

B. Submit forming plans for walls over 8 feet tall, suspended floors and beams, and other structures as requested by the Contracting Officer. Include materials; details of form types; shoring and falsework; methods of form construction and erection; design computations; location of form joints, construction joints, and form ties; waterstops; sleeves; bonding adhesives; schedule of erection and stripping; and all dimensions controlling concrete shapes.

C. Submit 6 inch by 6 inch sample of form facing materials for concrete surfaces exposed to public view.

D. Vapor Retarder: Submit two representative samples, 6 inches by 6 inches.

E. Certification:
   1. Submit certifications that form release agent is compatible with concrete admixtures, and where required, will not prevent bonding of subsequently applied coatings.

2. For early form removal: Submit certified test reports of specified concrete tests.
F. Calculations: Submit early form removal calculations as specified certified by a Professional Engineer, licensed in the State of Texas. Submit and obtain approval from the Contracting Officer in advance of form removal if forms are to be removed before the concrete attains the minimum strength specified under Article 3.10, herein.

1.4 QUALITY ASSURANCE

A. Responsibilities: Design and construction of formwork is the responsibility of the Contractor, subject to review by the Contracting Officer.

B. Design Criteria:
   1. Design formwork for vertical loads and lateral pressures, including weather conditions, in accordance with ACI 347 and for easy removal.
   2. Design formwork system which is adequately braced and has adequate strength and stability to provide finished concrete within the specified tolerances in accordance with applicable requirements of ACI 117 and ACI 347.
   3. When necessary to maintain the specified tolerances, design camber into the formwork to compensate for anticipated deflection and creep due to the weight and pressure of the fresh concrete and weight of formwork. Limit form deflection to 1/360 of the component span.

PART 2 - PRODUCTS

2.1 FORMING MATERIALS

A. General: Use materials suitable for exterior exposure and which have the strength to produce required tolerances.

B. Form Facing in Contact with Concrete: Wood, plywood, fiberglass reinforced plastic, steel, or other approved materials capable of producing the specified finish, that will not react with fresh concrete to cause loss of strength or durability in hardened concrete and that will not be damaged by the form release agent. Do not use materials that will stain concrete surfaces exposed to view.
   1. Except where otherwise specified or shown, use materials that do not exceed the roughness of dressed lumber or FED PS1-83.
   2. Where a smooth finish is specified or shown, use plastic, steel or wood products that will produce a hardened concrete surface equivalent to that produced by concrete cast against High Density Overlaid (HDO) plywood as per requirements of ACI 303.1.

2.2 FORM TIES

A. Factory-fabricated, snap-off metal type, of adequate design to minimize form deflection and preclude concrete spalling upon removal.

B. Fabricated so that portion of tie remaining after snap-off and removal of exterior portions is at least 1-1/2 inch below concrete surface.

C. Where concrete is to be left exposed, provide ties with removable cones 1-1/2 inch deep and not more than 1-1/4 inch in diameter leaving no metal closer than 1-1/2 inch from finished concrete surface, unless otherwise shown.

D. Provide ties with a water seal washer for retaining walls, basement walls, pit walls and liquid containing structures.

2.3 FORM RELEASE AGENT

A. Non-staining liquid form release product that will not bond with concrete and that will not impair bond of subsequently applied concrete coatings.

2.4 PREFORMED EXPANSION JOINT

A. General: Provide joint fillers that are compatible with sealants used. Joint fillers shall be used at all expansion joint locations unless otherwise noted.

B. Bituminous: AASHTO M33.

C. Cork: AASHTO M153, Type II.

D. Preformed joint seals: AASHTO M220.
E. Bonding adhesive: As recommended by manufacturer of preformed expansion joint filler.

2.5 WATERSTOPS
A. PVC: In accordance with COE CRD-C 572.

2.6 CHAMFER STRIPS
A. Except where other sizes are shown, 3/4 inch by 3/4 inch triangular fillets milled from clear, straight-grain pine, surfaced each side, or extruded vinyl type.

2.7 MISCELLANEOUS
A. Miscellaneous preformed strips for reveals, rustications and similar joints: Fabricate of wood, metal, plastic, or other approved material formed to cross-sections shown.
1. Redwood boards - CRA.
2. Polystyrene foam where shown on drawings.

2.8 SLEEVES
A. Schedule 40, galvanized, ASTM A53/A53M, Type E, Grade A or B steel pipe.

2.9 VAPOR RETARDER
A. Membrane Composition: Three or five ply nylon or polyester cord reinforced high density polyethylene sheet laminated to nonwoven geotextile fabric, 30 mils thick; 15 mil polyethylene; or 15 mil polyolefin.
B. Membrane Standard: ASTM E 1745, Class A.
C. Accessories: Lap tape as recommended by membrane manufacturer for compatibility with membrane.
D. Acceptable manufacturers and product:
1. Fortifiber Building Systems Group - “Moistop Ultra ‘A’”
2. Raven Industries - “Vapor Block 15”
3. Reef Industries, Inc. - “Griffolyn Type-65G”
4. Or approved equal.

2.10 DOVETAIL ANCHORS
A. 22-gauge electrogalvanized steel with removable filler.

2.11 COIL ROD INSERTS
A. As shown on Contract Drawings and per manufacturer’s recommendations.

PART 3 - EXECUTION

3.1 CONSTRUCTION AND WORKMANSHIP
A. Concrete finishes and usage locations of various types of forms and form lining: As shown or specified.
B. Unless otherwise shown for concrete surfaces exposed to public view, use form facing materials for an architecturally smooth finish that will provide a finished concrete surface free of form joint marks between abutting panel surfaces, rustications, or control and expansion joints.
C. Construct adequately braced formwork so that resulting concrete surfaces conform to tolerances specified in ACI 117 or as otherwise shown.
D. Brace forms, falsework, and centering adequately to retain forms in position as shown on approved Forming Plans. Install sills, grillages, or foundations of suitable types and size to prevent settlement of false work, form supports, and shoring.
E. Provide mortar-tight forms which conform to shapes, lines and dimensions shown, and which produce smooth surfaces without fins and projections. Provide back-up at form joints or filled joints to prevent leakage of cement paste.
F. Fabricate forms to facilitate their removal without damaging concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Bevel wood inserts for forming keyways, reglets, and recesses, to allow easy removal.
G. Make provisions in formwork to permit removal of debris from interior form spaces. Locate temporary openings in forms at inconspicuous locations.
H. Chamfer exposed corners and edges unless otherwise shown on drawings, using chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
I. Provide groove strip on form at control joint lines and construction joints used in lieu of control joints.
J. Use form ties in arrangements, numbers and sizes to resist lateral pressures exerted by fresh concrete and to prevent form deflection. Use specific tie arrangements where shown. When tie arrangements are not shown for concrete exposed to view, arrange ties in a uniform square grid.
K. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, or other debris just before concrete is placed. Retighten forms and bracing after concrete placement if required to eliminate mortar leaks and maintain proper alignment.
3.2 FIELD QUALITY CONTROL

A. Inspect and check complete formwork, shoring, and bracing to verify that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and parts are secure.

B. Inform the Contracting Officer when formwork is complete and has been cleaned, to allow for inspection. Do not place concrete until the Contracting Officer's inspection is complete.

C. During concrete placement, check formwork and related supports to verify that forms are not displaced and that completed work will be within specified tolerances.

3.3 COATING FORMS

A. Coat forms with Form Release Agent prior to placement of reinforcing steel.

B. Do not allow excess coating material to stand in puddles in forms nor to come into contact with concrete against which fresh concrete is to be placed.

C. Coat bolts and rods that are to be completely removed or that are to be free to move with bond breaker.

3.4 EMBEDDED ITEMS

A. Ensure that items to be embedded in concrete are free from oil and foreign matter that would weaken bond of concrete to such items.

B. Install in formwork inserts, anchors, sleeves and other items specified elsewhere. Close ends of conduits, piping and sleeves embedded in concrete with caps or plugs.

C. Install continuous dovetail anchor slots where specified or shown or where required for attachment of facing materials.

D. Before placing concrete, check location and support of piping, electrical conduits, and other items which are to be wholly or partially embedded.

3.5 OPENINGS AND RECESSES IN CONCRETE

A. Provide openings, recesses, and sleeves as shown and where required under other specification sections.

3.6 JOINTS

A. Unless otherwise approved in writing by the Contracting Officer, make contraction, expansion and construction joints only where shown.

B. Form keyways only where shown.

C. Install premolded expansion joint material in all expansion joints of the size and type shown on the drawings. Extend filler from bottom of concrete up flush to finish concrete surface or hold down below finish surface as shown or as required to receive sealant.

D. Make splices in premolded filler in a manner to preclude penetration of concrete between joint faces.

3.7 WATERSTOPS

A. Install waterstops in construction joints below grade and where shown on the drawings. Use 6 inch minimum width, except where otherwise shown.

B. Support and protect that portion of waterstop which extends beyond bulkhead, during placing of concrete and subsequent removal of forms.

C. Make field splices using manufacturer's printed instructions to develop watertightness equal to that of unspliced material. Use manufacturer's factory fabricated sections for corners and "T" intersections.

3.8 VOID BOXES

A. Where shown, place void boxes on prepared level subgrade beneath grade beams.

B. Use either rectangular or trapezoidal shaped void box as shown on the drawings. Use backfill retainers with rectangular void boxes.

C. Replace any damaged void boxes prior to placing concrete.

D. Tape ends of void boxes.

3.9 VAPOR RETARDER

A. Place, protect, and repair vapor-retarder sheets according to ASTM E1643 and manufacturer's written instructions.

3.10 REMOVAL OF FORMS, FALSEWORK, AND CENTERING

A. Unless otherwise shown or specified, maintain, and remove forms and related structures for cast-in-place concrete work in compliance with the ACI 347. For bridges refer to AASHTO HB-17.

B. In the determination of the time for removing formwork and constructing superimposed elements, consideration shall be given to the location and character of the structure, the weather, other conditions influencing setting of concrete, and material used in the mixture. Formwork shall include forms, braces, ties, guy wires, and other instruments of stabilization.
C. If removing formwork and forming for and placing concrete in superimposed elements are controlled by cylinder tests, the Contractor will be permitted to perform these operations when cylinder strengths reach the values specified in the Table 03100-1, "Requirements for Removing Formwork and Constructing Superimposed Elements". Cylinders shall be cured under conditions that are not more favorable than the most unfavorable conditions for the portions of concrete the cylinders represent.

D. The periods given in Table 03100-1, "Requirements for Removing Formwork and Constructing Superimposed Elements", exclusive of days when any portion of the concrete element surface is below 40 degrees F, shall be used if the control cylinder test is not used. The period of time shall be counted from the completion of concrete placement. These strengths and periods are intended only for indicated construction operations and shall not apply to the use of equipment or other live loads on the structure. Stockpiling materials or using unauthorized equipment on the structure will not be permitted until concrete has reached its 28 day required compressive strength (f'c).

E. Methods of form removal that will overstress concrete shall not be used. Supports shall be removed in a manner to permit the concrete to take, uniformly and gradually, the stresses caused by its own weight.

F. Do not alter loading conditions on concrete subsequent to removal of forms if alteration exceeds permissible stresses and deformations at attained concrete strengths.

3.11 COIL ROD INSERTS

A. In accordance with the Contract Drawings and the manufacturer's recommendations.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Concrete formwork will not be paid for under this section wherein no measurement will be made.

B. Concrete formwork specified in this section will not be paid for separately under this section, as all related costs will be considered as incidental or subsidiary to the particular cast-in-place or precast concrete work required by the Contract Documents.
### TABLE 03100-1

**REQUIREMENTS FOR REMOVING FORMWORK AND CONSTRUCTING SUPERIMPOSED ELEMENTS**

<table>
<thead>
<tr>
<th>Structural Element</th>
<th>Removing Formwork</th>
<th>Forming for Superimposed Elements</th>
<th>Placing Concrete in Superimposed Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time (days)</td>
<td>Strength (% f'(_c))(^1)</td>
<td>Time (days)</td>
</tr>
<tr>
<td>T-beam (centering)</td>
<td>14</td>
<td>90</td>
<td>18</td>
</tr>
<tr>
<td>T-beam (side forms)</td>
<td>2</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Deck slab</td>
<td>7</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Wall carrying load</td>
<td>7</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Column carrying load</td>
<td>7</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Footing</td>
<td>2</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>Pier or abutment cap</td>
<td>7</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Part not carrying load</td>
<td>2</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Minimum 28-day design compressive strength as specified in Section 03305, “Portland Cement Concrete”, or as indicated on the Drawings.

\(^2\)The load referred to is the immediate load that will be transmitted to the structural element as a result of removing falsework and bracing, not the load that will eventually be placed on the structural element.

**Note:** Curb and parapet face forms may be removed as soon as concrete has attained sufficient set to stand without slumping. When mineral admixtures are used in the concrete mixture, requirements for removing formwork and constructing superimposed elements shall be based on percentage of strength only.

END OF SECTION 03100
SECTION 03200
CONCRETE REINFORCEMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies conventional reinforcement and reinforcement accessories for cast-in-place concrete structures, masonry construction, precast concrete, and concrete paving.

B. Prestressing reinforcement is not specified in this section; refer to Section 03365, "Prestressed Concrete".

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO HB-17 - Standard Specification for Highway Bridges

B. American Concrete Institute (ACI):

1. ACI SP-66 - ACI Detailing Manual
2. ACI 117/117R - Standard Specification for Tolerances for Concrete Construction and Materials (ACI 117) and Commentary (ACI 117R)
3. ACI 301 - Specifications for Structural Concrete
4. ACI 315 - Details and Detailing of Concrete Reinforcement
5. ACI 318/318R - Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R)

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
5. ASTM A568/A568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
6. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
7. ASTM A706/A706M - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
8. ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
11. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
13. ASTM G12 - Standard Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel

D. American Welding Society (AWS):

1. AWS D1.4 - Structural Welding Code - Reinforcing Steel

E. Concrete Reinforcing Steel Institute (CRSI):

1. CRSI DA4 - Manual of Standard Practice
2. CRSI DE1 - Reinforcing Bar Detailing

F. Federal Highway Administration Office Of Highway Safety (FHWA):

1. FHWA RD 74 - NBS Non-Metallic Coating For Concrete Reinforcing Bars
2. FHWA N 5080.33 - Coated Reinforcing Steel for Highways and Bridges

G. Underwriters Laboratories (UL)

1. UL 83 - UL Standard for Safety Thermoplastic Insulated Wires and Cables
2. UL 514A - UL Standard for Safety Metallic Outlet Boxes

1.3 SUBMITTALS

A. Shop Drawings:

1. Prepare and submit drawings and schedules to illustrate fabrication, placement, and support of concrete reinforcement. Comply with CRSI Manual of Standard Practice, ACI SP66, and additional requirements specified herein. Contract Documents may not be reproduced for use as part of the shop drawings unless approved in writing by the Engineer of record. Include bar bending diagrams and bar lists. Provide placement drawings, which show reinforcement and its support by using, beam elevations, slab or mat placement plans for each layer of reinforcing, wall elevations, column schedules, and details. Develop details to show proper fit and arrangement of reinforcing. Show locations of bar splices, splice lengths, and bar cutoff points on placement drawings. Show clear concrete cover over reinforcing. Include type, size, and locations of supports required to maintain position of reinforcement.

2. For prestressed concrete, show location of mild steel reinforcing with respect to prestressing tendons. Arrange mild steel to avoid interference with prestressing tendons.

B. Certification:

1. Manufacturer's certificates including origin and product data that certifies conformance with specified requirements for welded wire fabric and reinforcing accessories and supports.

2. Mill test reports on each heat showing chemical and physical analyses performed in accordance with ASTM A615/A615M or A706/A706M.

3. Qualification of welders in accordance with AWS D1.4.

4. For galvanized and epoxy-coated reinforcing bars, furnish certificates of compliance with ASTM A767/A767M for galvanized and ASTM A775/A775M for epoxy-coated bars.

5. Certification of Electrical Testing Supervisor in accordance to NACE International Certified Corrosion Specialist.

1.4 QUALITY ASSURANCE

A. Allowable Tolerances: Cut and bend reinforcing steel to conform to required dimensions within the following tolerances:

1. Sheared length: Plus or minus 1 inch.

2. Depth of truss bars: Plus zero or minus 1/2 inch.

3. Stirrups, ties and spirals: Plus or minus 1/2 inch.

4. Other bends: Plus or minus 1 inch.

5. Placement tolerances not indicated on the contract drawings or specified above shall comply with requirements of ACI 117, ACI 301, ACI 318R, or CRSI DA4.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Ship reinforcing steel in bundles limited to one size and length or one bar mark number.

B. Tag each bundle at mill with waterproof tag showing name of mill, heat number, grade and size of bars, identifying bar mark number, and structural element into which the bar is to be placed.

C. Store above surface on platforms, skids, or other supports as necessary to prevent contact with ground.

D. Protect reinforcing steel and wire fabric from damage; foreign matter such as dirt, oil, and grease; and rust-causing conditions.

PART 2 - PRODUCTS

2.1 REINFORCEMENT MATERIALS

A. Deformed Bars: ASTM A615/A615M, Grade, 60 unless otherwise shown or specified.

B. Weldable Deformed Bars: Provide low alloy steel complying with ASTM A706/A706M.

C. Spiral Reinforcement: ASTM A82 or ASTM A615/A615M Grade 60, unless otherwise shown or specified.

D. Welded Wire Fabric (WWF): Provide in flat sheets for wire sizes W2.9 and greater, conforming to ASTM A185 for plain wire and ASTM A497 for deformed wire.
2.2 ACCESSORIES SUPPORT FOR REINFORCEMENT

A. Rebar supports to be in accordance with CRSI DA4 unless otherwise shown. Where concrete surfaces will be exposed to public view in finished structure use supports of Polypropylene plastic or plastic-protected steel legs complying with CRSI Class 1 - Maximum protection. Color of plastic to match finished concrete surface. Where concrete surface will be sandblasted use supports of stainless steel.

B. Steel wire for securing reinforcing bars and embedded items: ASTM A82, plain, cold-drawn, 16 gage or heavier; ASTM A884/A884M for welded steel wire fabric - epoxy-coated.

2.3 EPOXY COATING

A. Conforming to the requirements of FHWA-RD-74 NBS Non-Metallic Coating For Concrete Reinforcing Bars, FHWA N 5080.33 Coated Reinforcing Steel for highways and bridges, or ASTM A775/A775M Epoxy Coated Reinforcing Steel Bars, elsewhere.

B. Color: Green.

C. Ensure material used for repairing damaged or uncoated areas is compatible with the epoxy coating and is inert in concrete.

D. Coating Thickness: Seven mils plus or minus two mils after cure, applied in a uniform smooth coat, measured in accordance with ASTM G12.

E. Repair damaged or uncoated surfaces by application of repair material in accordance with manufacturer's printed instructions.

2.4 METAL-FILLED SLEEVE COUPLER

A. Capable of developing in tension 125 percent of yield strength of adjoining reinforcing bars.

B. Designed to produce complete fusion with 100 percent penetration of joint.

C. Connection produced by standard exothermic process whereby molten filler metal, contained by high-strength steel sleeve, is introduced into the annular space between bars and sleeve and between ends of bars.

2.5 MECHANICAL SLEEVE COUPLER

A. Capable of developing in tension 125 percent of yield strength of adjoining reinforcing bars.

B. Connection - Produced by threaded reinforcing bar ends and threaded coupler or by metal sleeves hydraulically pressed or forged onto butt-ended reinforcing bars.

C. Couplers - Comply with local building codes if reinforcement is used in private building modifications.

D. Capable of being installed in clear space indicated.

E. “Bar-Grip” as manufactured by Barsplice Products Inc.; “Sylgab Stricon” as manufactured by Sylgab Steel & Wire Corp.

2.6 ELECTRICAL BONDING AND TEST FACILITY MATERIALS

A. Bond Cables: Size as indicated, See Section 13100, Corrosion Control.

B. Test Wires: Size as indicated. See Section 13100, Corrosion Control.

C. Bonding Straps and Plates: Carbon Steel, ASTM A1008/A1008M and ASTM A568M.

1. Straps: 1/2 inch thick by 2 inch wide, with length as required.

2. Plates: 1/4 inch thick, of size indicated.

3. Straps and Plates: Galvanized in accordance with ASTM A123.

D. Exothermic Welding Materials: Connection produced by standard exothermic process whereby molten filler metal, contained by high-strength steel sleeve, is introduced into the annular space between bars and the sleeve. Use materials conforming to the manufacturer's recommendations regarding the mold size and shape, and charge size, and alloy mixture for the powder.

E. Test Boxes: Type as indicated, See Section 13100, “Corrosion Control”.

F. Test Recess Covers: Type as indicated. See Section 13100, “Corrosion Control”.

G. Flexible Conduit: ASTM D4385 polyethylene, of diameter indicated.

H. Conduits and Fittings - Rigid galvanized as specified in Section 16111, Conduits.

I. Identification Tags - Brass or copper alloy with minimum 1 inch width and minimum 1/8 inch thickness. Identifying letters and numerals - Die Stamped.
PART 3 - EXECUTION

3.1 GENERAL

A. Fabricate and place reinforcement in accordance with ACI 117, ACI 301, ACI 318R, CRSI Manual of Standard Practice, CRSI Recommended Practice for Placing Reinforcing Bars, and approved shop drawings.

3.2 CUTTING AND BENDING

A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.

B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

3.3 BAR SUPPORTS AND SPACERS

A. Support bars by means of bolsters or chairs at intervals not exceeding requirements by ACI Detailing Manual or CRSI.

B. Reinforcing steel in bottom of slabs resting on earth may be supported by concrete blocks or chairs with sand pads.

C. In walls, columns, piers and abutments hold reinforcing steel in position by means of pier sleds, bar supports or spacers wired to reinforcing steel.

D. Use of stones, clay bricks, wood blocks, or pieces of broken concrete to support reinforcing steel shall not be permitted.

E. Contractor shall not place bars or fabricated mats on layers of fresh concrete as work progresses.

3.4 PLACING AND FASTENING

A. Verify that surface over which concrete will be placed is clean and in proper condition prior to placing reinforcing.

B. Arrange and place reinforcing steel as shown within ACI 318 tolerances.

C. Reinforcing steel shall be free from rust and mill scale, dirt, oil, grease, and other materials which reduce or destroy bond with concrete.

D. Secure reinforcement positively against displacement during placing of concrete. Cut wires close to bars and bend wire away from concrete surfaces. Ensure that tie wires are not in contact with cast-in-place fastener inserts. Remove the clippings and other debris.

E. Wire or clip bars together as recommended in the CRSI Manual of Standard Practice except that reinforcing steel for bridge slabs shall be tied at each intersection.

F. Verify items to be embedded and block-outs are secure in place as required.

G. Position reinforcing steel to permit accurate location of anchor bolts for rail tie plates and other embedded items.

H. Before concrete placement, remove dirt, mill scale, rust scale, oil, grease, and other foreign matter from reinforcement and reinforcement supports.

I. Epoxy coated bars shall be fastened with nylon, epoxy, or plastic coated tie wire.

3.5 SPlicing

A. Furnish reinforcing bars in full lengths as shown on the Contract Drawings and approved shop drawings.

B. Unless otherwise shown, lap reinforcement shall have lap lengths in accordance with ACI 318.

C. Do not splice bars at locations other than those shown on Contract and approved shop drawings unless approved in writing by the Contracting Officer.

D. Lap splices shall not be made on reinforcement greater than No. 11.

E. Make mechanical or welded splices only when specified or shown, or approved in writing by the Contracting Officer. Use weldable rebar for welded splices. Weld in accordance with AWS D 1.4.

F. After installing mechanical connections on epoxy coated bars, all coating damages shall be repaired in accordance with Article 2.3 of this section. All parts of mechanical connections used on epoxy-coated bars shall be coated with same material used for repair of coating damages.

3.6 ELECTRICAL BONDING

A. Make connections between copper conductors, concrete reinforcement, and embedded metal components by exothermic-thermite welding of brazing. Procedures, materials and equipment for thermite welding - Conform to manufacturer’s recommendations. For brazing conform to AWS standard practices. Refer also to Section 16450, “Grounding and Bonding”.
B. Bonding and Longitudinal Reinforcement Steel for Track Invert:

1. Weld top layer of longitudinal reinforcement steel bars at splices in bridge decks, track slabs, bridging slabs and approach/transition slabs to form an electrically continuous path parallel to the trackway.

2. Use a minimum of two fillet welds, not less than 1 inch long, for each splice.

C. Transverse Collector Bars

1. Install transverse collector bars for top layer of longitudinal reinforcement steel at block outs, openings, changes in section, and other locations where longitudinal reinforcement is interrupted in bridge decks, track slabs, bridging slabs, and approach/transition slabs.

2. Weld transverse collector bars to top layer of longitudinal reinforcement steel bars for electrical continuity.

3. Provide test facilities at top transverse collector bar sites, as indicated.

D. Test Facilities:

1. Provide test facilities at each end of the structure and at distances along the structure not to exceed 200 feet. Connect to top layer longitudinal reinforcing steel in the concrete through connectors to the transverse collector bars. Weld top layer of longitudinal bars to transverse collector bars for electrical continuity at test station locations. Install test box with test wires for each transverse collector bar or pair of transverse collector bars at structure joints and other locations, as indicated. Terminate test wires connected to transverse collector bar in test box at an accessible location, as indicated.

2. Identify test wires terminating in test facilities with stamped brass identification tags.

E. Use polyurethane sealant in concrete notches at copper bonding: Section 07900, "Seals And Sealants".

3.7 INSTALLATION

A. Electrical Components:

1. Test boxes: Install at-grade, flush wall, and post mount, test boxes at the locations shown. Install blocking and concrete pad as shown to provide a rigid installation. Route all cabling in a manner that will not cause damage to the wire insulation. Allow enough slack to compensate for soil movements and to permit extension of the wires 18 inches minimum above the box. Coil excess wire in the box.

2. Cables: Bond mechanical joints in concrete reinforced structures as shown. Provide conduits and test wires of the size and type shown from each bonded facility and terminate at location shown. Weld bond, and test wires using exothermic welds following instructions of the manufacturer and as specified herein. Use of compression and split bolt connectors is prohibited. Identify each cable and test wire, test box using nonmetallic tags or pressure sensitive labels.

3.8 INSPECTION

A. Placement of concrete prior to approval by the Contracting Officer of reinforcement and electrical bonding work is prohibited.

B. After concrete has been placed in the accepted sections, the sections shall be retested.

3.9 CONCRETE PROTECTION FOR REINFORCEMENT (COVER)

A. Unless otherwise shown, provide concrete cover of reinforcement in accordance with ACI 318R.

B. For prestressed concrete bearing highway or transit loads provide cover in accordance with AASHTO HB-17 requirements.

3.10 QUALITY CONTROL

A. Do not cover test wires, bonding wires, and other buried and embedded components of corrosion control systems without inspection and approval of the Authority Corrosion Control Engineer. Any/all damage /defective material will be repaired/replaced at the Contractor’s expense.

B. The stations will be installed with adequate protection to insure the test station will not be damaged during subsequent construction. Contractor will be responsible for repair/replacement of the test station at no additional expense to Authority.
C. The Authority Corrosion Control Engineer will test all corrosion control systems. Tests to include, but not to be limited to, electrical continuity of bonding structures including wiring, splices, test cables, test stations. The Contractor will repair or replace deficiencies and damaged components to the satisfaction of the Authority Corrosion Control Engineer and at no additional expense to Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Reinforcing steel will not be measured or paid for separately, but shall be considered subsidiary to the concrete of each structure specified in Section 03300, “Cast-In-Place Concrete”.

B. Welded wire fabric will not be measured or paid for separately, but shall be considered subsidiary to corrosion control or concrete.

C. Increases in reinforcing steel quantity or added splices for the convenience of the Contractor, even though approved by the Contracting Officer, will not be measured for payment.

D. Materials and work related to the bonding and testing of the reinforcing steel will not be measured or paid for separately, but shall be considered subsidiary to concrete of each structure specified in Section 03300, “Cast-In-Place Concrete”.

END OF SECTION 03200
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for delivering, conveying, placing and curing cast-in-place Portland cement concrete in combination with Section 03305, “Portland Cement Concrete”, as indicated.

B. Finishing of formed and unformed concrete surfaces, are specified in Section 03350, “Concrete Finishing”.

C. Forming Requirements are specified in Section 03100, “Concrete Formwork”.

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1. ACI 116R - Cement and Concrete Terminology
2. ACI 117 - Standard Specification for Tolerances for Concrete Construction and Materials
3. ACI 301 - Specifications for Structural Concrete for Buildings
4. ACI 303.1 - Standard Specification for Cast-In-Place Architectural Concrete
5. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete
6. ACI 304.2R - Placing Concrete by Pumping Methods
7. ACI 305R - Hot Weather Concreting
8. ACI 306.1 - Standard Specification for Cold Weather Concreting
9. ACI 308.1 - Standard Specification for Curing Concrete
10. ACI 309R - Guide for Consolidation of Concrete
11. ACI 318/318R - Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R)
12. ACI 336.1 - Specification for the Construction of Drilled Piers
13. ACI 503.2 - 503.4 - Three Epoxy Standards

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete
3. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete
4. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C. Texas Department of Transportation (TxDOT):

1. TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges.
2. TxDOT Construction Bulletin C-1 – Concrete Construction Manual
3. TxDOT Construction Bulletin C-11 – Procedures for the Design and Control of Portland Cement Concrete Mixtures

1.3 DEFINITIONS

A. Mass Concrete: All pier stems and caps with a least dimension equal to or greater than 5'. Aerial station support columns and drilled shafts are excluded from mass concrete requirements.
1.4 SUBMITTALS

A. Implementation:

1. Submit plans for controlling concrete temperature and for placing concrete taking into account sun, heat, wind, ambient air temperature, and other limitations of facilities that will prevent proper finishing and curing.

2. Submit quality control plan for floor treatment prior to installation.

3. Submit field quality control test reports no more than 1 day after tests are made.

B. Product Data: Submit manufacturer’s product data for epoxy adhesive.

C. Records and Reports: Report the location in the finished work of each mix design, and the start and completion times of placement of each batch of concrete placed for each date concrete is placed. Reports shall be submitted no later than 1 day after placement.

D. Thermal Control Plan:

1. Prior to mass concrete construction, submit a Thermal Control Plan with design calculations.

2. Thermal Control Plan shall show complete details and determine the maximum allowable temperature differentials between the hottest point of the concrete and the exterior faces based on the design assumption that cracking as a result of heat of hydration shall not occur. As a minimum, the Thermal Control Plan shall include the following:
   a. Mix design.
   b. Duration and method of curing.
   c. Procedures to control concrete temperature at time of placement.
   d. Methods of controlling temperature differentials.
   e. Temperature sensor types and locations.
   f. Temperature monitoring and recording system.
   g. Field measures to ensure conformance with the maximum concrete temperature and temperature differential requirements.

1.5 QUALITY ASSURANCE

A. Tolerances:

1. Concrete Tolerances: Comply with the requirements of ACI 117 as applicable. Coordinate with the requirements specified in Section 03100, “Concrete Formwork”.

2. Tolerances for Slabs and Flatwork: Comply with the requirements specified in Section 03350, “Concrete Finishing”.

3. Tolerances tighter than those indicated in ACI 117 shall be provided at specific locations identified in the Contract Documents.
   a. Concrete supporting the glass fiber concrete warning strips shall be within plus or minus 1/2 inch of horizontal and vertical contract line and grade.

B. Architectural Concrete: Where concrete is indicated as architectural concrete and where concrete is exposed to public view, such concrete shall be produced in accordance with applicable requirements of ACI 301 and ACI 303.1.

1. Approved site mock-ups shall set the standard for the various architectural concrete features, formed finishes, and colors of the concrete. Provide as many mock-ups as required to show all the different features and formed surfaces of the concrete.

C. Cold Joints: Cold joints in concrete will not be permitted unless planned and treated properly as construction joints.

D. Qualifications of Contractor’s Engineer: Thermal Control Plan for mass concrete work shall be prepared by a Professional Engineer licensed in the State of Texas. Submit proof of licensing and qualifications to Contracting Officer. Contractor’s Engineer shall be qualified to evaluate mass concrete work, review reports and consult on related issues.

1.6 PROJECT CONDITIONS

A. Environmental Requirements:

1. Delivering and placing of concrete in hot weather and cold weather shall conform with applicable requirements of ACI 305R and ACI 306.1 and Section 03305, “Portland Cement Concrete”.

2. Do not place concrete when the rate of evaporation of surface moisture from concrete exceeds 0.2 pounds per square
PART 2 - PRODUCTS

2.1 MATERIALS

A. Formwork: Refer to Section 03100, “Concrete Formwork”, for requirements.

B. Joint Fillers and Sealers: Refer to Section 03100, “Concrete Formwork”, for requirements.

C. Waterstops: Refer to Section 03100, “Concrete Formwork”, for requirements.

D. Reinforcing Steel: Refer to Section 03200, “Concrete Reinforcement”, for requirements.

E. Portland Cement Concrete: Refer to Section 03305, “Portland Cement Concrete”, for mix designs and other requirements.

F. Epoxy Adhesive: ASTM C881, Type, Grade and Class as determined by project conditions and requirements.

1. For Concrete Repairs Exposed to Wet Conditions: Two-component compound, 100 percent solids, 100 percent reactive compound suitable for use on dry or damp surfaces.

   a. Acceptable manufacturers and product:

      1) “Shep Poxy Roads & Highways MV” by CMC Construction Services.
      2) “Sikadur 32 Hi-Mod LPL” by Sika Corporation.
      3) “Epobond” by L&M Construction Chemicals.

2. For Concrete Repairs and New Construction Not Exposed to Wet Conditions:

   a. Film-forming, freeze-thaw resistant material suitable for exterior or interior exposure.

   b. Acceptable manufacturers and product:

      1) “Everbond” by L&M Construction Chemicals.
      2) “Euco Weld” by Euclid Chemical
      3) “Weld-Crete” by Larson Products Corp.

3. For New or Repaired Construction Joints Exposed to Wet Conditions or where shown:

   a. High solids, acrylic polymer latex bonding agent conforming to ASTC C-1059-91 Type II (non-reemulsifiable).

   b. Acceptable manufacturers and product:

      1) Acrylic Bonding Agent J40 by Dayton Superior
      2) Acrylic Bonding Agent by White Cap Construction Supply
      3) Acry-Lok Bonding Agent by W.R. Meadows Co.

2.2 MECHANICAL COOLING SYSTEM FOR MASS CONCRETE

A. If the Contractor elects to use a mechanical cooling system, the mechanical cooling system shall be designed in conformance with the Thermal Control Plan and the following requirements:

1. The mechanical cooling system shall be embedded within mass concrete elements and surface connections to cooling pipes shall be removable to a depth of 4 inches from the surface.

2. Forms shall be designed so that removal of the forms shall not disrupt the cooling or temperature monitoring.

3. Cooling pipes shall not break and deform during mass concrete placement and shall be secured to prevent movement. Damaged Cooling pipes shall be removed and replaced immediately.

4. The mechanical cooling system shall be pressure tested at 30 psig for 30 minutes for leaking prior to mass concrete placement. Coolant circulation shall be in progress at the time that concrete placement begins.

5. After cooling is completed, cooling pipes shall be full grouted under pressure with a Structural Nonshrink Grout as specified in Section 03305, “Portland Cement Concrete”. The placement of structural nonshrink grout shall be in conformance with the manufacturer’s recommendations.

6. After surface connections to the cooling pipes are removed, the holes shall be reamed and filled with Portland Cement Grout as specified in Section 03305, “Portland Cement Concrete”.

DART Standard Specifications – July 2014

03300 - 3
CAST-IN-PLACE CONCRETE

PART 3 - EXECUTION

3.1 PREPARATION FOR CONCRETE PLACEMENT

A. Coordination:

1. In accordance with Section 01450, "Quality Control", and as directed during the program of work, notify Contracting Officer at least 24 hrs prior to the date and time concrete is scheduled to be placed and when the forms, reinforcement and embedded items will be ready for inspection by the Contracting Officer. Do not place concrete until the Contracting Officer's inspection is complete.

2. Notify all trades having work that will be embedded in the concrete unit being placed sufficiently in advance of the placement date to allow completion of their work prior to the Contracting Officer's inspection.

3. Schedule the presence of agencies, laboratories and manufacturers' representatives required to test sample or give direction during placement of concrete at least 5 days in advance of the concrete placement date.

4. Coordinate accessibility for concrete placement equipment with local traffic authorities and adjacent property owners.

B. Examination:

1. Prior to the Contracting Officer's inspection, inspect subgrades, adjacent concrete, work that will be covered by concrete formwork, reinforcement, and all required embedded items relevant to the concrete unit to be placed to verify their completeness and accuracy of location. Make corrections of all deficiencies prior to the start of the Contracting Officer's inspection.

2. The absence of the Contracting Officer's inspection does not relieve the Contractor of responsibility for the accuracy or completeness of the work.

C. Accessibility of Materials:

1. Have available at the site and ready to place in operation all materials and equipment in conjunction with hot or cold weather concreting requirements.

2. Verify that all curing materials are at the site and are in proper condition prior to concrete placement.

3. Initiate concrete placement only when all suitable materials, equipment, and personnel that are required for proper execution of concrete placement, finishing, curing, and protection are available at the site.

D. Installation of Embedded Items:

1. Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete.

2. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items.

3. Install miscellaneous steel and joint systems specified and shown.

4. Place and secure embedded items prior to concrete placement.

E. Joint Preparation:

1. Prepare surfaces of previously placed concrete against which fresh concrete will be placed as follows:
   a. Clean surfaces of all debris, curing compounds, scum, laitance, loose or defective concrete, standing water, ice, or other foreign matter.
   b. Where requirement for a "roughened joint" is specified or shown, verify that the hardened concrete has been finished rough or roughen any smooth surfaces by sandblasting or other approved methods. A rough surface is defined as having a textured amplitude of approximately 1/4 inch and that is free of loose particles and pockets that restrict concrete from flowing into the roughened concrete surfaces.
   c. Clean protruding waterstop surfaces of all laitance and hardened concrete material. Protect waterstops from damage during concrete cleaning and roughening operations.
   d. Apply appropriate bonding agent or cement slurry to joints only where shown or specified. If no bonding agent or cement slurry is specified, immediately prior to placing fresh concrete wet the joint surface and remove standing water.
   e. Allow at least 72 hours to elapse before continuing concrete placement at a construction joint. Approval for accelerating the minimum time elapsing between adjacent placements will be based on tests and methods which confirm that a minimum moisture loss at a
relatively constant temperature will be maintained for the period as necessary to control the heat of hydration and hardening of concrete, and to prevent shrinkage and thermal tracking.

f. Prior to mass concrete placement, Contractor’s Engineer or Technician under the supervision of the Contractor’s Engineer, shall inspect and test the temperature monitoring and recording system. The Contractor’s technician shall be present at the jobsite when the mass concrete operation is in progress and shall report to the Contracting Officer in writing on a daily basis the progress of the operation. A copy of the daily report shall be available at the jobsite.

g. Mechanical cooling systems may be used to control the internal temperature of mass concrete during curing.

2. Horizontal Construction Joints:
   a. Do not make horizontal construction joints within the top 18" of walls, piers, columns, or other vertical elements except where otherwise shown.
   b. Trowel the top surface of concrete within 1 inch of forms where joint will be exposed. Remove laitance from joint surfaces prior to placement of additional concrete.
   c. Construction joints shall be permitted only as shown in the plans and on shop drawings as approved by the Contracting Officer.

3. Supports for Conveying Equipment: Support concrete conveying equipment so supports and equipment will not travel or sit on reinforcement. Have all supports prefabricated, in place or readily accessible prior to concrete placement.

3.2 TRANSPORTING
   A. Concrete shall be central-mixed concrete from a central batch plant, transported to the jobsite in a truck mixer or shall be truck-mixed, both in accordance with the requirements specified in Section 03305, “Portland Cement Concrete”, and ASTM C94.
   B. Transport concrete to the jobsite in a manner that will assure efficient delivery of concrete to the point of placement without adversely altering specified properties with regard to water-cement ratio, slump, air entrainment, and homogeneity.

3.3 CONVEYING
   A. General Requirements:
      1. Provide equipment for conveying concrete in a continuous flow without segregation from point of Ready-Mix truck discharge to point of placement in the work. Equipment shall have sufficient capacity to provide a placement rate which will preclude cold joints and which shall deposit the concrete without segregation or loss of ingredients.
      2. Use pumps, pneumatic equipment, pipes, chutes, buggies, buckets, and troughs that have been thoroughly cleaned before use to convey concrete, and that are not constructed of aluminum.
   B. Chutes and Troughs: Where steep slopes are unavoidable, equip chutes or troughs with baffles to minimize segregation of aggregates.
   C. Adjustable Length Pipes (Elephant Trunks): Use pipes of ferrous metal, rubber or plastic, 6 inches minimum diameter so that concrete can be delivered in continuous flow to points not more than 5 feet horizontally and 5 feet vertically from final location. At no location shall free fall of concrete exceed 5 feet.
   D. Buggies: Operate buggies only on provided runways so they will not come into contact with concrete reinforcing steel.
   E. Pumping and Pneumatic Conveying Equipment:
      1. Use pumping and pneumatic conveying equipment designed to handle the types and volumes of concrete to be conveyed without segregation occurring.
      2. Operate pump or pneumatic equipment so that a continuous stream of concrete without air pockets is produced. Position discharge end of line as close as possible to final position of concrete, but in no case more than 5 feet away.

3.4 PLACEMENT
   A. General Requirements:
      1. Immediately prior to placing concrete, remove all debris and extraneous material from interior of forms.
      2. Place concrete continuously and as rapidly as possible after discharge from Ready-Mix
CAST-IN-PLACE CONCRETE

3. Place concrete in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams or planes of weakness. Cover each layer of concrete with fresh concrete within 45 minutes. Do not use vibrators for shifting mass of fresh concrete.

4. Do not place concrete which has attained initial set or concrete which has contained mix water for more than 90 minutes; or does not meet specified requirements.

5. Remove temporary spreaders in forms when concrete has reached elevation which makes them unnecessary.

6. Place column concrete using adjustable pipes or elephant trunks. In monolithic placements, do not deposit concrete in supported elements such as beams, girders and slabs until concrete previously deposited in columns or walls has completed its settlement shrinkage, but not to the point at which concrete in supporting members will not permit vibrator to sink into concrete by its own weight.

7. Do not place concrete when sun, heat, wind and limitations of facilities will prevent finishing and curing. Rate of evaporation of surface moisture from the concrete shall be as calculated per ACI 305R.

8. Comply with ACI 305R Hot Weather Concreting when air temperatures exceed 80 degrees F during placing, finishing and curing. The temperature of the concrete mix shall not exceed 95 degrees F at the time of placement, except for bridge decks concrete which shall not exceed 85 degrees F. The Contractor shall select and implement a procedure from ACI 305R at no additional cost to the Authority to ensure that the concrete mix temperature at the time of placement remains below this maximum.

9. Comply with ACI 306.1 Cold Weather Concreting when air temperatures will be 40 degrees F or less during concrete placement, finishing and curing. The temperature of the concrete, when placed, shall not be less than 50 degrees F.

10. Prior to placing fresh concrete against rock or previously placed concrete, remove all foreign matter which would adversely affect bond. Prepare surface as specified in Paragraph 3.1.E of this Section.

11. Except for drilled piers, concrete is not to be dropped over 5 feet without the use of tremies or chutes to prevent the segregation of concrete during placement. Free fall of concrete shall not exceed 5 feet.

B. Pumping:

1. Concrete may be placed by pumping if the maximum slump can be maintained and if accepted in writing by the Contracting Officer for the location proposed.

2. Placing concrete by pumping methods shall conform to applicable requirements of ACI 304R and ACI 304.2R.

3. Equipment for pumping shall be of such size and design as to ensure a continuous flow of concrete at the delivery end without separation of materials. Concrete from end of hose shall have a free fall of less than 5 feet. Pump hoses shall be supported on horses or similar devices so that reinforcement or post-tensioning ducts or tendons are not moved from their original position.

4. The concrete mix shall be designed to the same requirements as specified in Section 03305, “Portland Cement Concrete”, and may be altered for placement purposes with the prior written approval of the Contracting Officer.

C. Underwater Concrete Placement:

1. Place concrete mix designated for underwater placement carefully and continuously in compact mass by means of tremie or underwater bottom dump bucket; do not disturb after depositing. Do not allow concrete to freely drop more than 1 foot through water. Maintain still water at point of deposit. Use tight forms. Place concrete to produce approximately horizontal surfaces.

2. Do not perform dewatering within area until concrete has set at least 48 hours.

3. Tremie:

a. Provide tremie consisting of watertight tube, 10 inch minimum diameter, with hopper at top. Equip tube with device to close discharge end and prevent water from entering tube while charging tube with concrete. Refer to ACI 304R.

b. Support tremie to permit free movement of discharge end over entire top surface of work and to permit rapid lowering when necessary to retard or stop flow of concrete.
c. Close discharge end at start of work to prevent water entering tube and maintain entirely sealed, except when concrete is being placed. Keep tremie tube full of concrete. When concrete is discharged, place the end of the tremie on the surface upon which concrete is to be deposited or slightly embedded in previously placed fresh concrete. Maintaining end of tremie embedded in the fresh concrete, raise end as necessary to allow adequate flow to achieve the thickness of the layer being placed.

d. Maintain continuous flow until work is complete and resulting concrete seal is monolithic and homogeneous. Control tremies so that concrete will be effectively compacted into horizontal layers not more than 12 inches thick.

e. Space tremies so as to avoid segregation.

4. Underwater bucket:
   a. Provide underwater buckets with open tops manufactured so that bottom doors open freely and outwardly when tripped.
   b. Fill bucket completely and lower slowly to avoid backwash until it rests on surface upon which concrete is to be deposited.
   c. Discharge concrete slowly. After discharge, raise bucket slowly until well above concrete.

5. For drilled shaft foundation piers, follow concrete placement methods stated in ACI 336.1 and other requirements specified in Section 02375, “Drilled Shaft Foundations”.

3.5 CONsolidation

A. Consolidate concrete thoroughly as it is placed in order to secure a dense mass. Work concrete well around reinforcement, embedded items and into the corners of forms. Consolidate concrete in accordance with ACI 309R.

B. Use internal vibrators unless external vibrators are approved by the Contracting Officer.

C. Use vibrators capable of generating frequencies of not less than 7,000 impulses per minute. Vibrate so as to visibly affect mass of concrete of 1 inch slump over radius of at least 18 inches. Prevent formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove excessive water by pumping or other approved means.

D. When consolidating concrete in haunches, girders, beams, or slabs, ensure that vibrator penetrates and re-vibrates previously placed concrete in top of supporting members.

E. Do not allow vibrators to penetrate previously placed layers more than 2 inches in order to consolidate and prevent over vibration of previously vibrated layer. Do not use vibrators where internal vibration might cause damage to embedded items; in such cases spading is required.

F. Vibrator(s) are to be inserted and withdrawn vertically except in slabs and similar shallow areas at uniform spacing over the entire area of the placement. Space the distance between insertions such that their sphere of influence overlaps.

G. Provide at least 1 standby vibrator for emergency use in addition to those required for placement.

H. Vibration shall be supplemented by hand spading or rodding where necessary to execute proper consolidation.

3.6 CONSTRUCTION JOINTS

A. Construction joints will be permitted only where indicated or approved by the Contracting Officer.

B. Provide and prepare construction joints and install waterstops in accordance with the applicable requirements of ACI 301 and ACI 304R, and as specified in Section 03100, “Concrete Formwork” and Paragraph 3.1.E, herein.

C. Make construction joints straight and as inconspicuous as possible, and in exact vertical and horizontal alignment with the structure, as the case may be.

D. Use approved key, at least 1-1/2 inches in depth, at joints unless otherwise indicated or approved by the Contracting Officer.

E. Thoroughly clean the surface of the concrete at construction joints and remove laitance, loose or defective concrete, coatings, sand, sealing compound and other foreign material. Prepare surfaces of joints by sandblasting or other approved methods to remove laitance and expose aggregate uniformly.

F. Immediately before new concrete is placed, wet the joint surfaces and remove standing water. To allow for shrinkage, do not place new concrete against the hardened concrete side of a construction joint for a minimum of 72 hours.

G. Locate joints which are not indicated so that the strength of the structure is not impaired. Joint types
and their locations are subject to prior approval of the Contracting Officer.

H. Ensure that reinforcement is continuous across construction joints.

I. Place waterstops in construction joints where indicated.

J. Where bonding of the joint is required, provide epoxy adhesive hereinbefore specified and apply in accordance with ACI 503.2.

K. Retighten forms and dampen concrete surfaces before concrete placing is continued, unless bonding agent is used.

L. Allow at least 72 hours to elapse before continuing concrete placement at a construction joint. Approval for accelerating the minimum time elapsing between adjacent placements will be based on tests and methods which confirm that a minimum moisture loss at a relatively constant temperature will be maintained for the period as necessary to control the heat of hydration and hardening of concrete, and to prevent shrinkage and thermal cracking.

3.7 CURING AND PROTECTING

A. Curing and protection of concrete shall be done in accordance with Section 03350 “Concrete Finishing”.

3.8 REPAIR OF MINOR SURFACE DEFECTS

A. Refer to Section 03350, “Concrete Finishing” and 03360 “Special Concrete Finishes” for requirements.

3.9 TEMPERATURE MONITORING AND RECORDING SYSTEM FOR MASS CONCRETE

A. The temperature monitoring and recording system for mass concrete shall consist of temperature sensors connected to a data acquisition system capable of printing, storing, and downloading data to a computer. Temperature sensors shall be located such that the maximum temperature difference within a mass concrete element can be monitored. As a minimum, concrete temperatures shall be monitored at the calculated hottest location and surface.

B. Temperature readings shall be automatically recorded on an hourly or more frequent basis. The hourly temperature recording may be discontinued when the maximum internal temperature is falling, the difference between the interior concrete temperature and the average daily air temperature is less than the allowable temperature difference for 3 consecutive days, and there are no mass concrete elements to be cast adjacent. Data shall be printed and submitted to the Contracting Officer as requested.

C. Methods of concrete consolidation shall prevent damage to the temperature monitoring and recording system. Wiring from temperature sensors cast into the concrete shall be protected to prevent movement. Wire runs shall be kept as short as possible. The ends of the temperature sensors shall not come into contact with either a support or concrete form, or bar reinforcing steel.

D. When any equipment used in the temperature control and monitoring and recording system fails during the mass concrete construction operation, the Contractor shall take immediate measures to correct the situation as specified in the Thermal Control Plan. Failure to conform to the temperature requirements will be cause for suspension of the mass concrete work and review and adjustment of the Thermal Control Plan by Contractor’s Engineer and evaluation of the deficient concrete for acceptance or rejection.

3.10 MASS CONCRETE ACCEPTANCE

A. Mass concrete shall conform to the concrete acceptance criteria and the following temperature requirements:

1. The maximum allowable temperature of mass concrete shall not exceed 160 degrees F.

2. The maximum temperature differential of mass concrete shall not exceed the requirement as determined in the Thermal Control Plan.

B. Failure to conform to any of the temperature requirements above will be cause for suspension of the mass concrete work and review and adjustment of the Thermal Control Plan by Contractor’s Engineer and evaluation of the deficient concrete for acceptance or rejection. The rejected mass concrete shall be removed at the Contractor’s expense. The Contractor shall modify the Thermal Control Plan and design calculations to correct the problem and resubmit the revised Thermal Control Plan.

C. The Contractor shall allow the Contracting Officer 2 weeks for review and approval of the revised Thermal Control Plan. Mass concrete placement shall not begin until the Contracting Officer has approved the revised Thermal Control Plan. No extension of time or compensation will be made for any rejected mass concrete element or revisions of the Thermal Control Plan.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Quantities of cast-in-place concrete of the various classifications and color which constitute the completed structure segments specified herein, will be measured and paid for by mix type and the cubic
yard, each, or square foot as follows from the approved shop drawings for the location indicated.

1. Structure elements such as abutment and pier structures shall be measured by the cubic yard, which will include footings, walls, columns, and pier caps for each respective bridge.

2. Retaining wall construction shall be measured by the square foot of exterior surface area for the full height above foundation slab.
   a. Subdrains or underdrains for the retaining wall will not be measured separately for payment, but shall be considered subsidiary to the construction of the retaining wall.
   b. Foundation slab is subsidiary to the wall and will not be measured.

3. Superstructure concrete complete shall include bridge deck, catenary and signal supports, diaphragms and drainage systems on above grade structures, parapet walls, and shall be measured by the cubic yard. Cast-in-place prestressed concrete is included for payment under this item.

4. Ballast wall construction shall be measured by the linear foot along the front face for the full wall length including the foundation, as measured in the field.
   a. Subdrains or underdrains for the ballast wall will not be measured separately for payment, but shall be considered subsidiary to the construction of the ballast wall.
   b. Leveling pad and other pertinent items will not be measured separately for payment, but shall be considered incidental to the construction of the ballast wall.

5. Approach slab and track slab shall be measured by the cubic yard.

B. Cast-in-place concrete for at-grade station platforms and concourse slabs will not be measured, but will be paid for at the lump sum price for each station.

C. Excavation and earthwork, including backfill, will not be measured separately for payment, but shall be considered subsidiary to the various bid items.

D. Formwork, reinforcing, joint filler, and other pertinent items will not be measured separately for payment, but shall be considered incidental to the various bid items.

END OF SECTION 03300
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for Portland cement concrete, including materials, mix designs, batching, mixing, delivering, inspection, and testing.

B. Portland cement concrete shall be composed of Portland cement with or without fly ash, fine aggregate, coarse aggregate, and water, with or without admixtures as approved by the Contracting Officer, proportioned and mixed as specified herein.

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1. ACI 116R - Cement and Concrete Terminology

2. ACI 117 - Standard Specification for Tolerances for Concrete Construction and Materials

3. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

4. ACI 211.2 - Standard Practice for Selecting Proportions for Structural Lightweight Concrete

5. ACI 301 - Specifications for Structural Concrete

6. ACI 304R - Guide for Measuring, Mixing, Transporting, and Placing Concrete

7. ACI 304.2R - Placing Concrete by Pumping Methods

8. ACI 305R - Hot Weather Concreting


10. ACI 318 - Building Code Requirements for Structural Concrete

B. American Association of State Highway and Transportation Officials (AASHTO)

1. AASHTO T26 - Standard Method of Test for Quality of Water to Be Used in Concrete

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field

2. ASTM C33 - Standard Specification for Concrete Aggregates


4. ASTM C40 - Standard Test Method for Organic Impurities in Fine Aggregates for Concrete

5. ASTM C42/C42M - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

6. ASTM C78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)


8. ASTM C88 - Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate


12. ASTM C127 - Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate


15. ASTM C142 - Standard Test Method for Clay Lumps and Friable Particles in Aggregates
16. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete
18. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete
19. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
20. ASTM C192/C192M - Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
21. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
22. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete
25. ASTM C330 - Standard Specification for Lightweight Aggregates for Structural Concrete
26. ASTM C413 - Standard Test Method for Absorption of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
27. ASTM C470/C470M - Standard Specification for Molds for Forming Concrete Test Cylinders Vertically
28. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete
30. ASTM C567 - Standard Test Method for Determining Density of Structural Lightweight Concrete
31. ASTM C579 - Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
32. ASTM C580 - Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
33. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
34. ASTM C641 - Standard Test Method for Staining Materials in Lightweight Concrete Aggregates
35. ASTM C685/C685M - Standard Specification for Concrete Made by Volumetric Batchig and Continuous Mixing
36. ASTM C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
37. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete
38. ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
39. ASTM D75 - Standard Practice for Sampling Aggregates
40. ASTM D512 - Standard Test Methods for Chloride Ion in Water
41. ASTM E329 - Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

D. National Institute of Standards and Technology (Formerly National Bureau of Standards (NBS)) (NIST)

1. NIST Handbook 44 – Specifications, Tolerances and Other Technical Requirements for Weighing and Measuring Devices (Formerly NBS Handbook 44)

E. Texas Department of Transportation (TxDOT)

1. Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges (TxDOT Standard Specifications)
   a. DMS 4610 – Fly Ash
1.3 SUBMITTALS

A. Testing Laboratory and Quality Control:

1. In accordance with Section 01450, “Quality Control”, for the testing laboratory requirements.


B. Concrete Mix Designs: Submit mix designs as herein specified in Article 2.4. Include laboratory test reports of trial strength tests.

C. NRMCA or TxDOT batch plant certification to the Contracting Officer 30 days before delivery of concrete to Worksite.

1. Mix design, laboratory test reports, and mill or manufacturer’s certificates attesting the conformance of ingredients with these Specifications. Use ingredients in design mix which are representative samples of materials used in Work. Provide one design mix for each class of concrete. Establish mix design through an accepted laboratory.

2. Certifications by concrete supplier of design mixes to specified requirements in respect to strength, unit weight, maximum size aggregate, air-entrainment, slump and water-cement ratio.

3. If source, brand or characteristic properties of ingredients need to be varied during term of Contract, submit revised laboratory mix reports and Certificate of Compliance to Contracting Officer.

D. Product Data: Submit manufacturer’s product data for proposed concrete admixtures.

E. Certifications:

1. Cement mill certificates.

2. Concrete Ingredients:

a. Submit with mix design reports, laboratory test reports and mill or manufacturer’s certificates verifying that ingredients conform to specified requirements. Use ingredients in design mix which are representative samples of materials to be used in the work. All test reports and certificates are to be dated within six months of submittal date.

b. In case the source, brand or characteristic properties of ingredients need to be varied during the term of the Contract, submit revised laboratory mix report in accordance with procedures specified for original mix design.

3. Concrete Batch Tickets: Before unloading concrete at the site, submit certification or delivery ticket from concrete supplier with each batch delivered to the site bearing the following information.

a. Name of supplier.

b. Name of batching plant and location.

c. Serial number of ticket.

d. Date.

e. Truck number.

f. Specific job designation: Contract number and location.

g. Volume of concrete in cubic yards.

h. Class and type of concrete.

i. Time loaded.

j. Type and brand of cement.

k. Weight of cementitious materials and individual materials (e.g. cement, fly ash, etc.) which make up the total cementitious material.

l. Maximum size of aggregates.

m. Weights of coarse and fine aggregates.
n. Maximum amount of water to be added and amount of water added at the site.

o. Kind and amount of admixtures.

p. DART concrete mix design designation.

F. Implementation Plans and Reports:

1. Mix Design Reports:

a. Thirty days prior to placing concrete, submit mix designs for each concrete mix, certifying that proposed concrete ingredients and proportions will result in concrete mixes meeting specified requirements and that ingredients are those that will be used in the work.

b. The Contractor may present for approval a concrete mix previously approved by the Contracting Officer provided such mix is made with proposed ingredients that meet requirements, and provided that concrete has complied with compressive strength requirements based on ACI 318 5.3 and 5.4. The compressive strength tests results for such mix designs shall be no more than 12 months old.

c. Submit manufacturers literature, including instructions for use, for admixtures, surface treatments, curing materials, grouts and bonding agents to be used on this project.

1.4 STORAGE AND HANDLING OF CONCRETE INGREDIENTS

A. Deliver packaged materials in manufacturers original, unopened containers bearing manufacturer’s name and brand.

B. Load, transport, handle, store, and batch concrete materials in a manner to ensure materials are not contaminated, unclean, segregated or affected in any way detrimental to the final product.

C. Aggregates:

1. Transport and stock pile aggregate separately according to sources and gradations. Handle as to prevent segregation, loss of fines and contamination by earth or other foreign materials.

2. If aggregates show segregation or if different grades become mixed, rescreen before placing in proportioning bins.

3. When conditions require the use of two (2) or more sizes of aggregates, the aggregates shall be separated to prevent intermixing. Where space is limited, stockpiles shall separated by physical barriers. Aggregate from different sources shall stored in difference stockpiles unless the aggregates are pre-blended as approved by the Contracting Officer prior to stockpiling.

4. Do not transfer aggregates directly from trucks or railroad cars to proportioning bins when moisture content is such that it will affect accurate proportioning of concrete mixture. In such cases, stockpile aggregate until excess moisture drains off.

D. Packaged Cement:

1. Deliver to project site in original sealed packages labeled with weight, name of manufacturer, brand and type.

2. Store packages in water-tight building.

3. Do not use cement which has been reclaimed by cleaning bags.

4. Do not use cement which has been exposed to moisture or contaminated.

5. Deliver packages conforming to weight specified.

6. Packaged cement will be subject to testing.

E. Bulk Cement:

1. Store bulk cement separately from other cement and protect to prevent exposure to moisture and contamination.

2. In ready-mix plant, provide facilities to maintain separation of specified cements.

3. Provide sampling facilities at cement manufacturer’s plant at weighing hopper or in feed line immediately before entering hopper.

F. Store admixtures to prevent contamination, evaporation or damage. Protect liquid admixtures from harmful temperature ranges.
PORTLAND CEMENT CONCRETE

1.5 QUALITY ASSURANCE

A. The Contractor shall select a qualified concrete supplier capable of meeting project requirements and the requirements of these Specifications. Furnish evidence of plants capacity to produce and deliver concrete conforming to specified requirements at required rate and which has laboratory capability to develop acceptable concrete mix designs and control quality of concrete production.

1. Batch plant: Semi automatic batching systems as described in NRMCA checklists for Certification of Ready Mix Concrete Production Facilities.

2. Certification: NRMCA currently and continually certified batch plant. In lieu of NRMCA certification, proper, current, and continuing certification by TxDOT will be considered adequate.

B. In conformance with applicable requirements of Section 01450, "Quality Control", the Contractor shall provide a quality control plan to assure control and uniformity of materials, conformance with accepted mix designs, and prompt and proper delivery of concrete to the jobsite in accordance with applicable requirements of ASTM C94. Include in the plan all tests the Contractor will perform to verify compliance with Specification requirements, and the independent laboratory the Contractor intends to engage to perform the tests.

C. Quality Control For Batch Plant:

1. Batch plant quality control inspection during batching operations: By an independent certified testing laboratory retained and paid for by Contractor, for performing tests in accordance with reference standards listed. Plant inspections shall be on periodic basic, at frequency to ensure consistent quality concrete production and in accordance with Contractor's Approved Quality Control Plan. Provide concrete from batching plant, reviewed and accepted by Contractor and meeting the following requirements:

   a. Arrangement:

      1) Provide separate bins or compartments for each size or classification of aggregate and for bulk Portland cement.

      2) Provide compartments of ample size and constructed to maintain materials separately under working conditions. Equip batching plant so flow of each material into batcher is stopped automatically when designated weight has been reached. Weigh aggregates in a separate scale in a separate weight batcher. Water may be measured by weight or by volume. If measured by weight, do not weigh cumulatively with other ingredients.

      3) Arrange plant to facilitate inspection of operations. Provide suitable facilities for obtaining representative samples of aggregate from each of the bins or compartments for test purposes. Provide delivery of materials from batching equipment to within accuracies specified in ASTM C94.

   b. Water Batcher and Dispensers for Admixtures

      1) Provide equipment for batching water and air entraining or other admixtures at batching plant except in cases where mixing is performed at Worksite in paving mixers or in truck mixers.

      2) Provide a suitable water measuring device capable of measuring mixing water within specified requirements for each batch. Provide a mechanism for delivering water to mixers so leakage will not occur when valves are closed. Interface filling and discharge valves for weighing batcher so discharge valve cannot be opened before filling valve is fully closed.

      3) Provide measuring devices for admixtures capable of ready adjustment that have at least three percent accuracy, to permit varying quantity of admixture...
4) Interface dispenser for admixtures with batching and discharging operations so batching and discharging of admixture will be automatic.

c. Moisture Control: Provide a plant capable of ready adjustment to compensate for varying moisture contents of aggregate and to change weights of materials being batched. Provide electric moisture meter acceptable to Contractor for measurement of moisture in fine aggregate and calibrate as often as required. Do not exceed 8 percent moisture content of fine aggregate. Arrange sensing element so measurement is made near batcher charging gate of sand bin or in sand batcher.

d. Scales: Provide adequate facilities for accurate measurement and control of each material entering each batch of concrete. Conform to applicable requirements of NIST Handbook 44 for accuracy of weighing equipment. Provide each weighing unit with a visual springless dial or electronic readout to indicate scale load at all stages of weighing operation or include a beam scale with beam balance indicator to show scale in balance at zero load and at any beam setting. Provide indicator having over and under travel equal to at least 5 percent of capacity of beam. Provide standard test weights and other auxiliary equipment for checking operating performance of each scale or other measuring device. Make periodic tests in presence of Contractor in a manner and at intervals as directed. Upon completion of each check test and before further use of indicating, recording or control devices, make adjustments, repairs and replacements as required to secure satisfactory performance.

e. Recorders:

1) Provide accurate graphical or digital printout record of scale readings, including initial readings, after each of the aggregates, water, cement and admixtures have been batched before delivery to mixer, using accurate recorder or recorders.

2) Record Data: Show on each printout, date and time of batching; identification number - identical to concrete ticket and codes for mix design and for Contract Section.

3) House each recorder in a secure location, assuring proper operations.

4) Clearly indicate different types of mixes used by stamped letters, numerals, colored ink or other suitable means on charts or tapes so that variations in batch weights of each type of mix can be readily observed.

a) Show on charts or tapes, date and time of day (stamped or preprinted) at intervals of not more than 15 minutes.

b) Provide recorders of a type that prints required information in duplicate. One copy of recorded batch weights for each load shall accompany each delivery ticket as supplied by producer. Verify that the identification number is identical to concrete delivery ticket. Deliver one copy with its
5) Place recorders in a position convenient for observation by plant operator and Contractor.

2. Protect weighing, indicating and control equipment against exposure to dust and weather and insulate against vibration or movement caused by operating equipment in plant.

1.6 PROJECT CONDITIONS

A. Environmental Conditions:

1. Hot Weather Concreting:
   a. Batching, mixing, and delivering of concrete in hot weather shall conform to the applicable requirements of ACI 305R.
   b. When ambient temperatures exceed 80 degrees F, or are forecast to exceed 80 degrees F within 12 hours of concrete placement, the Contractor shall prepare steps to keep the concrete temperature at time of placement below the maximum allowable, as shown below. The method(s) used shall be approved by the Contracting Officer. For bridge decks the maximum concrete temperature shall be 85 degrees F. For all other concrete, unless specified elsewhere, the maximum concrete temperature shall be 95 degrees F.

2. Cold Weather Concreting:
   a. Batching, mixing, and delivering of concrete in cold weather shall conform to the applicable requirements of ACI 306.1.
   b. When the ambient temperature drops below 35 degrees F, or is forecast to drop below 35 degrees F during hours of concrete placement, the temperature of the mix shall be heated by adding hot water, not exceeding 180 degrees F, or by steam heating the aggregates, or both. Other methods of heating aggregates will not be permitted. Steam heating the aggregates may require an adjustment in the mixing water. Even if accelerators are used to assist setting, the concrete shall maintain a minimum temperature of 50 degrees F.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: ASTM C150, Type I, II, I/II, and III.

B. Fly Ash: ASTM C618, Class F or Class C (Type B), meeting TxDOT Material Specification DMS 4610 and on the TxDOT approved fly ash source list.

C. Coarse and Fine Aggregates

1. Coarse aggregate: Use ASTM D75 for standard practice for sampling aggregates. Test coarse aggregate in accordance with ASTM C33, Section 11.

2. Deleterious substances: Do not allow the amount of deleterious substances present in coarse aggregate to exceed the following:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Maximum Allowable Percentage by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Particles</td>
<td>5.0</td>
</tr>
<tr>
<td>Coal and Lignite Particles</td>
<td>0.2</td>
</tr>
<tr>
<td>Clay Lumps and Friable Particles</td>
<td>0.25</td>
</tr>
<tr>
<td>Material Passing Size 200 Sieve</td>
<td>1.0</td>
</tr>
<tr>
<td>Thin or Elongated Pieces</td>
<td>15.0</td>
</tr>
<tr>
<td>Other Local Deleterious Substances</td>
<td>1.0</td>
</tr>
</tbody>
</table>

a. Thin and elongated pieces: Defined as pieces having a length greater than five times the smallest dimensions of a circumscribing rectangular prism.

3. Wear: 45 percent maximum when tested in accordance with ASTM C131 and C535.

4. Weighted percentage of loss: 15 percent maximum by weight when subjected to 5 cycles of magnesium sulphate...
PORTLAND CEMENT CONCRETE soundness test in accordance with ASTM C88.

5. Gradation: In accordance with ASTM C33, Table 2, and represented by a smooth gradation curve within required limits.

6. Fine aggregate:
   a. Washed and natural sand or washed stone sand: Manufactured sand may be subject to special gradation requirements as directed.
   b. Gradation in accordance with ASTM C33: Minimum percentages of material passing Size 50 and Size 100 sieves may be reduced to 5 and zero respectively if aggregate is to be used in concrete with three percent minimum air-entrainment or in concrete containing more than 5.5 bags of cement per cubic yard.
   c. Weighted percentage of loss not more than 12 percent by weight when subjected to 5 cycles of magnesium sulphate soundness test in accordance with ASTM C88.
   d. Deleterious Substances: Do not allow following substances to be present individually in amounts exceeding the following:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Maximum Allowable Percentage by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Lumps and Friable Particles</td>
<td>1.0</td>
</tr>
<tr>
<td>Coal and Lignite</td>
<td>0.2</td>
</tr>
<tr>
<td>Material Passing the No. 200 Sieve</td>
<td>5.0</td>
</tr>
<tr>
<td>Other Deleterious Substances such as shale, alkali, mica, coated grains, soft and flaky particles</td>
<td>2.0</td>
</tr>
</tbody>
</table>

   e. Provide Fine aggregate free from injurious amounts of organic impurities as determined by ASTM C40. Should material fail to pass test for organic impurities in sand for concrete, retest in accordance with ASTM C87. If fine aggregate shows by calorimetric test a darker color than that of sample originally approved for the work, stop using such aggregate until approved tests have been made to determine whether change in color is indicative of injurious amount of deleterious substances.

7. Aggregates for Lightweight Structural Concrete:
   a. Coarse aggregate: ASTM C330, with the following additional requirements:
      1) Composition: Expanded shale, clay or slate, predominantly lightweight cellular, and granular.
      2) Percentage loss: Ten percent maximum by weight when subjected to 5 cycles of the magnesium sulphate soundness test in accordance with ASTM C88.
      3) Gradation: In accordance with ASTM C330, Table 1.
      4) Unit weight: In accordance with ASTM C330, Table 2, except unit weight of concrete shall not exceed 120 lb/ft³.
      5) Loss on ignition: 5 percent maximum in accordance with ASTM C142.
      6) Deleterious substances, clay lumps and friable particles: 2 percent maximum in accordance with ASTM C142.
      7) Wear: 40 percent maximum in accordance with ASTM C131 and C535.
      8) Staining: In accordance with ASTM C641.
   b. Fine aggregate: Same as fine aggregate for Normal Weight Concrete.
D. Water - Meet the following requirements:

1. Natural potable water with no pronounced taste or odor.

2. Containing no impurities, suspended particles, algae, or dissolved natural salts in quantities that will cause:
   a. Corrosion of reinforcing steel.
   b. Volume change that will increase shrinkage cracking.
   c. Efflorescence.
   d. Excessive air entraining.

3. pH: Not less than 5.

4. When tested in accordance with AASHTO T26, indication of unsoundness, change in setting time in excess of plus or minus 30 minutes, and reduction in strength in excess of 10 percent will be sufficient cause for rejection of the water under test.

5. Water from municipal supplies approved by the State Health Department will not require testing, but water from other sources shall be tested in accordance with this section prior to use in structural concrete.

6. Free from substance which would interfere with the chemical reaction by which concrete is formed, detract from concrete strength and durability, cause variations of concrete color, or cause a combination of such defects. Limit chloride concentrations in total mixing water to 500 ppm, and limit sulfate concentrations to 1500 ppm.

7. Wash aggregates with potable water, or water meeting the above requirements. Recycled wash water may be used in mixing concrete. Wash water, if used, shall conform to the acceptance criteria of ASTM C94, as modified above (paragraphs 2 through 6) and shall not exceed 25 percent of the total water used in a batch.

E. Admixtures:

1. Air-entraining admixtures: When shown in Table 03305-1 herein, or when required under other specification items or shown in the plans, air-entraining admixtures shall conform to ASTM C260. Air-entrainment will not be required for precast, prestressed concrete bridge members.

2. Chemical Admixtures: When shown under Paragraph 2.4.B.1 herein, chemical admixtures will be allowed upon approval. Other chemical admixtures may be allowed only if approved by the Contracting Officer. Calcium Chloride or admixtures containing more than 0.05 percent chloride are not permitted. Chemical admixtures shall conform to ASTM C494 of the Type specified as follows:
   a. Water-Reducing Admixtures: Type A.
   b. Water-Reducing and Retarding Admixtures: Type D.
   c. High Range Water Reducing Admixture Plant or Field Added: Type F.
   d. High Range Water Reducing and Retarding Admixture: Type G.
   e. Accelerators - conform to Type C.

2.2 GROUT

A. Portland Cement Grout:

1. Prepare grout composed of Portland cement, sand and water.

2. Do not use staining ingredients in grout exposed to view.

3. Formulation: 2 parts sand and 1 part cement measured by volume. Use blend of White Portland cement and regular Portland cement to produce grout of color to match surrounding concrete when grout and concrete are dry.

4. Mix grout with sufficient water to permit placing and packing within approximately 45 minutes prior to use.

B. Structural Nonshrink Grout: Premixed, prepackaged, pretested, nonmetallic, noncorrosive, nonstaining product containing selected silica sands, Portland cement, shrinkage compensating agents, and water-reducing agents.

1. 5000 psi minimum compressive strength at 7 days when tested by ASTM C109. Shrinkage limited to zero inches in plastic state when tested in accordance with ASTM C827 and in hardened state when tested in accordance with ASTM C1107.
2. Products:
   a. "Five Star Grout" by Five Star Products, Inc.
   b. "Masterflow 928" by ChemRex.
   c. "Crystex" by L&M Construction Chemicals.
   d. "NS" by the Euclid Chemical Company.

C. Flowable Grout:
   1. Use for grouting anchor bolts or dowels.
   2. Products:
      a. "NS" by the Euclid Chemical Company.
      b. "Masterflow 713 Plus" by ChemRex.

D. Epoxy Grout: Nonshrink, nonstaining, 100 percent solids, two-component, or three-component epoxy resin system that has a documented history of successful use for an equivalent applications.
   1. On horizontal applications: Self-leveling type.
   2. On vertical and overhead surface application: Non-sag type.
   3. Physical properties:

<table>
<thead>
<tr>
<th>ASTM Test Property</th>
<th>Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>C307 - Tensile</td>
<td>Minimum in 7 days</td>
<td>1,800 psi</td>
</tr>
<tr>
<td>C579 – Compressive</td>
<td>Minimum in 28 days</td>
<td>13,500 psi</td>
</tr>
<tr>
<td>C580 – Modulus of</td>
<td></td>
<td>13,500 psi</td>
</tr>
<tr>
<td>C413 – Water</td>
<td>Maximum, 2 Hours at 212</td>
<td>1 percent</td>
</tr>
<tr>
<td></td>
<td>degrees F</td>
<td></td>
</tr>
</tbody>
</table>

2.4 CONCRETE MIX DESIGNS

A. Design of concrete mixes, including recommended amounts of admixture and water to be used in the mixes, shall be obtained by the Contractor from a qualified independent testing laboratory or agency, or ready-mix plant, properly equipped to design concrete mixes. The design shall be performed and certified by a professional engineer currently licensed in the State of Texas. The laboratory, agency or ready-mix plant shall meet applicable requirements of ASTM E329, and shall be approved by the Contracting Officer. Costs of obtaining the mix designs shall be paid by the Contractor.

B. Proportioning:
   1. Using materials that will be used in the work, establish proportions of Portland cement, fly ash coarse and fine aggregates, water, and admixtures to produce the properties specified for each concrete mix type based on field experience or trial batch method described in ACI 318. Substantiate attainment of all specified properties by designated ASTM test methods. Provide concrete that has 28-day strengths that exceed the specified design strength in accordance with ACI 318. Selection of mix proportions shall conform to the applicable requirements of ACI 211.1 and ACI 211.2. Concrete shall comply with ACI 301 and ACI 318, as applicable. Acceptability of concrete strength will be based on requirements for ultimate strength design.
      a. Use admixtures in accordance with manufacturer's directions. Use amounts of water-reducing admixtures where required that will permit the use of 5 percent less water to produce the specified slump. The slumps
specified are the slumps obtained from tests conducted at the point of placement, unless otherwise noted in these specifications.

b. Where indicated, total cementitious material means the total amount of cement plus fly ash admixture. Fly ash shall be mandatory where indicated in the mix design.

c. Use Type I or Type I/II cement unless otherwise specified, except that Type III may be used for precast concrete.

2. Superplasticized Concrete Mixes: Proportion mixes that will contain superplasticizers by the ACI 318 Laboratory Trial Batch Method to meet the performance required for the specific mix type. Proportion the water-reducing admixture dosage rate to provide slumps no greater than 7 inches, unless otherwise specified. Follow manufacturer's recommendations for dosage rates, mixing time, and compatibility with other admixtures. Provide written observations of mix workability after superplasticizer is added.

a. Obtain instructions from the manufacturer of the water-reducing admixture relative to the quantity necessary to produce the specified slumps and adjustments in dosages to maintain desired slumps and setting times with varying air temperature, humidity, and concrete temperature.

b. When not specifically required in this section, water-reducing admixtures may be used in the specified mix types upon written approval from the Contracting Officer.

3. Design Mix Reports: Prepare written concrete mix reports suitable for ordering concrete from a ready-mix concrete supplier in accordance with ASTM C94 and that contain the following information for each type:

a. Aggregate source of supply, type rock, size, and gradation for coarse aggregate.

b. Tests of aggregates, or certificates demonstrating compliance with specified requirements of ASTM C33 for Normal Weight Aggregate; ASTM C330 for Lightweight Aggregate.

c. Brand and type of cement.

d. Dry weights of cement and SSD weights of sand, and coarse aggregate per cubic yard of concrete.

e. Amounts of each admixture and fly ash per cubic yard of concrete; include manufacturer's instructions and certificates of compatibility. Identify source of fly ash.

f. Water-cement ratio.

g. Slump: ASTM C143.

h. Mix consistency and workability.

i. Entrained air content: ASTM C173 for Lightweight Concrete; ASTM C231 for Normal Weight Concrete.

j. Equilibrium dry weight of concrete per cubic foot for Lightweight Concrete: ASTM C567.

k. The method of concrete placement for which the mix is proportioned.

l. Standard deviation in accordance with ACI 318 for concrete production facility and associated strength required greater than the design strength, f’c. Determine standard deviation from concrete produced and tested within the 12 months preceding first concrete placement.

m. For proportions established by laboratory trial batches, provide the curve establishing the relationship between water-cement ratio and compressive or flexural strength required by ACI 318 and compressive or flexural strengths developed at 7 days and 28 days from three compressive or flexural strength tests, made in accordance with ASTM C39 and ASTM C192, for each mix type.

n. For proportions established by field experience, provide for each mix type, compressive strengths developed at 7 and 28 days from thirty consecutive compressive
2.5 BATCHING, MIXING, AND TRANSPORTING

A. Batching, mixing, and transporting Portland-cement concrete shall conform to the applicable requirements of ACI 301 and ACI 304R.

B. Concrete shall be central-mixed concrete from a central batch plant, to be transported to the jobsite in a truck mixer or shall be truck-mixed, both in accordance with the requirements of ASTM C94. Equipment used in the manufacture of concrete shall be kept clean at all times. Use readymix concrete produced at facilities meeting certification requirements of the National Ready-Mix Concrete Association, and complying with requirements specified, and ASTM C94. Unless otherwise approved, use concrete materials from sources and manufacturers that are the same as those used to establish concrete proportions for each concrete mix type. Provide batch tickets which show the information listed in Paragraph 1.3.E.3 of this Section.

C. Mixers shall be equipped with operational automatic device for recording number of revolutions of drum prior to completion of mixing operation. Each transit mixer shall also be equipped with operational water measuring devices consisting of either accurately calibrated water tanks or water meters.

D. Concrete in truck mixer shall be mixed continuously until discharged. The discharge time for concrete after all ingredients have been added to the mixer shall not exceed 90 minutes or 300 revolutions of the drum, whichever comes first. Delivery tickets shall show departure time and drum revolutions count from plants.

E. Mixing shall begin immediately after all ingredients are in the mixer and continue for at least 70 revolutions of the drum as required to obtain uniformity of concrete as defined in ASTM C94. The introduction of additional water into transit type mixers after leaving the plant will not be permitted unless approved by the Contracting Officer at the site. If the introduction of additional water is approved, the drum shall be revolved not less than 30 revolutions after the water is added and before discharge is commenced. The total water in the mix, the sum of the amount added at the plant and the site, shall not result in the specified water-to-cement ratio being exceeded.

F. Adding Water-Reducing Admixtures: Comply with manufacturer’s printed recommendations. Add Type G Water-Reducing, High Range and Retarding at the batch plant. Type F may be added at the plant, unless directed otherwise by the Contracting Officer.

G. Adding Polypropylene Fibers: Add polypropylene fibers into concrete mixes after the mixing water has been blended well with cement and aggregates. Extend mixing time as recommended by manufacturer of fibers. Add fibers at batch plant, unless otherwise acceptable to the Contracting Officer.

2.6 EPOXY MORTAR AND LATEX EMULSIONS

A. Epoxy mortar used to cover the ends of the prestressed concrete beams as specified in the plans shall consist of an epoxy binder mixed with aggregate. The epoxy resin and hardener ratio shall be as specified by the manufacturer.
Siliceous aggregate is required unless otherwise approved by the Contracting Officer. Aggregate shall be clean and dry.

B. Latex emulsion used for latex based grout/mortar, latex adhesive grout/mortar or other purposes shall conform to TxDOT Materials Specification DMS-8110 “Coatings for Concrete”.

2.7 PNEUMATICALLY PLACED CONCRETE

A. Pneumatically placed concrete, where required to stabilize soil of drilled shaft retaining walls, shall conform to TxDOT Standard Specifications Item 431, “Pneumatically Placed Concrete”.

PART 3 - EXECUTION

3.1 CONCRETE TESTING AND QUALITY CONTROL

A. General:

1. This paragraph will complement Section 01450, “Quality Control”.

2. Allow the Authority’s testing agency and Contracting Officer free access to material stockpiles, facilities for batching, mixing and placing concrete and the work in progress.

3. Quality control is the Contractor’s responsibility. Results of any testing performed by the Contracting Officer’s testing agency will be made available to the Contractor and the Contractor may use such testing as part of the Contractor’s Quality Control program, but will not be in lieu of the Contractor’s testing requirements.

4. Furnish molds and concrete for all testing. Provide tools necessary for making test specimens, slump tests, and yield tests. Furnish labor and equipment for obtaining and handling all test samples. Provide proper curing location and supplies as required by ASTM C31.

5. At least 24 hours in advance of placing concrete in the structure, notify the Contracting Officer of the date, time, and location in the structure and quantity of concrete to be placed.

6. Each concrete mix type has specific performance requirements. Verify that requirements are met for each mix type by sampling and testing at least equal to that required herein.

7. Verify that batch tickets from ready-mix supplier properly describes the mix for the work being performed prior to permitting the discharge of concrete from the supplier’s truck.

8. Ensure that the ready-mix transport trucks are equipped with an operational drum revolution counter, and the drum turn rates are established prior to concrete placements with the approval of the Contracting Officer.

B. Sampling and Testing Fresh Concrete: Fresh concrete used in the work shall be sampled and tested by the testing laboratory using technicians certified by the American Concrete Institute to determine its acceptability as required by ACI 318 and to demonstrate general conformance with specified properties as follows:

1. Sampling Fresh Concrete: ASTM C172.

2. Slump: ASTM C143; one test for each set of compressive strength test specimens. Perform additional slump tests when requested by Contracting Officer.

   a. When superplasticizers are added at site, make slump tests before adding superplasticizers and after superplasticizers have been properly mixed into the fresh concrete.

   b. When liquid nitrogen is used to cool the concrete, make slump test before adding liquid nitrogen to the concrete mix.

3. Air Content: ASTM C173, volumetric method for lightweight concrete; ASTM C231 pressure method for normal weight concrete; one for each set of compressive strength specimens.

4. Concrete Temperature: ASTM C1064; test concrete hourly when air temperature is 40 degrees F and below, and when 80 degrees F and above; and when each set of compression test specimens is made.

5. Compressive Strength Specimens: ASTM C31; one set of four standard cylinders for each 100 cubic yards or fraction thereof, of each concrete type placed in any one day, or for each 5000 sq. ft. of surface area placed, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens.

6. Compressive Strength Tests: ASTM C39; one specimen tested at 7 days, two
PORTLAND CEMENT CONCRETE

at 28 days, and one retained in reserve for later testing if required. When frequency of testing will provide less than five strength tests for a given mix of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

7. Flexural Strength Specimens: ASTM C31; When flexural strength is specified, one set of three beam molds for each 100 cubic yards or fraction thereof, of each concrete type placed in any one day or for each 5000 square foot of surface area placed, unless otherwise directed. Mold and store beams for laboratory cured test specimens.

8. Flexural Strength Tests: ASTM C78; Two specimens tested at 7 days. Retain one in reserve for later testing, if required.

9. The Contractor shall provide a protected area or container for storage of the concrete test specimens during the initial curing period (the first 16 to 48 hours after molding). Specimens shall be stored under conditions that maintain the temperature immediately adjacent to the specimens in the range of 60 to 80 degrees F and prevent loss of moisture from the specimens. Initial curing shall meet the requirements of ASTM C31.

C. Sampling and Testing Hardened Concrete:

1. Make additional tests of in-place concrete as required by the additional jurisdictional agencies, and as directed by Contracting Officer when test results indicate specified concrete strengths and other qualities have not been attained in the work. Conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42, or by other methods acceptable to the Contracting Officer. Additional tests performed on concrete previously determined deficient shall be done at Contractor’s expense.

a. When laboratory test results indicate concrete to be more than 500 psi below the specified strength, or if there is a likelihood of low strength concrete, a significant reduction in load-carrying capacity, or absence of desired durability in the concrete, the Contracting Officer will require tests of cores to be drilled from the areas in question.

1) The cores shall be drilled no earlier than 28-days and no later than 56-days after pouring of the concrete in question.

2) A minimum of three cores shall be taken for each 100-cubic yards or fraction thereof, of concrete classified as deficient as a result of the cylinder tests. Not less than 1 set (3-cores) shall be taken for each set of cylinders, which had deficient test results.

3) Prior to coring reinforcing steel and other embedded items shall be located by suitable means in order to minimize the risk of damage.

b. Test cores shall be obtained from each member or area of suspect strength, from locations designated by the Contracting Officer, and test specimens shall be prepared by the Contractor in accordance with ASTM C42.

c. Concrete in the area represented by the core tests will be considered structurally adequate if the average of the three cores is equal to at least 85 percent of the specified design strength and no single core test is less than 75 percent of the specified design strength. Locations represented by erratic core strengths shall be retested at the direction of the Contracting Officer.

d. Should the first set of cores show deficient strength, the contractor will have the option, at his expense, of obtaining one additional set of cores for further testing. These additional cores shall not exceed the number drilled for the first set and shall be subject to the criteria above. However, the results from all cores will be used in determining the average strength.

e. The Contractor shall, at his expense, fill core holes in
accordance with the requirements of Section 03350, “Concrete Finishing”, for repair of surface details.

2. Make cores of slabs-on-grade of Bus and LRT maintenance facilities to verify proper subbase, location of reinforcement and proper penetration of sealer or hardener, as directed by the Contracting Officer, and/or as required by the Jurisdictional Authority. For every 1,000 square feet of slab area, two cores will be taken to determine compliance with these specifications. Area found deficient, will have an additional four cores taken and the average value will be used to determine compliance.

3. Prepare and test samples of hardened concrete each time a supplier is changed and each time a supplier changes material source, as follows, to determine soluble chloride ion content, on bridge decks.

   a. A standard 3 inch diameter by 6 inch long, 7 day cured concrete sample shall be ground and pulverized. One hundred percent of the resulting powder shall pass a number 20 sieve.

   b. Mix powder with an equal or greater amount of distilled or deionized water, by weight; boil for 5 minutes and soak for 24 hours at 70 degrees F to 72 degrees F.

   c. Test the water extract for soluble chloride ions in accordance with ASTM D512. Test for Chloride Ion in Water and Waste Water. Calculate soluble chloride ion content as a function of the powder/water concentration from 3b above.

   d. Soluble chloride ion content in hardened concrete shall not exceed 250 ppm (approximately 0.15 percent by weight of cement).

4. Rejection of Concrete, Repair and Replacement: The Contracting Officer shall have authority to reject concrete work, which does not meet specification requirements, and to require repair or replacement as necessary to complete the work.

5. Acceptance of Structure: Acceptance of the completed concrete work requires conformance with the dimensional tolerances, appearance, and strengths specified in these Specifications, in ACI 301, and in ACI 117.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

   A. Portland cement concrete will not be measured separately for payment. It will be measured in accordance with the Sections specifying construction requiring concrete.

   B. Portland cement concrete will be paid for as part of the indicated Contract unit prices or lump-sum prices for the associated concrete work as indicated in the Bid Schedule of the Bid Form.

   C. Grout will not be measured separately for payment.

   D. Concrete which fails to meet minimum strength requirements may be rejected or structural review may be made by the Contracting Officer. Such concrete which is proven structurally adequate may be accepted at adjusted price based on following formula:

   \[ A = 0.10Bp + 0.75(Sa/Ss)^2 \]

   a. \( A \) = Amount to be paid per unit of measurement

   b. \( Sa \) = Actual strength from beams or cores

   c. \( Ss \) = Minimum required strength (specified)

   d. \( Bp \) = Unit bid price

END OF SECTION 03305
### TABLE 03305 – 1 MIX DESIGNATIONS

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>Mix Design</th>
<th>Use</th>
<th>Strength</th>
<th>Slump (if standard TxDOT mixes used, see TxDOT Sec. 421, Table 8 for slumps)</th>
<th>Maximum &amp; Allowable Aggregate</th>
<th>Cementitious Material</th>
<th>Water to Cement Ratio</th>
<th>Air Entrainment</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DART</td>
<td>TxDOT</td>
<td></td>
<td>28-Day Compressive (psi)</td>
<td>7-Day Flexural (psi)</td>
<td>Without Plasticizer</td>
<td>With Plasticizer</td>
<td>ASTM C33 (Max)</td>
<td>TxDOT Sec. 421 (Allowable)</td>
<td>Min (lbs)</td>
</tr>
<tr>
<td>S-1 S</td>
<td>Mass Structural Concrete; Bridge Substructure, Retaining Walls, Wingwalls, Culverts (except top slab of direct traffic culverts), Underwater Placement</td>
<td>4000</td>
<td>-</td>
<td>4</td>
<td>7</td>
<td>Gr. 57</td>
<td>4 &amp; 5</td>
<td>See TxDOT Sec. 421</td>
<td>0.45</td>
</tr>
<tr>
<td>S-2 S</td>
<td>Structural Concrete (Non-Mass); Drilled Shafts, Bridge Substructure, Retaining Walls, Wingwalls, Ballast Walls, Parapet Walls, Culverts (including top slab of direct traffic culverts) and Bridge Superstructures</td>
<td>4000</td>
<td>-</td>
<td>4</td>
<td>7</td>
<td>Gr. 57</td>
<td>4 &amp; 5</td>
<td>See TxDOT Sec. 421</td>
<td>0.45</td>
</tr>
<tr>
<td>S-3 H</td>
<td>Precast Concrete; Tilt-up Concrete Walls, Prestressed Concrete, Approach Slabs and Track Slabs</td>
<td>5000 Min</td>
<td>-</td>
<td>4</td>
<td>Na</td>
<td>Gr. 57</td>
<td>4, 5 &amp; 6</td>
<td>See TxDOT Sec. 421</td>
<td>0.45</td>
</tr>
<tr>
<td>S-4 Na</td>
<td>Structural Lightweight Concrete</td>
<td>4000</td>
<td>-</td>
<td>4</td>
<td>7</td>
<td>Gr. 67</td>
<td>5</td>
<td>See TxDOT Sec. 421</td>
<td>-</td>
</tr>
<tr>
<td>S-5 Na</td>
<td>Fiber Reinforced Concrete</td>
<td>4000</td>
<td>-</td>
<td>4</td>
<td>Na</td>
<td>Gr. 57</td>
<td>4</td>
<td>See TxDOT Sec. 421</td>
<td>-</td>
</tr>
<tr>
<td>S-6 CO</td>
<td>Structural Toppings</td>
<td>4600</td>
<td>-</td>
<td>4</td>
<td>7</td>
<td>Gr. 7</td>
<td>6</td>
<td>See TxDOT Sec. 421</td>
<td>0.45</td>
</tr>
<tr>
<td>S-7 A</td>
<td>Sidewalks (except Curb Ramps); Median Paving and Other Structural Concrete Work (for Structural Concrete not specified above)</td>
<td>3000</td>
<td>-</td>
<td>4</td>
<td>Na</td>
<td>Gr. 57</td>
<td>4 &amp; 8</td>
<td>See TxDOT Sec. 421</td>
<td>0.60 Except for interior floor slabs</td>
</tr>
<tr>
<td>M-1 B</td>
<td>Encasement of Electrical and Communication Ducts</td>
<td>2000</td>
<td>-</td>
<td>3</td>
<td>7</td>
<td>Gr. 7</td>
<td>6 &amp; 7</td>
<td>See TxDOT Sec. 421</td>
<td>0.60</td>
</tr>
<tr>
<td>P-1 P</td>
<td>Alley &amp; Roadway Pavement (Slip Form Placement)</td>
<td>4400</td>
<td>570</td>
<td>2</td>
<td>Na</td>
<td>Gr. 57</td>
<td>4</td>
<td>See TxDOT Sec. 421</td>
<td>0.45</td>
</tr>
<tr>
<td>P-2 P</td>
<td>Alley &amp; Roadway Pavement (Hand Placement)</td>
<td>4400</td>
<td>570</td>
<td>4</td>
<td>Na</td>
<td>Gr. 57</td>
<td>4</td>
<td>See TxDOT Sec. 421</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Fly Ash: Fly Ash, conforming to the TxDOT DMS 4610, shall be substituted for cement in mixes S-1, S-2, S-7, M-1, P-1 and P-2 at the rate of 15 to 30 percent by absolute weight. Fly Ash shall be optional for all other mix designs at a maximum rate of 30 percent by absolute weight.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the finishing and curing of formed and unformed concrete surfaces, including the repair of surface defects.

B. Concrete formwork is specified in Section 03100, "Concrete Formwork".

C. Cast-in-place concrete is specified in Section 03300, "Cast-In-Place Concrete".

D. Sandblasted and color concrete are specified in Section 03360, "Special Concrete Finishes".

E. Repair of concrete defects caused by spills, cracks, or delaminations are specified in Section 03905, "Concrete Repair and Restoration".

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M182 - Standard Specification for Burlap Cloth Made from Jute or Kenaf

B. American Concrete Institute (ACI):

1. ACI 117 - Standard Specification for Tolerances for Concrete Construction and Materials
2. ACI 301 - Standard Specifications for Structural Concrete
3. ACI 308 - Standard Practice for Curing Concrete
4. ACI 503.2 - 503.4 - Three Epoxy Standards
   a. ACI 503.2 - Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive
   b. ACI 503.3 - Specification for Producing a Skid-Resistant Surface on Concrete by the Use of Epoxy and Aggregate
   c. ACI 503.4 - Standard Specification for Repairing Concrete with Epoxy Mortars ACI 503.1 - 503.4 - Four Epoxy Standards

C. American Society for Testing and Materials (ASTM):

1. ASTM C33 - Standard Specification for Concrete Aggregates
2. ASTM C150 - Standard Specification for Portland Cement
3. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete
4. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
5. ASTM C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

D. Texas Department of Transportation (TxDOT):

1. Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges

1.3 SUBMITTALS

A. Submittals involving exposed concrete finishes require approval of the Contracting Officer before they may be incorporated in the Work.

B. Shop Drawings: Submit drawings, or diagrams to scale, that indicate the location in plan and elevation of all concrete finishes.

C. Product Data: Submit manufacturers' product data for manufactured products.

D. Samples:

1. Submit 1/2-pint sample container of aluminum oxide and silicon carbide abrasive grit for review and acceptance where "non-slip finish" is indicated.
2. Submit samples not less than 12 inches by 12 inches in size of each type of sand blast finish, indicating materials and methods used to produce the sand blast finishes. Review by the Contracting Officer will be for color and texture only. Approved samples will become the Contracting Officer's control samples.
1.4 QUALITY ASSURANCE

A. Finishes:
   1. Finishing of formed concrete surfaces shall conform with applicable requirements of ACI 301.
   2. Finishes for slabs and flatwork shall conform with applicable requirements of ACI 301.

B. Bridge deck finishes shall conform with applicable requirements of TxDOT Standard Specification Item 420.19. Tolerances:
   1. Formed Surfaces: Conform with applicable requirements of ACI 117.
      a. Where elastomeric bearing pads are indicated, the level plane upon which bearing pads are placed shall not vary more than 1/16-inch from a 2-foot straightedge placed in any direction across the area and the area shall extend a minimum of 1 inch beyond the limits of the pads.
      b. Bearing surfaces of girders on a slope or girders with a camber shall be finished on a horizontal/level plane so that loads are uniformly distributed over the entire surface of the elastomeric bearing pads.
      c. Finished plane shall not vary more than 1/8-inch from the elevation indicated.
   2. Slabs and Flatwork: Conform with applicable classification requirements of ACI 117, as follows:
      a. Very Flat Tolerance: True plane with maximum variation of 1/8-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.
      b. Flat Tolerance: True plane with maximum variation of 3/16-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.
      c. Straightedge Tolerance: True plane with maximum variation of 5/16-inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.
      d. Bullfloated Tolerance: True plane with maximum variation of 1/2 inch in 10 feet when measured with a 10-foot straightedge placed anywhere on the slab in any direction.

C. Curing: Conform with requirements of ACI 301 and ACI 308, as applicable.

D. Site Mock-Ups: Provide site mock-ups, at least 3 feet by 4 feet in size, of finishes of formed surfaces in exposed locations and of exposed slab finishes for the Contracting Officer’s review and approval. Refer to Section 01454, “Field Samples and Mock-ups”, for requirements and procedures.

E. Site Mock-ups of Architectural Concrete: Provide site mock-ups of architectural concrete showing finish texture and pattern of exposed formed concrete surfaces.
   1. Size of mock-up shall be a minimum of 8 feet by 10 feet, unless otherwise approved by the Contracting Officer to be smaller.
   2. The number of mock-up panels required shall be the number necessary to obtain the Contracting Officer’s approval of pattern and texture of panel.
   3. Approved mock-up shall be used as the standard for the aesthetic quality of the surface finish of architectural concrete.

PART 2 - PRODUCTS

2.1 TOOLS AND EQUIPMENT

A. Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing the required concrete-finishing work.

2.2 REPAIR AND FINISHING MATERIALS

A. Portland Cement: ASTM C150, Type II, of same brand as used in the work. Furnish white portland cement where required to produce color matching color of surrounding concrete.

B. Aggregate:
   1. For Bonding Grout: ASTM C33, washed clean sand passing a No. 30 sieve.
   2. For Patching Mortar: ASTM C33, washed clean, graded fine aggregate of suitable size for areas to be repaired. Clean coarse aggregate up to Size No. 8 may be added for repair of larger pockets and voids.

C. Commercial Patching Mortar: A structural repair mortar may be furnished if appropriate for the use and approved by the Contracting Officer.

D. Epoxy Patching Mortar: As specified in ACI 503.4 for Epoxy Mortar.
2.3 CURING MATERIALS

A. Damp Curing Materials:

1. Waterproof Sheet Materials: ASTM C171, waterproof paper with white paper face, polyethylene film pigmented white, or white burlap-polyethylene sheeting.

2. Burlap: AASHTO M182, of class or weight suitable for the use and location. Do not use burlap where concrete is exposed to direct sunlight.

B. Curing Compound: ASTM C309, liquid membrane-forming curing compound, Type 1, Class A or B as appropriate for the use or location.

1. Where concrete surfaces will receive architectural finishes, such as paint, or membrane waterproofing, membrane-forming curing compound shall not leave a coating or residue which will impair bond of adhesives, paints, and coatings with concrete.

PART 3 - EXECUTION

3.1 REPAIR OF SURFACE DEFECTS

A. Repair Standards: Repair of surface defects shall conform with applicable requirements of ACI 301. Repair with epoxy mortar, conform with applicable requirements of ACI 503.4.

B. Surface Defects:

1. Repair of surface defects shall begin immediately after form removal. For repair with epoxy mortar, concrete shall be dry.

2. Surface defects are defined to include: form-tie holes, air voids or pockets, bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, rock pockets, visible construction joints, fins and burrs.

3. Repair of surface defects shall be tightly bonded and shall result in concrete surfaces of uniform color and texture, matching adjacent surfaces, and free of shrinkage cracks.

C. Repair Work:

1. Remove honeycombed and other defective concrete including graffiti down to sound concrete. Saw-cut the edges perpendicular to the surface or slightly undercut. Feather-edges will not be permitted. Dampen the area to be patched and an area at least 6 inches wide surrounding it to prevent absorption of water from the patching mortar.

2. Where rock pockets or similar defects or voids expose steel reinforcement, cutout to solid surface behind the reinforcing steel to provide suitable key-lock for patching mortar. Patching mortar shall envelope the exposed reinforcing bar.

3. Bond patching mortar to concrete with bonding grout or epoxy adhesive. Bonding grout shall consist of 1 part Portland cement to 1 part No. 30 mesh sand, mixed to the consistency of a thick cream, and then well brushed onto the concrete. Bond commercial patching mortar to concrete in accordance with the manufacturer's instructions.

4. Make the patching mortar of the same materials and of approximately the same proportions as used for the concrete, except omit the coarse aggregate. Use not more than 1 part Portland cement to 2-1/2 parts sand by damp loose volume, and substitute white Portland cement for a portion of the regular gray Portland cement to produce patching mix matching the surrounding concrete in color when dry. Determine the proportion of white Portland cement by trial mixes and test areas, prior to repair of actual defective areas.

5. After surface water has evaporated from the area to be patched, brush the bond coat well into the surface. When the bond coat begins to lose the water sheen, apply the patching mortar. Compact the mortar into place and strike off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, leave the patch undisturbed for at least 1 hour before being finally finished. Keep the patched area damp for 7 days.

6. Neatly finish patched surfaces to match adjacent surrounding surface texture of concrete. Grind or fill surfaces to produce level and plumb, true planes.

7. For walls exposed in the finish work, form tie holes shall be patched and finished flush with adjacent surface. For holes passing entirely through walls, a plunger type injection gun or other suitable device shall be used to completely fill the holes.
8. Patching of honeycombed areas or rock pockets which are too large and unsatisfactory for mortar patching shall be cut out to solid surface, keyed, and packed solid with matching concrete to produce firm bond and flush surface. Patching shall match texture of adjacent surfaces where exposed in the finished work.

9. Repair work in exposed locations which does not match the texture and color of surrounding adjacent surfaces or which was not well performed shall be removed and performed again until the repair work conforms with Specification requirements.

10. Surfaces to receive membrane waterproofing shall have fins and loose material removed, and voids and cracks patched flush with adjacent surfaces.

11. Completed repairs shall be cured as herein specified under Article 3.4, Curing.

### 3.2 FINISHING OF FORMED SURFACES

**A. Unexposed Surfaces:**

1. Concrete which will not be exposed in the completed structure shall be any form finish as specified in Section 03100, "Concrete Formwork", and ACI 301 for "rough form finish."

2. Concrete to receive membrane waterproofing shall receive a "smooth form finish" in accordance with ACI 301.

**B. Exposed Surfaces:** Unless indicated otherwise, concrete which will be exposed in the completed structure shall receive the following finishes as indicated:

1. Smooth Form Finish: Conform to ACI 301.

2. Smooth Rubbed Finish: Conform to ACI 301.

3. Grout Cleaned Finish: Conform to ACI 301.

4. Unspecified Finish: When finish is not indicated, provide "smooth form finish" as specified above.

### 3.3 SLABS AND FLATWORK

**A. Placement and Finishing Standards:** Slabs and flatwork shall be placed, consolidated, and finished in accordance with applicable requirements of ACI 301. Coordinate with Section 03300, "Cast-In-Place Concrete", as applicable.

**B. Placement:**

1. Slabs and flatwork shall be placed and finished monolithically. Strike off and screed slabs to true, plane surfaces at required elevations, and thoroughly consolidate concrete with vibrators, finish with straight edges and floats. Finish slab within four hours of concrete placement or as needed to provide specified finish.

2. Whether indicated or not, in areas where drains occur, slope finished slab to drains. Slope shall be a minimum of 1/8 inch per foot unless otherwise indicated.

**C. Slab Finishes:** Unless indicated otherwise, slabs and flatwork shall receive the following finishes as indicated:

1. Scratched Finish: Conform to ACI 301. Provide "scratched finish" for slab substrates to receive cementitious toppings or finishes, such as terrazzo or mortar setting bed for ceramic tile.

2. Floated Finish: Conform to ACI 301. Provide "floated finish" for track slabs and mud slabs and for slabs and flatwork to receive roofing and membrane waterproofing.

3. Troweled Finish: Conform to ACI 301. Provide "troweled finish" for interior slabs and flatwork to be exposed in the completed structure, for slabs to receive resilient floor coverings, and for flatwork to receive elastomeric bearing pads.

4. Broom Finish: Conform to ACI 301. Exact texture and coarseness of the broom finish shall match the approved site mock-up. Provide fine or medium-coarse "broom finish" as indicated for exterior sidewalks and paving, garage floors, exterior ramps, equipment and transformer pads, and subway invert slab.

5. Nonslip Finish: Conform to ACI 301. Nonslip materials shall be aluminum oxide and silicone carbide grit particles. Provide "nonslip finish" for interior pedestrian ramps, walkways, subway cross-passage floors, and other floor areas where indicated.

6. Unspecified Finish: When finish is not indicated or specified, provide finishes as specified in ACI 301.

**D. Surface Tolerances:** Conform with ACI 117, as follows:

1. Flat Tolerance: Slabs and flatwork with "troweled finish" and with "nonslip finish."
2. **Straightedge Tolerance:** Slabs and flatwork with fine "broom finish" or medium-coarse "broom finish."

3. **Bullfloated Tolerance:** Slabs and flatwork with "scratched finish," with "floated finish," and with coarse "broom finish."

E. **Joints:**

1. Construction, expansion, isolation, and contraction joints shall be located as indicated. Construction joints shall act as contraction joints. Where additional contraction joints are required to prevent shrinkage cracks, saw-cut such joints. All joints shall be straight and true to line.

2. Expansion joints materials shall cover full depth of concrete.

3. Mark-off lines or edges at formed construction and expansion joints shall be finished with 1/4 inch radius curved edging tool, neat and true to line, uniform throughout.

### 3.4 CURING AND PROTECTING

**A. General Requirements:**

1. Protect freshly placed concrete from excessively hot or cold temperatures, rapid temperature changes and physical damage including graffiti. Maintain without drying for period of time necessary for hydration of cement and proper hardening of concrete. Curing shall conform with the applicable requirements of ACI 301 and ACI 308, except as modified herein.

2. Unless otherwise specified or directed, cure newly placed concrete continuously for seven days at ambient temperature in excess of 55 degrees F. Initiate curing methods as soon as free water has disappeared from concrete surface after finishing but not later than 1 hour following the completion of final finishing procedures. Avoid rapid drying at end of curing period.

3. Where water is used with a curing method, only use specified potable water.

**B. Curing Methods: Use the following methods where specified:**

1. **Method A:** Water ponded on horizontal surfaces keeping surface continuously submerged for required curing period.

2. **Method B:** Water applied by continuous sprinkling with nozzle or nozzles which, during first 24 hours, atomize flow of water providing a mist and not a spray. Do not apply moisture under pressure directly upon concrete; avoid flowing or washing on surfaces while susceptible to erosion.

3. **Method C:** Cover entire surface of concrete with double thickness burlap sheet, laid directly on concrete and kept continuously wet with water. Maintain in good condition.

4. **Method D:** Immediately cover with waterproof curing sheet, free from holes or tears. Hold in position so that entire surface of concrete is fully and continuously covered. Weight down the sheets and overlapped edges enough to resist moderate winds. Maintain sheet free of holes during curing period.

5. **Method E:** Membrane forming curing compound applied to concrete surfaces by methods and at coverage rates recommended by the manufacturer within two hours after final finishing operations.
   
   a. Use Type 1 compound, except where surfaces are subject to sunlight, use Type 2 compound.

   b. Do not apply curing compounds to surfaces requiring bond to additional concrete or where bonded surface coating such as paint, tile, damp-proofing, waterproofing or roofing is to be applied, or to floors to be chemically sealed.

   c. Apply curing compound in two coats. Apply first coat immediately after stripping of forms and acceptance of concrete finish.

   d. If surface is dry, thoroughly wet concrete with water and apply curing compound just as surface film of water disappears. Apply second coat after first coat has set.

   e. Protect coating against damage for at least 10 days after application. If damage occurs, apply additional coating.

   f. If use of curing compound results in streaked or blotchy appearance, cease operations and use other methods of curing until cause of defective appearance is corrected.

**C. Application of Curing Methods:**

1. **Curing Interior Building Slabs Supported On Grade:** Use curing Method D for a period of 7 days.
2. Curing Exterior Building Slabs Supported On Grade: Use curing Methods A through D for a period of 7 days. Method E may be used if not prohibited by Sec. 3.4.B.5.b.


4. Curing Formed Surfaces: Cure formed concrete surfaces, including undersides of beams, supported slabs, walls and other similar surfaces, by keeping forms in place or by Method E. Shade forms exposed to sun when air temperature exceeds 80 degrees F or keep forms cooled by continuous wetting. If forms are removed prior to full length of curing period, continue curing by Method E.

5. Curing Roadway Paving: Use curing Methods C, D, or E for minimum period of 72 hours.

6. Curing Bridge Concrete: Use curing Methods for bridge decks as specified for water and membrane curing in Section 420.20 of the TxDOT Standard Specifications.

D. Floor Treatment Curing: Cure in accordance with recommendations of manufacturer of floor hardener.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Repair of surface defects, finishing, and curing of concrete will not be measured separately for payment.

B. Repair of surface defects, finishing, and curing of concrete will be paid for as part of the indicated Contract unit price for the associated concrete work as indicated in the Bid Schedule of the Bid Form.

END OF SECTION 03350
PART 1 - GENERAL

1.1 DESCRIPTION
A. This Section includes specifications for sandblasted and integrally colored concrete finishes.
B. Standard concrete finishes are specified in Section 03350, “Concrete Finishing”.
C. Concrete formwork is specified in Section 03100, “Concrete Formwork”.
D. Cast-in-place concrete is specified in Section 03300, “Cast-In-Place Concrete”.

1.2 REFERENCED STANDARDS
A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M182 - Standard Specification for Burlap Cloth Made from Jute or Kenaf
B. American Concrete Institute (ACI):
   1. ACI 117 - Standard Specification for Tolerances for Concrete Construction and Materials
   2. ACI 301 - Specifications for Structural Concrete
   3. ACI 308 - Standard Practice for Curing Concrete
   4. ACI 503.1 - 503.4 - Four Epoxy Standards
C. American Society for Testing and Materials (ASTM):
   1. ASTM C33 - Standard Specification for Concrete Aggregates
   2. ASTM C150 - Standard Specifications for Portland Cement
   3. ASTM C171 - Standard Specifications for Sheet Materials for Curing Concrete
   4. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
   5. ASTM C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
   6. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete

1.3 SUBMITTALS
A. Submittals involving exposed concrete finishes require approval of the Contracting Officer before they may be incorporated in the Work.
B. Product Data: Submit manufacturers' product data for manufactured products.
C. Samples:
   1. Submit samples not less than 12 inches by 12 inches in size of each color of integrally colored concrete, indicating materials and methods used to produce colors. Review by the Contracting Officer will be for color and texture only. Approved samples will become the Contracting Officer's control samples.
   2. Submit samples not less than 12 inches by 12 inches in size of each type of sand blast finish, indicating materials and methods used to produce the sand blast finishes. Review by the Contracting Officer will be for color and texture only. Approved samples will become the Contracting Officer's control samples.

1.4 QUALITY ASSURANCE
A. Finishes:
   1. Finishing of formed concrete surfaces shall conform with applicable requirements of ACI 301.
   2. Finishes for slabs and flatwork shall conform with applicable requirements of ACI 301.
   3. Special architectural finishes for formed concrete surfaces shall conform with applicable requirements of ACI 301.
B. Colored Concrete Work:
   1. Finisher must have a minimum of 5 years experience with colored concrete work.
   2. The only approved concrete finishers for colored concrete flat work are:
      b. Texas Unique Concrete Technologies (972) 669-9442.
c. North Texas Bomanite (972) 484.8465.

C. Tolerances:

1. Formed Surfaces: Conform with applicable requirements of ACI 117.
   a. Where elastomeric bearing pads are indicated, the level plane upon which bearing pads are placed shall not vary more than 1/16 inch from a 2 foot straightedge placed in any direction across the area and the area shall extend a minimum of 1 inch beyond the limits of the pads.
   b. Bearing surfaces of girders on a slope or girders with a camber shall be finished on a horizontal/level plane so that loads are uniformly distributed over the entire surface of the elastomeric bearing pads.
   c. The finished plane shall not vary more than 1/8 inch from the elevation indicated.

2. Slabs and Flatwork: Conform with applicable classification requirements of ACI 117, as follows:
   a. Very Flat Tolerance: True plane with maximum variation of 1/8 inch in 10 feet when measured with a 10 foot straightedge placed anywhere on the slab in any direction.
   b. Flat Tolerance: True plane with maximum variation of 3/16 inch in 10 feet when measured with a 10 foot straightedge placed anywhere on the slab in any direction.
   c. Straightedge Tolerance: True plane with maximum variation of 5/16 inch in 10 feet when measured with a 10 foot straightedge placed anywhere on the slab in any direction.
   d. Bullfloated Tolerance: True plane with maximum variation of 1/2 inch in 10 feet when measured with a 10 foot straightedge placed anywhere on the slab in any direction.

D. Curing: Conform with requirements of ACI 301 and ACI 308, as applicable.

E. Site Mock-Ups: Provide site mock-ups, at least 4 feet by 4 feet in size, of finishes of formed surfaces in exposed locations and of exposed slab finishes for the Contracting Officer's review and approval. Refer to Section 01454, "Field Samples and Mock-ups", for requirements and procedures.

F. Site Mock-ups of Architectural Concrete: Provide site mock-ups of architectural concrete showing finish texture and pattern of exposed formed concrete surfaces.

1. Size of mock-up shall be a minimum of 8 feet by 10 feet, unless otherwise approved by the Contracting Officer to be smaller.

2. The number of mock-up panels required shall be the number necessary to obtain the Contracting Officer's approval of pattern and texture of panel.

3. Approved mock-up shall be used as the standard for the aesthetic quality of the surface finish of architectural concrete.

4. Approved mock-ups may become part of the completed Work if undisturbed at time of Final Completion.

G. Requirements of Regulatory Agencies: Comply with air pollution regulations of governing authorities for sand-blasting activities and operations.

PART 2 - PRODUCTS

2.1 INTEGRALLY COLORED CONCRETE MATERIALS

A. Coloring Admixture: ASTM C979, synthetic mineral-oxide pigments or colored water-reducing admixtures, free of carbon black; color stable, nonfading, and resistant to lime and other alkalis.

2.2 REPAIR AND FINISHING MATERIALS

A. Portland Cement: ASTM C150, Type II, of same brand as used in the work. Furnish white Portland cement where required to produce color matching color of surrounding concrete.

B. Aggregate:

1. For Bonding Grout: ASTM C33, washed clean sand passing a No. 30 sieve.

2. For Patching Mortar: ASTM C33, washed clean, graded fine aggregate of suitable size for areas to be repaired. Clean coarse aggregate up to Size No. 8 may be added for repair of larger pockets and voids.

C. Commercial Patching Mortar: A structural repair mortar may be furnished if appropriate for the use and approved by the Contracting Officer.

D. Epoxy Patching Mortar: As specified in ACI 503.4 for Epoxy Mortar.
SPECIAL CONCRETE FINISHES

2.3 CURING MATERIALS

A. Damp Curing Materials:
   1. Waterproof Sheet Materials: ASTM C171, waterproof paper with white paper face, polyethylene film pigmented white, or white burlap-polyethylene sheeting.
   2. Burlap: AASHTO M182, of class or weight suitable for the use and location. Do not use burlap where concrete is exposed to direct sunlight.

B. Curing Compound: ASTM C309, liquid membrane-forming curing compound, Type 1, Class A or B as appropriate for the use or location.
   1. Where concrete surfaces will receive architectural finishes, such as resilient floor coverings or paint, or membrane waterproofing, membrane-forming curing compound shall not leave a coating or residue which will impair bond of adhesives, paints, and coatings with concrete.

2.4 CONCRETE MIXES

A. In addition to requirements of Section 03305, “Portland Cement Concrete”:
   2. Obtain written approval of color pigment manufacturer of admixtures proposed for use in integrally colored concrete.
   3. Coloring Admixture: Add coloring admixture to architectural concrete mix according to manufacturer’s written instructions.
   4. To help maintain consistent color of integrally colored and sandblasted concrete, use same brand of cement and same concrete aggregates throughout and maintain consistency of water content and slump.

PART 3 - EXECUTION

3.1 REPAIR OF SURFACE DEFECTS

A. Repair Standards: Repair of surface defects shall conform with applicable requirements of ACI 301. When using epoxy mortar, conform with applicable requirements of ACI 503.4.

B. Surface Defects:
   1. Repair of surface defects shall begin immediately after form removal. For repair with epoxy mortar, concrete shall be dry.
   2. Surface defects are defined to include: form-tie holes, air voids or pockets, bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, rock pockets, visible construction joints, fins and burrs.
   3. Repair of surface defects shall be tightly bonded and shall result in concrete surfaces of uniform color and texture, matching adjacent surfaces, and free of shrinkage cracks.

C. Repair Work:
   1. Remove honeycombed and other defective concrete down to sound concrete. Saw-cut the edges perpendicular to the surface or slightly undercut. Feather-edges will not be permitted. Dampen the area to be patched and an area at least 6 inches wide surrounding it to prevent absorption of water from the patching mortar.
   2. Where rock pockets or similar defects or voids expose steel reinforcement, cutout to solid surface behind the reinforcing steel to provide suitable key-lock for patching mortar. Patching mortar shall envelope the exposed reinforcing bar.
   3. Bond patching mortar to concrete with bonding grout or epoxy adhesive. Bonding grout shall consist of 1 part Portland cement to 1 part No. 30 mesh sand, mixed to the consistency of a thick cream, and then well brushed onto the concrete. Bond commercial patching mortar to concrete in accordance with the manufacturer’s instructions.
   4. Make the patching mortar of the same materials and of approximately the same proportions as used for the concrete, except omit the coarse aggregate. Use not more than 1 part Portland cement to 2-1/2 parts sand by damp loose volume, and substitute white Portland cement for a portion of the regular gray Portland cement to produce patching mix matching the surrounding concrete in color when dry. Determine the proportion of white Portland cement by trial mixes and test areas, prior to repair of actual defective areas.
   5. After surface water has evaporated from the area to be patched, brush the bond coat well into the surface. When the bond coat begins to lose the water sheen, apply the patching mortar. Compact the mortar into
place and strike off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, leave the patch undisturbed for at least 1 hour before being finally finished. Keep the patched area damp for 7 days.

6. Neatly finish patched surfaces to match adjacent surrounding surface texture of concrete. Grind or fill surfaces to produce level and plumb, true planes.

7. For walls exposed in the finish work, form tie holes shall be patched and finished flush with adjacent surface. For holes passing entirely through walls, a plunger type injection gun or other suitable device shall be used to completely fill the holes.

8. Patching of honeycombed areas or rock pockets which are too large and unsatisfactory for mortar patching shall be cut out to solid surface, keyed, and packed solid with matching concrete to produce firm bond and flush surface. Patching shall match texture of adjacent surfaces where exposed in the finished work.

9. Repair work in exposed locations which does not match the texture and color of surrounding adjacent surfaces or which was not well performed shall be removed and performed again until the repair work conforms with Specification requirements.

10. Surfaces to receive membrane waterproofing shall have fins and loose material removed, and voids and cracks patched flush with adjacent surfaces.

11. Completed repairs shall be cured as herein specified under Article 3.4, Curing.

3.2 FINISHING OF FORMED-surfaces

A. Sand Blast Finish:

1. Blasting Operations and Requirements:
   a. Apply sandblasted finish to exposed concrete surfaces where indicated.
   b. Perform sand blasting at least 72 hours after placement of concrete. Coordinate with formwork construction, concrete placement schedule, and formwork removal to ensure that surfaces to be blast finished are blasted at the same age for uniform results.
   c. Determine type of nozzle, nozzle pressure, and blasting techniques required to match the Contracting Officer’s control samples.
   d. Abrasive blast corners and edge of patterns carefully, using back-up boards, to maintain uniform corner or edge line.

2. Depths of Cut: Use an abrasive grit of proper type and gradation to expose aggregate and surrounding matrix surface to match the Contracting Officer’s control samples as follows:
   a. Brush Sand Blast Finish: Remove cement matrix to expose face of fine aggregate; no reveal.
   b. Light Sand Blast Finish: Expose fine aggregate with occasional exposure of coarse aggregate; maximum 1/16-inch reveal.
   c. Medium Sand Blast Finish: Generally expose coarse aggregate; 3/16-inch to 1/4-inch reveal.

3. Surface Continuity: Perform sand blast finishing in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish on each surface or area of work. Maintain patterns of variances in depths of cuts as indicated.

4. Construction Joints: Use technique acceptable to the Contracting Officer to achieve uniform treatment of construction joints.

5. Protection and Repair:
   a. Protect adjacent materials and finishes from dust, dirt, and other surface or physical damage during abrasive blast finishing operations. Provide protection as required and remove from site at completion of the work.
   b. Repair or replace other work damaged by finishing operations.

6. Clean-up: Maintain control of concrete chips, dust, and debris in each area of the work. Clean up and remove such material at the completion of each day of operation. Prevent migration of airborne materials by use of tarpaulins, wind breaks, and similar containing devices.

3.3 SLABS AND FLATWORK

A. Placement and Finishing Standards: Slabs and flatwork shall be placed, consolidated, and finished in accordance with applicable requirements of ACI 301. Coordinate with Section 03300, “Cast-In-Place Concrete”, as applicable.
B. Placement:

1. Slabs and flatwork shall be placed and finished monolithically. Strike off and screed slabs to true, plane surfaces at required elevations, and thoroughly consolidate concrete with vibrators, finish with straight edges and floats. Finish slab within four hours of concrete placement, or as needed to provide specified finish.

2. Whether indicated or not, in areas where drains occur, slope finished slab to drains. Slope shall be a minimum of 1/8 inch per foot unless otherwise indicated.

C. Slab Finishes: Unless indicated otherwise, slabs and flatwork shall receive the following finishes:

1. Broom Finish: Conform to ACI 301. Exact texture and coarseness of the broom finish shall match the approved site mock-up. Provide fine or medium-coarse "broom finish" as indicated for exterior sidewalks and paving, garage floors, exterior ramps, equipment and transformer pads, and subway invert slab.

D. Surface Tolerances: Conform with ACI 117, as follows:

1. Straightedge Tolerance: Slabs and flatwork with fine "broom finish" or medium-coarse "broom finish."

E. Joints:

1. Construction, expansion, isolation, and contraction joints shall be located as indicated. Construction joints shall act as contraction joints. Where additional contraction joints are required to prevent shrinkage cracks, saw-cut such joints. All joints shall be straight and true to line.

2. Mark-off lines or edges at formed construction and expansion joints shall be finished with 1/4-inch radius curved edging tool, neat and true to line, uniform throughout.

3.4 CURING

A. Curing Standards: Curing of concrete shall conform with applicable requirements of ACI 301 and ACI 308, except that the duration of the curing period shall be ten days. Curing with earth, sand, sawdust, straw, and hay will not be permitted.

B. Curing Requirements:

1. Concrete shall be cured with waterproof sheet materials, damp burlap, or curing compounds.

2. Curing compounds shall not be used on surfaces when their use may be detrimental to bonding of concrete, mortar, membrane waterproofing, calking and sealants, adhesives, plaster, paint, or the specified surface finish or coating.

C. Damp Curing:

1. Vertical surfaces shall be cured by keeping the forms wet at all times and by leaving the forms in place as long as possible as specified in Section 03100, Concrete Formwork. After removal of forms, concrete shall be kept continuously damp by fog spraying or otherwise washing down the concrete in an accepted manner until ten days after placing. Protect exposed surfaces by covering with sheet materials or burlap kept continuously moist.

2. Horizontal surfaces shall be cured and protected by covering the finished surfaces with waterproof sheet materials or damp burlap, left in place for a minimum of ten days and kept continuously moist.

3. Fog spray freshly placed slabs until finishing operations commence. Do not allow slabs to become dry until finishing operations are complete.

D. Curing Compound: Application of curing compound shall conform to applicable requirements of ACI 308.

3.5 PROTECTION

A. Protect exposed concrete surfaces, including flatwork, as required to prevent damage from impact or strains.

B. Protect fresh concrete from drying winds, rain, damage, or soiling.

C. Refer to Section 03300, "Cast-In-Place Concrete", for additional requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Sandblasted concrete described in this section will be measured and paid for at the unit price per square foot, installed.

B. Integrially colored concrete described in this section will not be measured or paid for separately but will be considered as incidental to the various bid items for concrete with integral color.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies prestressed concrete work including the requirements for determining, providing, and installing prestressing reinforcement for concrete members, where prestressing reinforcement tendons are tensioned as follows:

1. Pretensioning, in which the tendons are tensioned prior to concrete placement and curing; and the tension is released and transferred from the anchorages to the concrete after the development of the specified concrete strength.

2. Post-tensioning, in which the tendons are installed in ducts or voids in the concrete structure and are tensioned and anchored when the specified concrete strength has developed.

B. This section specifies requirements for providing and installing prestressing accessories which include sheaths, ducts, or voids for bonded and unbonded prestressing systems; tendon anchoring and splicing systems; and grouting for bonded tendon installations.

C. This section specifies the requirements for determining non-prestressed deformed reinforcement that may be required at anchorages and splices and provided and installed under Section 03200, "Concrete Reinforcement".

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1. ACI 301 - Specifications for Structural Concrete
2. ACI 318/318R - Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A416/A416M - Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
2. ASTM A421/A421M - Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete.
3. ASTM A722/A722M - Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete.

7. ASTM C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.
8. ASTM D1248 - Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

C. Precast/Prestressed Concrete Institute (PCI):

1. PCI/CONCRT MNL 116 - Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products
2. PCI/CONCRT MNL 120 - Design Handbook - Precast and Prestressed Concrete

D. Post-Tensioning Institute (PTI):

1. PTI/POST A - Post-Tensioning Manual

E. Corps of Engineers (COE):

1. COE CRD-C 79-94 - Handbook for Concrete and Cement Standard Specification for Pigments for Integrally Colored Concrete

F. Texas State Department of Highways and Public Transportation:


1.3 SUBMITTALS

A. Shop Drawings: Have drawings and calculations for prestressed products certified by a Professional Engineer licensed in the State of Texas. Include, at a minimum, the following:

1. Description of equipment to be used and procedure for installing and stressing
prestressing tendons. Unless otherwise shown on the plans, the Contractor has the option of furnishing any type of post-tensioning system which meets the requirements of these specifications. The system selected shall provide the magnitude and distribution of prestressing force and ultimate strength required by the plans without exceeding allowable temporary stresses.

2. Ductwork and method of holding ducts and tendons in position, tendon or bar sizes, splicing of bars, unit weights, materials and stress grade, jack clearances and procedures, stressing sequence, initial tensioning forces, pressure gauge or load cell for determining loads, calculated friction and elastic shortening losses and tendon or bar elongation, anchorage details and anchorage slippage losses, bonding and grouting procedures, mild steel requirements, and clearances.

3. Complete details and substantiating calculations of method and materials proposed for use in prestressing operations, both pretensioning and post-tensioning, including any required additions or rearrangement of reinforcing steel from that shown on the plans. Calculate, detail and show individual tendon and anchorage arrangement to satisfy design requirements and to avoid interferences. Coordinate with embedded items. Changes or rearrangement of details shown permitted only with approval of Structural Engineer of Record. Ensure that spacing of tendon is sufficient for full encasement of each tendon in concrete. Plan sequence of installation to minimize fitting problem of various components embedded in prestressed member.

4. Stress/strain curve of tendons and bars. Show amount of slip normally expected in seating anchorage devices as opposed to that assumed in design calculations. Show friction wobble coefficient and friction curvature coefficient expected from tendons and bars and duct material. Show complete stress diagram for each tendon.

5. Bills of materials, erection diagrams and details of connections to other work.

6. Details and design calculations for size and thickness of anchor plates and corresponding reinforcement necessary for each system to provide safe transfer of forces into end block. Show amount, size and arrangement of such reinforcement to be installed at anchorage zones to prevent bursting and splitting concrete members when subjected to prestressing forces.

B. Submit the following samples of materials and tendons, selected by the Contracting Officer from prestressing steel at plant or job site:

1. For wire, strand, or bars: One sample of each size from each heat or reel.

2. If prestressing tendon is to be prefabricated, one completely fabricated prestressing tendon 5 feet in length for each size of tendon, including anchorage assemblies. If the prestressing tendon is to be assembled at job site, sufficient wire or strand and end fittings to make up one complete prestressing tendon 5 feet length for each size of tendon, including anchorage assemblies.

3. If prestressed tendon is a bar, one 5 feet length complete with one end anchorage; if couplers are to be used with the bar, two 4 feet lengths of bar equipped with one coupler and fabricated to fit coupler.

C. Grout for Ducts:

1. Furnish results of tests performed by the Authority’s testing laboratory or by an independent laboratory approved by the Contracting Officer demonstrating that proposed grout mixture meets the specified requirements.

2. Furnish a graph from said laboratory relating compressive strength of the grout to age covering a span from 24 hours to 28 days.

D. Working Drawings: Have working drawings and design calculations for falsework and formwork certified by a Professional Engineer licensed in the State of Texas. Include, at a minimum, the following:

1. Complete working drawings and all necessary calculations for formwork and falsework when constructing cast-in-place prestressed units.

2. Complete working drawings and all necessary calculations for any falsework required for constructing precast concrete members.

3. Include in calculations compensation for deflections, consider all loads, forces and stresses to be imposed during casting and tensioning in order to construct the structure to proper lines and grades shown on the plans.

4. Include structural grade requirements for formwork and falsework materials.

E. Samples: As previously specified.
F. Certification:

1. Tendons:
   a. Certificates for each five reels or coils or fraction thereof.
   b. Applicable certificates to accompany each shipment of tendons.
   c. For each size of strand to be used in the work, submit test certificates showing physical, chemical and stress/strain test properties including modulus of elasticity and stating guaranteed minimum ultimate tensile and yield strength.
   d. With each sample of prestressing steel wires, bars or strands furnished for testing, submit certificate stating manufacturer’s minimum guaranteed ultimate tensile strength of sample furnished. Prior to installation submit certified test results from each manufacturer for each type of low-relaxation steel.

2. Hydraulic jacks: Certified calibration curves for each hydraulic jack.

G. Documentation:

1. Specified calculations.
2. Records of tendon elongation promptly upon completion of post-tensioning of each member.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Precast work to be performed by a PCI certified plant regularly engaged in design and construction or structural precast, prestressed concrete members with a minimum of 5 years experience.

2. Submit name, qualifications and evidence of 5 years experience on work comparable to that specified.

3. Fabricators of post-tensioning systems are to be members of the Post-Tensioning Institute (PTI) and are to have PTI certified facilities.

4. Do not commence work until Prestressor has been approved.

B. Sampling and Testing of Tendons:

1. Furnish samples for testing from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coil of prestressing steel wire and from each lot of anchorage assemblies and tendon couplers to be used.

2. Test tendons, anchorage assembly and coupler samples using approved ASTM test methods and other appropriate test methods required to demonstrate the values of properties specified.

3. Assign individual lot number to bars of each size from each mill heat, wire from each coil, and strand from each manufactured reel to be shipped to site and tag so that each lot can be accurately identified at job site. Identify each lot of anchorage assemblies and tendon couplers to be installed.

4. Unidentified prestressing steel, anchorage assemblies or bar couplers received at site will be rejected.

5. For prefabricated tendons, notify the Contracting Officer at least 10 working days prior to commencing installation of end fittings or heading of wires. The Contracting Officer will inspect end fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for testing of material shipped to the site.

6. Do not ship pre-fabricated tendons to the site until they are released by the Contracting Officer. Tag each tendon before shipment as specified.

7. Material released by the Contracting Officer will be rejected if subsequently damaged or found defective.

C. Testing Laboratory and Quality Control: In accordance with Section 01450, “Quality Control”, and Section 03300, “Cast-In-Place Concrete”.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Protect prestressing steel against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Physically damaged prestressing steel will be rejected. Rust or other corrosion will be cause for rejection. Any reel containing broken wires will be rejected.

B. Package prestressing steel in containers or shipping forms for protection against physical damage and corrosion during shipping and storage. Place corrosion inhibitor and rust preventive in package or form or use corrosion-inhibiting carrier-type packaging material. If approved, apply corrosion inhibitor directly to steel.

C. For tendons that will be in direct contact with concrete, use corrosion inhibitor which has no
deleterious effect on steel, concrete or bond strength of steel to concrete.

D. Replace or restore to original condition damaged packaging or forms.

E. Clearly mark shipping package or form with statement that package contains high-strength prestressing steel, and caution that care be used in handling. Show type, kind, amount, and placement date of corrosion inhibitor used. Include safety recommendations and instructions for use.

F. Store strand in a weatherproof enclosure. Mark each coil with order number, coil number, and heat number.

G. Provide strand that will lay straight with maximum deviation not exceeding 3 inch offset from theoretical centerline in any 5 feet in length.

H. Replace strand with sharp kinks or short radius bends.

I. When prestressing steel for post-tensioning is installed in members prior to placing and curing concrete, provide protection against rust or other corrosion, until grouted, by means of corrosion inhibitor placed in ducts or applied to steel in duct.

J. Protect prefabricated post-tensioning elements from moisture by taping or wrapping the ends and all openings in the conduit or by other acceptable means.

PART 2 - PRODUCTS

2.1 CONCRETE

A. In accordance with Section 03300, "Cast-In-Place Concrete", and Section 03305, "Portland Cement Concrete". Concrete mix design shall be S-3 with \( f'c = 5,000 \text{ psi} \) unless noted otherwise on the plans.

2.2 FORMWORK

A. In accordance with Section 03430, "Structural Precast Concrete".

2.3 TENDON GROUT

A. Material for tendon grout: Cementitious grout, compatible and non-corrosive to steel, free from calcium chloride.

   2. Sand: ASTM C144
   3. Water: Potable, clean, limits of injurious substances not to exceed:
      a. Nitrates: 13 parts per million.
      b. Sulfides: 00 parts per million.
      c. Sulfates: 15 parts per million.
      d. Chlorides: 20 parts per million.
   4. Expanding Admixtures: Provide 2 percent to 4 percent expansion.
   5. Water Content: Minimum necessary but not to exceed the water-cement ratio of 0.45, or approximately 5 gallons per 94 pound sack of cement.
   6. Pumpability: Determine in accordance with COE CRD-C 79-94. Efflux time of grout sample immediately after mixing not to be less than 11 seconds.
   7. Other use of pozzolans not permitted.

B. Alternate Material: Commercial cement-based grout mixture meeting the requirements of this specification, properly certified, subject to approval.

2.4 REINFORCEMENT

A. In accordance with Section 03200, "Concrete Reinforcement".

2.5 TENDONS, ANCHORAGE, COUPLERS, AND DUCTS

A. Tendons are defined as follows:

   1. For post-tensioned units, a tendon is each bar, each group of wires or each group of strands having common end anchorage.
   2. For pre-tensioned units, a tendon shall be each individual strand.

B. Pretensioning tendons:

   1. Steel strand: ASTM A416, Grade 270, regular or low-relaxation.
   2. Steel wire: ASTM A421.

C. Post-tensioning tendons:

   1. Strand as specified or shown for pretensioning either in single-strand units or in multiple-parallel-strand units, with wedge-type anchorages.

   2. Button heads to be cold formed symmetrically about axes of wires so that button develops minimum guaranteed ultimate tensile strength of wire. Use of cold-forming process that causes indentations in wire is prohibited.
3. Prestressing bars:
   a. Fabricated and processed in accordance with ASTM A722 and as specified.
   b. High-tensile-strength hot-rolled alloy steel, individually cold stretched and thermally stress-relieved to ensure uniform stress/strain characteristics and to obtain yield strength not less than 85 percent of required minimum guaranteed ultimate tensile strength.
   c. In accordance with the following minimum requirements:

<table>
<thead>
<tr>
<th></th>
<th>Regular Grade</th>
<th>Special Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate tensile strength</td>
<td>150,000psi</td>
<td>160,000 psi</td>
</tr>
<tr>
<td>Modulus of elasticity at 70% of manufacturer's minimum guaranteed ultimate strength</td>
<td>$29 \times 10^6$ psi</td>
<td>$30 \times 10^6$ psi</td>
</tr>
</tbody>
</table>

D. Anchorages and couplers:
   1. Steel anchorages and couplers compatible with particular installation. Anchorage devices to hold prestressing steel at load producing stress of not less than 95 percent of specified minimum ultimate tensile strength of prestressing steel. Anchorages with cut threads or notches are prohibited on prestressing steel. Fabricate stressing anchorages to provide adjustable seating loss. Ensure that each anchorage is capable of lift-off, detensioning and retensioning tendon at any time prior to grouting.

E. Ducts:
   1. Galvanized ferrous metal.
   2. Spiral corrugated plastic duct. ASTM F405 and made of high density polyethylene conforming to ASTM D3350 with cell classification PE 335433C or ASTM D1248, Type 3, Grade P34, Category 5.
   3. Strong enough to retain shape and resist damage during construction.
   5. Incapable of causing electrolytic action or deterioration in concrete.

6. Ensure that inside area of duct is at least two times the area of the enclosed prestressing steel.
7. Ensure capability of ducts to accommodate the anchorage system.
8. Equip ducts with fittings for injection of the grout, ports for venting, and drain holes at low points for draped tendons.
9. Pipes for grouting and for vent holes of 1/2 inch diameter metal or plastic. Fit pipes with positive mechanical shut-off valves capable of withstanding grouting pressures. Connect pipe to duct with structural fasteners, either metal or plastic. Tape connections with waterproof tape.
10. Ensure that couplers provide mortar-tight connection.

**PART 3 - EXECUTION**

3.1 GENERAL

A. The general requirements of Section 03300, "Cast-In-Place Concrete", govern for cast-in-place concrete box girder construction. Forms for cast-in-place concrete box girder construction shall conform to the requirements of this section and Section 03430, "Structural Precast Concrete".

3.2 JACKS

A. Furnish suitable jacks for stressing the tendons.
B. Equip each jack used to stress tendons with pressure gauge or load cell to determine jacking stress.
C. If pressure gauge is used, provide accurate, easily readable dial at least 6 inches in diameter. Calibrate each jack and its gauge as a unit with cylinder extension in approximate position in which it will be at final jacking force. Provide certified calibration chart as specified from an approved independent testing laboratory.
D. If inconsistencies occur between measured elongation and jack gauge reading, recalibrate gauge. If further discrepancies occur, determine cause and report to the Contracting Officer. Agreement within 5 percent will be satisfactory.
E. If load cell is used, calibrate and provide with indicator by means of which prestressing force in tendon may be determined. Ensure that range of load cell is such that lower 10 percent of manufacturer's rated capacity will not be used in determining jacking stress.
F. Provide independent system from which elongation can be measured to the nearest 1/16 inch.
3.3 INSTALLATION OF TENDONS AND DUCTS

A. Prior to stringing tendons and installing ducts, inspect bottom of forms for cleanliness and accuracy of alignment.

B. Accurately place and hold securely in place prestressing strand for pretensioned members and ducts for post-tensioned members during placing concrete.

C. String tendons singly or in multiples.

D. Splicing of wires or strands is prohibited.

E. Place tendons and ducts within tolerance of plus or minus 1/4 inch from locations shown on plans.

F. Cut length of each tendon between tendon vise and coil or reel.

G. Do not string tendons incorporating points previously gripped by tendon vises or wedges within lengths to be stressed. Do not use notched, nicked, pitted, rusted or otherwise damaged tendons.

3.4 PRETENSIONING

A. Provide tendon vises or wedges capable of anchoring stressing loads positively with a minimum of differential slippage. Have vises or wedges cleaned, lubricated and inspected between each use.

B. Discard grips which become visibly worn or distorted or which allow excessive slippage. Furnish full set of cleaned and inspected tendon vises or wedges before commencing each stressing operation. Ensure that vises and wedges are free of rust and physical damage.

C. After straight wire tendons have been positioned, apply initial force to each tendon to eliminate slack and to provide uniform initial stress condition in all tendons prior to final stressing. Initial force may be applied only by pressure jacks equipped with proper gauging system for measuring initial force.

D. The initial force shall be within 50 pounds or 2 percent of that required.

E. Strands shall be stressed as a group (multiple strand stressing) shall be brought to a uniform initial tension prior to full pretensioning.

F. Maintain records of elongation of each tendon and tension applied to each tendon.

G. Use load cells to calibrate load measuring devices and to check initial force on at least 10 percent of tendons.

H. Do not use elongation measurements as measure of initial stress. The initial force shall be measured by a dynamometer or other approved method, so that it can be used as a check against elongation as computed and measured.

I. Draped tendons shall be held in their draped positions by means of rollers, pins or other approved methods during jacking. Approved low-friction devices shall be used at points of change of slope of draped tendons.

J. Perform final stressing as shown on approved shop drawings.

K. When tendons have been final stressed, and approved, concrete shall be placed. Tendon stress shall be maintained between anchorages until concrete has reached the compressive strength of shown on the plans for release.

3.5 POST-TENSIONING

A. Post-tensioning forces shall not be applied until the concrete has attained the specified compressive strength shown on the plans as the required minimum concrete strength at post-tensioning.

B. Perform sequence and staging of post-tensioning in accordance with approved shop drawings.

C. Stress post-tensioned prestressing steel by means of hydraulic jacks equipped with accurately calibrated, easily readable hydraulic pressure gauges or load cells to permit reading stress in prestressing steel throughout stressing operation.

D. Anchor prestressing steel at initial stresses (transfer) calculated to result in final force shown. Initial stress not to exceed 70 percent of minimum ultimate tensile strength of prestressing steel at any point of tendon.

E. During jacking of prestressing steel, do not exceed 80 percent of the minimum guaranteed ultimate tensile strength of tendon.

F. Permanent force and permanent stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic shortening of concrete, relaxation of steel, thermal effects, losses in post-tension prestressing steel due to sequence of stressing, friction and take-up of anchorages, and all other losses peculiar to method or system of prestressing, have taken place or have been provide for.

G. Keep records of tension and elongation of each tendon at all stages and submit records as specified. Make readings of elongations to within plus or minus 1/32 inch when dial indicators are used, reading accuracy to be accordingly higher.

H. At the time of stressing first member of each type, check stresses in individual tendons and verify...
calculated frictional losses and seating losses to establish post-tensioning procedure and ensure uniform results.

I. Recheck may be directed, if it appears that stress shown is not being obtained.

J. Use approved tendon cutting tools for cutting prestressing steel after tensioning. Obtain written approval before capping post-tensioned anchorage.

K. Make accurate measurements of anchorage slippage losses at time of anchoring first tendon of each type of member and compare with assumed slippage losses. In case of deviation, detension tendon; repeat tensioning in accordance with special approved procedure or by shimming as necessary for particular system.

L. When necessary and approved, make adjustments to post-tensioning procedure to obtain required stresses.

M. Submit for approval proposed remedy for inconsistencies which occur between measured elongation and jack-gauge readings and which cannot be corrected by specified recalibration of gauge nor by lubrication of tendons. Replace tendon, if necessary.

N. Immediately after concreting, check ducts for obstructions by drawing cleaning device through them, by blowing through or by movement of tendon. Immediately prior to installation of tendons in ducts, demonstrate that ducts are free of water, debris, and other obstructions.

3.6 GROUTING

A. Immediately prior to grouting, remove the plug, clean ducts of foreign materials and remove any corrosion inhibitor by thoroughly flushing duct with water and dry by blowing.

1. After post-tensioning and anchoring of a tendon has been completed and accepted, the annular space between the prestressing steel and the duct shall be grouted.

2. Immediately after post-tensioning, a plug shall be inserted in each end to prevent entry of air and water until grouted.

3. Tendons shall be grouted within 48 hours after completion of post-tensioning.

B. Placing Grout:

1. Start grouting at the lowest injection point with all vent holes open.

2. Maintain pumping pressure through the pipe until grout is continuously wasted at the next vent hole, and until no visible slugs or other evidence of water or air are ejected, and the grout being ejected has the same consistency as the grout being injected.

3. Close vent, hold the pumping pressure for a number of seconds and then close injection port.

4. In the event one-way flow of grout cannot be maintained, or in the event of blockage or interruption of grouting, remove grout immediately from the duct by flushing with water.

5. Do not open shut-off valves serving as injection ports or vent ports until grout has taken its final set.

6. If temperature is anticipated to fall below 32 degrees F, prevent water from being entrapped in ungrouted ducts.

7. No grouting may be done when temperature of grout is below 45 degrees F.

8. Maintain the temperature of the concrete or surrounding air at 35 degrees F or higher from the time the grout is placed until the compressive strength of the grout, as determined from tests on 2 inch cubes cured under the same site conditions, exceeds 800 psi.

9. Do not grout when temperature of grout reaches or exceeds 90 degrees F. If necessary, mixing water may be chilled.

C. Mixing Grout: Mix grout as recommended by manufacturer, as tested and approved or for 1-1/2 minutes in high-speed mechanical mixer; pass through strainer into pumping equipment which has provision for recirculation. Begin pumping grout as soon as possible after mixing. Pumping may be continued as long as grout retains proper consistency.

1. When approved, finely ground aluminum powder or other gas evolving material which is well dispersed throughout the mixture, may be used to obtain a maximum of 4 percent unrestrained expansion of the grout.

2. Base proportions of materials on results of tests made on grout to achieve the following:

a. Water content: Minimum necessary for proper placement with a maximum 0.45 water-cement ratio, measured by weight.

b. Minimum 7-day compressive strength: 5,000 psi (average of 3 cubes) for 2 inch cubes molded, cured and tested in accordance with ASTM C109.
3. Grout shall be placed within 30 minutes of mixing.

4. Grout may not be retempered by adding water to modify consistency after the initial mixing procedure has been completed.

3.7 PROTECTION OF PRESTRESS ANCHORAGES

A. Within 14 days after tensioning and grouting is completed, exposed end anchorages, strands, and other metal accessories shall be cleaned of rust, misplaced mortar, grout, and other materials.

B. Coat the entire surface of the anchorage recess (all metal and concrete) with a uniform coating of an approved epoxy bonding compound.

C. Immediately following application of the epoxy bonding compound, tight-fitting forms shall be installed while epoxy is 'tacky' and the anchorage recess shall be filled with a non-shrink cement based grout.

D. The grout shall exhibit 0 percent shrinkage when tested in accordance with ASTM C827, and shall contain no aluminum powder, iron particles, chlorides, sulphides, fluorides or nitrates.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Precast Work: Structural precast and architectural precast members either pretensioned, post-tensioned, or combined pretensioned and post-tensioned are not measured for payment under this section. Measurement and payment will be under Section 03430, "Structural Precast Concrete", and Section 03450, "Architectural Precast Concrete".

B. Cast-in-place Prestressed Concrete:

1. Cast-in-place prestressed concrete members will not be measured for payment under this item, but will be measured by the cubic yard in accordance with Section 03300, "Cast-In-Place Concrete".

2. Prestressing steel for cast-in-place concrete will not be measured, but will be paid for at the lump sum price for "Prestressing Steel", for each bridge or structure, including wires, strands, and bars.

C. Ducts, grout fittings, grouting of ducts, anchorage, bearing plates, dowels, joint fillers, sealers, and stressing wires, strands, and bars will not be measured separately, but will be paid for under the various bid items for architectural precast concrete, structural precast prestressed concrete, and prestressing steel for cast-in-place concrete.

END OF SECTION 03365
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the requirements for the construction and erection of precast prestressed concrete bridge members in accordance with the plans. Structural precast concrete members shall include the following:

1. AASHTO Beams.
2. Double Tee Girders.
3. Single or Double Cell Box Girders.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO HB-17 - Standard Specification for Highway Bridges

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

5. ASTM A709/A709M - Standard Specification for Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges

C. Precast/Prestressed Concrete Institute (PCI):

1. PCI/CONCRT MNL 116 - Manual of Quality Control for Plants and Production of Precast and Prestressed Concrete Products

D. Texas Department of Transportation (TxDOT):

1. TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges.

1.3 SUBMITTALS

A. Shop Drawings: Have drawings and calculations for structural precast, prestressed members certified by a Professional Engineer licensed in the State of Texas. Include as a minimum, the following:

1. Location and layout of precaster's casting site for the precast members.
2. Details of form fabrication, profiles, reinforcing steel, inserts, lifting devices. Include adjustment capabilities of the forms and procedures for checking control points prior to start of casting.
4. Schedule of casting and curing sequence and method of handling and storing members and segments prior to shipping and erection.
5. Details for erection procedures for precast units sequence of erection and required handling equipment.
6. Design mix: Determine the mix proportions which shall conform to the strengths required. Perform work and tests required to substantiate the mix design. Include mix reports, material certificates and laboratory test reports.

B. Samples: As specified.

C. Certification: Certificates from concrete supplier as specified in Section 03300, "Cast-In-Place Concrete".

D. Certificates, required back up information, and testing data shall be dated within 6 months of submittal date.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Precast work to be performed by a PCI certified plant regularly engaged in design and construction or structural precast, prestressed concrete members with a minimum of 5 years experience.
2. Submit name, qualifications and evidence of 5 years experience on work comparable to that specified.
3. Do not commence work until fabricator (precastor) has been approved.
B. Sampling and Testing of Concrete:

1. Perform sampling, testing and frequency of testing in accordance with Section 03300, "Cast-In-Place Concrete", except as otherwise specified.

2. Mold three sets of at least two cylinders for each casting bed each day or for each 100 cubic yards of concrete or fraction thereof for each prestressed concrete structure. In any case, have at least six cylinders cast for each group of members cast from each batch.

3. Cure cylinders for stress transfer in same environment as members or structures they represent.

4. Test one set of cylinders for compressive strength at stress transfer, and one set of each on day 28.

5. The Contracting Officer may require testing of the concrete at any time during the fabrication operations.

C. Testing Laboratory and Quality Control: In accordance with Section 01450, "Quality Control", and Section 03300, "Cast-In-Place Concrete".

D. Comply with the requirements for mass concrete in Section 03300, "Cast-in-Place Concrete", for all structural precast concrete members except that the maximum allowable temperature of mass concrete shall not exceed 170 degrees F instead of 160 degrees F.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store and handle basic materials in accordance with Section 03300, "Cast-In-Place Concrete".

B. Avoid damaging surfaces, edges, and corners and creating stresses within units.

C. Handle and store precast structural members in upright position with points of support in approximately the same position as designated for final position in the structure.

D. Lift member with lifting devices as approved on shop drawings or by other methods approved by the Contracting Officer in writing.

E. Do not lift nor transport member until concrete has attained proper compression strength shown on the plans.

F. Mark all structural precast members with correct erection mark corresponding to that shown on the approved erection drawings.

G. Store precast prestressed members with adequate blocking so that warpage or cracking will not occur. Support fully across their width on battens not less than 4 inches wide.

H. Stack members in storage only with approval of Contracting Officer.

I. Keep precast units under cover and protected until installed.

PART 2 - PRODUCTS

2.1 CONCRETE

A. In accordance with Section 03300, "Cast-In-Place Concrete", and Section 03305, "Portland Cement Concrete". Concrete mix design shall be S-3, unless noted otherwise on the plans.

2.2 FORMWORK

A. Construct side and bottom forms for all structural precast prestressed concrete members with steel of sufficient thickness and adequate bracing and stiffeners to withstand forces due to placement and vibration of concrete.

B. Use wood for inside forms.

C. Forms shall be capable of accommodating block outs, openings and protrusions for post-tensioning. Forming system shall be capable of adjusting to changes in geometry and for correcting previous casting errors to prevent accumulation.

D. Treat forms with approved form oil or other bond breaking coating prior to placing concrete to facilitate stripping without damage to concrete. Material used shall not react or stain the concrete.

E. Forms shall be thoroughly cleaned prior to each casting operation, and shall be free from rust, grease, and other foreign materials.

2.3 REINFORCEMENT

A. In accordance with Section 03200, "Concrete Reinforcement".

2.4 TENDONS, ANCHORAGES, COUPLERS, AND DUCTS

A. In accordance with Section 03365, "Prestressed Concrete".

2.5 MISCELLANEOUS STEEL

A. Steel Plates and Shapes: Steel, ASTM A709, Grade as indicated on drawings.

B. Welded Headed Studs: ASTM A108, Grade 1015 or 1020, cold finished carbon steel headed studs.

D. Finish of Steel: Exposed galvanized per ASTM A153.

E. Bearing: In accordance with items 434 and 435 of the TxDOT Standard Specifications for Construction of Highways, Streets, and Bridges.

F. Dowels: As shown.

2.6 BIRD REPELLENT SYSTEM

A. Bird repellent system shall be Bird Spike 2000 manufactured by Bird-B-Gone, or as approved by the Authority. Repellent system shall be attached to interior sloping surfaces of AASHTO beams, prior to painting, using exterior grade construction adhesive (no mechanical fasteners) as recommended by the manufacturer. Limits of repellent system to be centered over sidewalks and path where shown on the drawings, 30 feet in length.

PART 3 - EXECUTION

3.1 FABRICATION

A. Forms:

1. Ensure that joints are smooth and tight to prevent leakage of mortar. Maintain accurate alignment of forms during casting operations. Check form alignment and grade for each casting.

2. Make provisions in form anchorage system for anticipated differential movements of beds and forms during casting and curing operations. In providing forms, ties, inserts, bulkheads and other accessories, use details of forms and anchor them so as to avoid any differential movement or loosening, but to enable movement without damage to members or forms. Ensure that bearing devices supporting prestressed members are free to rotate and that expansion bearings are free to translate during post-tension operation.

3. Clean beds and forms thoroughly before casting. Do not allow coatings for bond breakers to accumulate in bottoms of forms. For members to be cured by artificial heat, provide for ventilation of void forms.

4. In areas subject to freezing and thawing, make provisions for draining voids.

5. Treat surfaces in contact with concrete with effective bond breaker.

6. Prevent contamination of tendons by bond breaker, mud, grease or other detrimental substances.

7. Provide bolting fittings and welding plates for embedment in prestressed members to allow later attachment of conduits, pipes, boxes, and similar items.

B. Concrete:

1. Mixing and Placing: Mix concrete in accordance with the requirements of Section 03305, “Portland Cement Concrete”, with the following additional requirements:

   a. Do not use admixtures containing chlorides, fluorides, or nitrates.

   b. Use more than one admixture only if compatible with each other. If used, add separately during batching sequence.

   c. Placement of concrete: Section 03300, “Cast-In-Place Concrete”.

2. Sampling and Testing: Perform sampling and testing as specified.

3. Concrete Protection for Reinforcement: Section 03200, “Concrete Reinforcement”.

4. Consolidation of Concrete:

   a. Consolidate concrete by means of internal, external, or surface vibrators as approved and as follows:

      1) Use internal vibrators on sections that are sufficiently large to admit them.

      2) Use external vibrators on smaller sections produced by extrusion or slip-form method.

      3) Surface or screed vibrators may be used for flat slabs.

   b. Use vibrators having operating frequencies of at least 7,000 impulses per minute and higher frequencies if approved. Use vibrators only for consolidating, not for moving concrete along forms.

5. General Patching: Thoroughly clean and hammerpack holes left by tie rods, strand hold-down devices or other temporary inserts with stiff dry mortar made with same type of sand and cement used in concrete. In areas of tensile stress, bond hole patches with approved epoxy resin.

C. Curing: Keep structural precast members continuously wet until conclusion of curing period. Cure by covering with burlap or jute mats kept
continuously wet, by moist air, by live steam, or combination.

1. **Wet Mat Method**: Secure mats, sheets, or blankets to provide continuous contact with all concrete surfaces.
   a. Enclose surfaces not in direct contact with mats, adequately anchored, so that outside air cannot enter the enclosure.
   b. Keep mats wet and air inside enclosure sufficiently moist to maintain all the surfaces wet for the required curing time.

2. **Water Spray Method**: Use overlapping spray or sprinkles to keep concrete surfaces continuously wet.

3. **Steam Method**: Do not commence steam curing for a minimum present time of 3 hours after placing concrete, except if ambient temperature is below 50 degrees F, whereby apply steam at a rate sufficient to keep surrounding air at temperature between 50 degrees F and 70 degrees F.
   a. Provide an unobstructed air space of not less than six inches between concrete surfaces and the steam jacket.
   b. After preset time, apply steam at a rate not to increase temperature of air surrounding the member more than 40 degrees F per hour.
   c. Do not exceed maximum curing temperature of 160 degrees F. Concrete exposed to temperatures exceeding 180 degrees F will be cause for rejection.
   d. Do not fluctuate temperatures within enclosure or at adjacent locations within enclosure by more than 30 degrees F.
   e. Furnish and have available two portable recording thermometers, capable of automatically producing a temperature record during entire curing period. Record temperatures at every 15 minutes.
   f. Steam outlets shall not impinge directly against the concrete surfaces.
   g. Continue curing until required strength for transfer of load as shown on plans, have been developed and until detensioning has been performed.
   h. Reduce temperature inside chamber, after expiration of curing period, at a reduction rate of not more than 40 degrees F per hour until temperature is within 20 degrees F of air outside enclosure.

D. **Finishes**: Surface finish in accordance with Section 03300, "Cast-In-Place Concrete", except as modified herein.
   1. Do not repair cracks in members scheduled for post-tensioning prior to final post-tensioning.
   2. Screed or rough float top surfaces of prestressed concrete girders, if scheduled for embedment into cast-in-place concrete. At the approximate time of initial set, the surface shall be roughened by brushing, brooming or other approved methods.

E. Fabricate units in number and sizes shown and specified. Prestress as required in accordance with Section 03365, "Prestressed Concrete".

F. Deliver units to site in compliance with erection schedule.

G. Fabricate structural precast, prestressed units within the dimensional tolerances and levels of workmanship specified in Item 424 of the TxDOT Standard Specifications for Construction of Highways, Streets and Bridges.

3.2 **DEFECTIVE AND DAMAGED CONCRETE UNITS**

A. Diagonal cracks indicating torsion damage, longitudinal cracks following stressing tendons, cracks extending to plane of reinforcement, spalls, concrete breakage, and honeycombs are subject to structural review by the Contracting Officer prior to acceptance.

B. Any defects, damage, cracks, breakage or spalls in any fabricated precast unit shall be subject to review by the Contracting Officer as to repairability and shall be cause for rejection if so deemed by the Contracting Officer.

C. Repair of concrete units shall be in conformance with Section 03905 “Concrete Repair and Restoration”.

3.3 **HANDLING, STORING, HAULING, AND ERECTION**

A. Handle, lift, support, and erect structural precast members with utmost care so as to prevent damage or overstressing.

B. Handle members in accordance with details, and at points, as shown on the approved shop drawings and erection plan.
C. Move no member from casting yard until all requirements for tensioning (when specified), curing and strength requirements have been attained.

D. Erect and position members in structure properly leveled, aligned and braced as required until diaphragms are in place for lateral stability.

E. Fill erection holes with mortar made flush with surrounding concrete.

F. For requirements related to post-tensioning, if required, refer to Section 03365, “Prestressed Concrete”.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.1 MEASUREMENT**

A. Structural precast prestressed concrete girders, double tee girders, and box girders described in this section will be measured and paid for at the unit price per linear foot per type specified.

B. The unit prices for precast prestressed concrete girders, double tee girders and box girders will include full compensation for manufacturing the members; furnishing and tensioning the prestressing steel (pretensioning and post-tensioning, as required); furnishing and placing reinforcing steel and structural concrete; bearing plates and pads; grouting of holes and repairs as required; temporary work; and transporting and erecting the bridge or structure, complete-in-place.

C. Cast-In-place post-tensioned concrete units including box girders, etc., will not be measured under this section. Refer to Sections 03365, “Prestressed Concrete”, and 03300, “Cast-In-Place Concrete”. Miscellaneous incidentals such as those mentioned in Section 03365, “Prestressed Concrete”, Part 4, will not be measured for payment.

END OF SECTION 03430
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the fabrication and installation of precast concrete for building walls, sound barriers, wall panels, and other precast concrete building elements designated as Architectural Precast Concrete.

1.2 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. ACI SP-66 - ACI Detailing Manual
2. ACI 308.1 - Standard Specification for Curing Concrete
3. ACI 318/318R - Building Code Requirements for Structural Concrete (ACI 318) and Commentary (ACI 318R)

B. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code - Steel
2. AWS D1.4 - Structural Welding Code - Reinforcing Steel

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

5. ASTM A193/A193M - Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
7. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

D. Concrete Reinforcing Steel Institute (CRSI):

1. CRSI DA4 - Manual of Standard Practice

E. Precast/Prestressed Concrete Institute (PCI):

1. PCI/CONCRT MNL-116 - Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products
2. PCI/CONCRT MNL-117 - Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products
3. PCI/CONCRT MNL-119 - Drafting Handbook - Precast and Prestressed Concrete
4. PCI/CONCRT MNL-122 - Architectural Precast Concrete

1.3 SUBMITTALS

A. Shop Drawings:

1. Prepare drawings in accordance with PCI/CONCRT MNL-119, ACI SP66 and CRSI DA4. Take and include field verified dimensions, details of form fabrication, profiles, joints, reinforcing steel, clips, anchors, inserts, reglets, lifting devices, openings, electrical and structural embedded items, connection to other work and placement, and erection sequence. Shop drawings shall be prepared, sealed and signed by a Professional Engineer.

8. ASTM A884/A884M - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement
9. ASTM C33 - Standard Specification for Concrete Aggregates
10. ASTM C94 - Standard Specification for Ready-Mixed Concrete
11. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete
12. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete
13. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
14. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete
2. Prior to installation of units, submit schedule indicating sequence of installation, joints, support and bracing systems, and anchoring system.

3. Design Calculations: Submit complete calculations for the design of precast units and precast connections 60 days prior to start of precast fabrication. Do not proceed with fabrication of units until notified in writing that the Contracting Officer has completed review of calculations and approved the submittal.

4. Design mix: Submit concrete mix to comply with product requirement of this section: Part 2 - PRODUCTS.

B. Product Data: Submit manufacturer’s product data and specifications, with application and installation instructions for manufactured materials and products. Include concrete mix reports, material certificates and laboratory test reports as specified in Section 03300, “Cast-In-Place Concrete”.

C. Samples:
   1. Panels representing color, texture and general finish of test units and production panels, each 12 inches square by 1-1/2 inches thick: Submit two samples prior to fabrication.
   2. Gasket and flashing materials proposed for use: Submit two, each 12 inches long.

D. Job Mock-Up: After acceptance of material samples, construct full-size sample of each required architectural precast concrete unit for Contracting Officer’s inspection at production plant or on site prior to start of installation work. Include representative items encountered in work, per Contracting Officer’s directive. Cast, finish, cure, and erect job mock-up panel in same manner as will be employed in work. Acceptable full-size samples may be incorporated in job installation.

1.4 QUALITY ASSURANCE

A. Qualifications:
   1. Fabricator Qualifications: Firms which have a minimum of 5 years successful experience in the fabrication of Architectural Precast Concrete units, similar to units required for this project, will be acceptable. Fabricator must have sufficient production capacity to produce, transport, and deliver required units without causing delay in the work.

2. Qualifications of Erector: Firms which have a minimum of 2 years successful experience in the erection of Architectural Precast Concrete units, similar to units required for this project, will be acceptable.

B. Certifications:
   1. Fire-Resistance Rated Precast Units: Where precast concrete units are shown or scheduled as requiring fire-resistance classification, provide units tested and listed by UL in “Fire Resistance Directory”, or with each unit bearing UL label and marking.
   2. Certificate of Conformance: Provide written certification that all material, shipped or used and shown on invoices for this project, including chemical test results for mills, meets the contract requirements.
   3. Concrete Testing: Requirements for testing laboratories, and sampling and testing to demonstrate compliance with specified properties, are as specified in Section 03300, “Cast-In-Place Concrete”, and Section 01450, “Quality Control”.
   4. Precast Unit Design: The precast units have been proportioned to resist in-place service loading conditions only. Using the services of a Professional Engineer, licensed in the State of Texas and experienced in providing engineering services that resulted in successful installation of precast concrete units similar in material, design and extent as required by this Project, analyze the units for stresses resulting from fabrication, handling, shipping, storage, erection, connection to the supporting structure and temperature changes, and select concrete strength, reinforcement, and lifting devices and procedures necessary to provide precast units conforming to requirements shown and specified. Maintain general design concept shown without increasing or decreasing sizes of members or altering profiles and alignment shown. Provide complete design calculations and drawings prepared, sealed and signed by the Professional Engineer.
   5. Precast Connections: Design Modifications to connection configurations shown may be made only as necessary to meet field conditions and to ensure proper fitting of the work, and only as acceptable to Contracting Officer. Precast connections have been shown on the drawings indicate general types acceptable and locations of connections. Using the services of a Professional Engineer, licensed in the State of Texas, analyze and design the
connections and anchorage for dead load, service load and temperature stresses. Where possible, provide mechanical fasteners to minimize field welding; where field welding is necessary, conform to the AWS D1.1/D1.1M qualification requirements. Provide complete design calculations and drawings prepared, sealed and signed by the Professional Engineer.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store and handle basic materials in accordance with Section 03300, "Cast-In-Place Concrete".

B. Avoid damaging surfaces, edges, and corners and creating of stresses within units.

C. Keep units under cover and protected until installed.

D. Lift and support units only at designated lifting or supporting points as shown on final shop drawings. Verify that sealers used to protect precast concrete units prior to erection are compatible with caulking and painting requirements.

E. Deliver anchorage items, which are to be embedded in other construction before the start of such work. Provide setting diagrams, templates, instructions and directions as required for installation.

PART 2 - PRODUCTS

2.1 CONCRETE

A. In accordance with Section 03300, "Cast-In-Place Concrete", except as modified in this section.

B. Mix Designs: Establish mix designs to produce specified appearances and that have qualities as follows:

1. $f'c = 5000$ psi; minimum; normal weight aggregates; coarse aggregates size to meet requirements of ACI 318/318R and specified appearance; air entrainment must be in accordance with ACI 318/318R.

2. Portland Cement:
   a. ASTM C150, Type I, II or III.
   b. Use only one brand, type, and source of supply of cement throughout production, unless noted otherwise.
   c. Use white Portland cement with concrete pigment for concrete mix as necessary to match Contracting Officer approved sample.

3. Aggregates:
   a. Sand to conform with ASTM C144 passing through No. 16. sieve of washed and dried silica or other acceptable material with successful use in production.
   b. Aggregate used in precast concrete units shall conform to ASTM C33 and match in size (not to exceed 5/8 inch), color, texture, and aggregate exposure to that used in the Contracting Officer approved sample.


5. Admixtures: Conform to ASTM C260 for air entrainment, ASTM C494/C494M for chemical admixtures, or ASTM C618 for fly ash or natural pozzolan admixtures; at manufacturer's option. Do not use admixtures that contain more than 0.1 percent chloride ions.

6. Coloring Agent:
   a. Conform to ASTM C979; ultraviolet and alkali resistant; high-temperature stable; harmless to concrete set or strength.
   b. Match color to that of Contracting Officer's control sample.
   c. The amount of coloring agent shall not exceed 10 percent of the cement weight.

C. Batching and Mixing:

1. In accordance with PCI/CONCRTMNL-117.

2. Use ready-mix concrete in accordance with ASTM C94 unless otherwise approved in writing by the Contracting Officer.

2.2 FORMWORK

A. Materials and construction to conform with PCI/CONCRTMNL-117.
ARCHITECTURAL PRECAST CONCRETE

B. Unless otherwise approved in writing, use one of the following form facing materials.
   1. Fibrous-glass-reinforced plastic.
   2. Steel.
C. Use forms which produce units without visible joint marks.
D. Use form liners as required to produce patterns or textures shown and specified.

2.3 REINFORCEMENT
A. In accordance with Section 03200, "Concrete Reinforcement"; welded wire fabric ASTM A884/A884M, epoxy coated.
B. Conform to requirements in Section 03365, "Prestressed Concrete", for prestressed concrete.

2.4 BEARING PADS AND SHIMS
A. Elastomeric Bearing Pads:
   1. Preformed resilient pads of specified uniform thickness (plus 15 percent) composed of a homogeneous blend of rubber elastomer and high-strength random synthetic fiber cords cured together to form a durable material with uniform behavior in all directions and suitable to support structural loads. Provide pads with required dimensions for proper load transfer and of enough thickness to accommodate not less than 0.01 radians rotation of support member. Increase pad plan dimensions when necessary in order to withstand anticipated loads without exceeding a compressive strain of 30 percent.
   2. Provide finished pads which have a Shore A Durometer hardness of 75 (plus 5), a shear modulus of 265 (plus 80) psi, an ultimate compressive strength of 8000 psi minimum, an initial tensile strength of 900 psi minimum and an initial tear strength of 400 lbs./inch minimum.
B. Bearing Shims: Multipolymer plastic; chemically inert, weatherproof, non-staining, 2500 psi minimum allowable bearing pressure; sized for dead and live loads prior to grouting.

2.5 MISCELLANEOUS STEEL
A. Anchors, Dowels, Shims, and Accessories Cast Into Precast Units: Steel, ASTM A36/A36M, hot-dip galvanized, ASTM A153/A153M.
B. Welded Headed Studs: ASTM A108, Grade 1015 or 1020 Cold finished carbon steel headed studs.

2.6 JOINT CONNECTIONS
A. Stainless Steel, ASTM A666, where subject to uncontrolled environment or weather.
B. ASTM A36/A36M where connection is totally within an interior environment controlled for human comfort.
C. Bolts: Stainless steel, ASTM A193/A193M where connections are stainless steel and ASTM A307 bolts where ASTM A36/A36M steel is used.

2.7 STRUCTURAL NON-SHRINK GROUT
A. As specified in Section 03300, "Cast-In-Place Concrete".

2.8 FLASHING REGLETS
A. Stainless steel ASTM A167, Type 302, soft temper minimum 0.011 inch thick; open type having continuous groove not less than 1-1/8 inch deep by 3/16 inch wide opening and sloped upwards at 45 degrees, unless otherwise shown. Furnish with easily removable filler strip.

2.9 FABRICATION
A. Formwork:
   1. Accurately construct forms, mortar-tight, and of sufficient strength to withstand pressures due to concrete placing operations, temperature changes, and prestressed pretensioning and detensioning operations. Maintain formwork to provide completed precast concrete units of shapes, lines and dimensions indicated, within specified fabrication tolerances.
   2. Unless forms for prestressed concrete units are stripped prior to detensioning, design forms so that stresses are not induced in precast units due to deformation of concrete under prestress or to movement during detensioning.
B. Built-In Items: Provide reglets, slots, holes, and other accessories in units to receive windows, dowels, reglets, waterstops, flashings, and other similar work as indicated. Cast in structural inserts, bolts, and plates as shown. Cast in electrical embeds specified and shown. At all lifting and handling
embeds, provide hairpin reinforcing as required by analysis.

C. Anchorages: Provide loose steel plates, clip angles, seat angles, anchors, dowels, hangers, and other miscellaneous steel shapes not provided by other trades, necessary for securing precast units to supporting and adjacent members.

D. Pretensioning: Pretensioning of tendons for prestressed concrete may be accomplished either by single-strand tensioning method or multiple-strand tensioning method. Comply with PCI/CONCRT MNL-116 requirements and Section 03365, "Prestressed Concrete".

E. Fabricate Units complying with manufacturing procedures and dimensional tolerances of PCI/CONCRT MNL-117. Provide number and finished sizes of units shown and specified to match approved sample units. Precast units that are warped, cracked, broken, spalled, stained, or otherwise defective will not be accepted.

F. Surface Finishes: Provide exposed surface finishes for precast units as shown or specified:
   1. Abrasive Blast Finish: Use abrasive grit, equipment, application techniques and cleaning to expose aggregate and surrounding matrix surfaces, to match approved control samples designated as light, medium or heavy.
   2. Exposed Aggregate Brush Finish: Use washing and brushing procedures to match approved control sample.
   3. Smooth Surface Finish: Finish free of pockets, sand streaks, and honeycomb, with uniform color and texture to match approved control sample.
   4. Textured Surface Finish: Finish imparted by form liners or inserts. Provide surfaces free of pockets, streaks and honeycomb, with uniform color and texture to match approved control sample.
   5. Formed or float finish for unexposed surfaces.

G. Curing: Do not apply liquid membrane curing compounds to surfaces which will be sealed or painted. Follow specifications in ACI 308.1 and recommendations in PCI/CONCRT MNL-117.

2.10 QUALITY CONTROL

A. Fabricate precast units complying with manufacturing and testing procedures, quality control recommendations, and following dimensional tolerances, unless otherwise indicated.

B. Accurately construct forms mortar-tight of rigid materials that will result in finished units conforming to profiles, lines, and dimensional tolerances indicated, within specified fabrication tolerances.

C. Dimensional Tolerances of Finished Units: Overall height and width measured at face adjacent to mold at time of casting:
   1. Length, width, and height of unit: Plus or minus 1/16 inch.
   2. Angular deviation of plane of mold: 1/16 inch total.
   3. Out of Square (difference in length of two diagonal measurements): 1/8 inch.
   4. Skin Thickness: Plus 1/4 inch or minus 0.
   5. Architectural Facing Thickness, if required: Plus 1/16 inch or minus 0, plus domes.
   6. Tolerances of other dimensions not otherwise indicated: Plus or minus 1/16 inch.

D. Fabricate units straight, smooth, and true to size and shape, with exposed edges and corners precise and square unless otherwise indicated.

E. Units that are warped, cracked, broken, spalled, stained, or otherwise defective will not be acceptable.

F. Fabricate units and provide exposed surface finishes to match the Contracting Officer's control sample.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions under which precast work is to be installed, and make provisions for the proper and timely completion of work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 DEFECTIVE AND DAMAGED CONCRETE UNITS

A. Do not install units with surface imperfections such as air bubbles, joint lines, stains, uneven matrix plane, and uneven exposure of aggregate.

B. Do not install units which are warped, cracked, broken, spalled, stained, or otherwise defective.
3.3 INSTALLATION

A. General: Deliver anchorage items which are to be embedded in other construction before start of such work. Provide setting diagrams, templates, instructions, and directions as required for installation.

1. Do not install precast units until concrete has attained its design compressive strength.

2. Install precast concrete members plumb, level, and in alignment within PCI/CONCRT MNL-117 standard tolerances. Provide temporary supports and bracing as required to maintain position, stability, and alignment until members are permanently connected. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.

3. Install precast concrete units so that the joints between units meet the following:
   a. Face width of joints: plus or minus 1/16 inch.
   b. Joint taper: 1/16 inch maximum.
   c. Jog in alignment of finished surfaces: 1/16 inch maximum.
   d. Variation from level: run plus or minus 1/4 inch in any 20 feet.
   e. Variation from plumb: plus or minus 3/8 inch in 20 feet.

B. Accessories: Install clips, hangers, and other accessories required for erection of precast units to supporting members and back-up materials.

C. Connections:

1. Anchor units in final position by bolting, welding, grouting, or as otherwise indicated. Remove temporary shims, wedges, and spacers as soon as possible after anchoring is completed.
   a. At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.
   b. At welded connections, apply rust-inhibitive coating on damaged areas, same as shop-applied material. Use galvanizing repair coating on damaged galvanized surfaces.
   c. All welds shall be of sound construction; free from porosity slag inclusions, undercutting and other defects shall be of clean and regular appearance.

2. After precast concrete units are in place, remove all temporary lifting and handling devices cast into the concrete unless protectively treated and acceptable to the Contracting Officer. Do not torch cut connected anchors and clips. Patch holes with cement and sand mortar which will blend with the finished surface in texture and color.

D. Cleaning: Clean exposed facings to remove dirt and stains which may be on units after erection and completion of joint treatments. Wash and rinse in accordance with precast manufacturer's recommendations. Protect other work from damage due to cleaning operations. Do not use cleaning materials or processes which could change the character of exposed concrete finishes or joint sealants.

3.4 PERFORMANCE REQUIREMENTS

A. Conduct inspections and make repairs or replace unsatisfactory precast units as required.

1. Develop procedures and techniques for repair and corrective work to precast concrete units during the early steps of production.

2. Modify concrete proportions and blends of cement or ratio of aggregate to cement to provide an appearance of repair area that matches the remaining surfaces of the precast concrete units. Do not implement repair methods until approved by the Contracting Officer.

3. Limitations as to amount of repairs which will be permitted is subject to acceptance of Contracting Officer.

4. Make repairs to match texture and color of adjacent finished surfaces to the satisfaction of the Contracting Officer.

5. Cure and finish repair area in accordance with approved procedures.

B. In-place Precast units may be rejected for any one of the following:

1. Do not match job mock-up.

2. Exceeding specified installation tolerances.
3. Damaged during construction operations.

4. Exposed-to-view surfaces which develop surface finish deficiencies.

5. Other defects as listed in PCI/CONCRTMNL-117.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Architectural Precast Concrete described in this section will be paid for on a lump sum basis wherein no measurement will be made.

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SECTION 03462
GLASS FIBER REINFORCED CONCRETE WARNING STRIPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the procurement, handling and installation of glass fiber reinforced concrete (GFRC) warning strips.

B. The precast glass fiber reinforced concrete warning strip shall consist of glass fibers, aggregate, Portland cement, embedded hardware, and other miscellaneous anchors and accessories necessary for complete installation field modifications or additional materials.

1.2 REFERENCE STANDARDS

A. Americans with Disabilities Act Accessibility Guidelines (ADAAG).

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

2. ASTM C33 - Standard Specification for Concrete Aggregates

3. ASTM C39 - Standard Specification for Compressive Strength of Face Mix

4. ASTM C136 - Standard Sieve Analysis of Sand for Backing

5. ASTM C138 - Standard Specification for Slurry Unit Weight


8. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete

9. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete

10. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

11. ASTM C947 - Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)

12. ASTM C1028 - Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method

C. Precast/Prestressed Concrete Institute (PCI):

1. PCI/CONCRT MNL-117 - Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products

2. PCI/CONCRT MNL-128 - Recommended Practice for Glass Fiber Reinforced Concrete Panels

D. Texas Accessibility Standards (TAS).

1.3 SUBMITTALS

A. Product Data:

1. Submit manufacturer's product data and specifications, with application and installation instructions for manufactured materials and products. Include concrete mix reports, material certificates and laboratory test reports as specified in Section 01450, "Quality Control".

2. Include water absorption test reports.

B. Shop Drawings:

1. Submit shop drawings prepared by or under supervision of a Professional Engineer licensed in the State of Texas showing complete information for fabrication of glass fiber reinforced concrete warning strip units. Indicate unit dimensions and cross-sections, fabrication tolerances, location, size, and type of reinforcement, including any special reinforcement and lifting devices necessary for handling.

2. Shop drawings are to be sealed and signed by the Professional Engineer.

3. Detail inserts, connections, and joints, including accessories and construction at openings in glass fiber reinforced concrete units.

4. Show location and details of anchorage devices to be embedded in or connected to other construction.

5. Submit design mix for approval prior to fabrication of samples.
C. Samples: Submit three samples, approximately 12 inches by 12 inches to illustrate typical range of color, pattern, and texture and of appropriate thickness; these are to be submitted prior to fabrication of project glass fiber reinforced concrete warning strip units.

D. Mock Ups: Submit two units 2 feet wide by 2 feet 6 inches long for use as a field performance mock-up. Provided the product meets the testing criteria outlined in Paragraph 1.2 of this specification section, units will be installed in a location to be determined by the Contracting Officer.

1.4 QUALITY ASSURANCE

A. Engineer Qualifications: The engineering work for this specification section shall be done by or under the supervision of a Professional Engineer registered to practice in the State of Texas, and experienced in providing engineering services that have resulted in successful installation of glass fiber reinforced concrete units similar in material, design, and extent as required for this Project. Comply with procedures in PCI/CONCRT MNL-117.

B. Manufacturer Qualifications: Firms which have a minimum of 5 years successful uninterrupted production experience in the fabrication of glass fiber reinforced concrete units, similar to units required for this Project, will be acceptable. Manufacturer must have sufficient production capacity to produce, transport, and deliver required units without causing delay in the work. The GFRC Manufacturing plant shall be certified by the Prestressed Concrete Institute's Plant Certification Program, prior to bid date.

C. Testing Laboratory and Quality Control: In accordance with Section 01450, "Quality Control". Testing shall be in accordance with ASTM C94 - as modified by PCI/CONCRT MNL-128.

D. The following testing shall be required in accordance with ASTM C241, C947 and C1028 and PCI/CONCRT MNL-128 and MNL-117:

1. Flexural yield strength.
2. Flexural ultimate strength.
3. Slurry unit weight test.
4. Slurry slump test.
5. Aggregate gradation testing.

E. Tolerances: Manufacture GFRC panels so that tolerances for dimensions and appearance shall be as indicated in PCI/CONCRT MNL-128 and PCI/CONCRT MNL-117.

F. Records: Keep quality control records available for two years after final acceptance.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver glass fiber reinforced concrete warning strip units to Worksite in such quantities and at such times to assure continuity of installation. Handle and transport units in a position consistent with their shape and design in order to avoid excessive stresses or damage.

B. Store units at Worksite to prevent cracking, distorting, warping, staining, or other physical damage and so that markings are visible. Lift and support units only at designated lifting or supporting points as shown on final shop drawings.

C. Keep units under cover and protected until installed.

D. Deliver anchorages items which are to be embedded in other construction before the start of such work. Provide setting diagrams, templates, and directions as required for installation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are "acceptable" only if manufacturer can evidence product compliance with requirements of Contract Documents.

1. GFRC Cladding Systems, Inc.
2. GFRC Specialties
3. Hand and Spirit, Inc.

2.2 GLASS FIBER REINFORCED CONCRETE (GFRC) MATERIALS

A. Portland Cement:

1. ASTM C150, Type I.
2. Use only one brand, type, and source of supply of cement throughout GFRC production, unless noted otherwise.
3. Use colored Portland cement with concrete pigment for concrete mix as necessary to match Contracting Officer's GFRC concrete warning strip control sample.

B. Aggregates:

1. Sand to conform with ASTM C144 passing through No. 16. sieve of washed and dried
GLASS FIBER REINFORCED CONCRETE WARNING STRIPS

2. Aggregate used in GFRC units shall conform to ASTM C33 and match in size (not to exceed 1/2 inch), color, texture, and aggregate exposure to that used in the Contracting Officer's GFRC warning strip control sample.

C. Water: Drinkable, free from foreign materials in amounts harmful to concrete and embedded steel.

D. Admixtures: Conform to ASTM C260 for air entrainment, ASTM C494/C494M for chemical admixtures, or ASTM C618 for fly ash or natural pozzolan admixtures at manufacturer's option. Do not use admixtures that contain more than 0.1 percent chloride ions.

E. Coloring Agent:
   1. Conform to ASTM C979; ultraviolet and alkali resistant; high-temperature stable; harmless to concrete set or strength.
   2. Match color to that of Contracting Officer's GFRC warning strip control sample.
   3. The amount of coloring agent shall not exceed 10 percent of the cement weight.

F. Glass Fiber: Specifically designed for compatibility with aggressive alkaline environment of Portland cement-based composites, complying with PCI/CONCRTMNL-117 and PCI/CONCRTMNL-128.

G. Forms: Provide forms consisting of a form-facing material of metal, plastic, rubber, high density wood, or other acceptable material that is non-reactive with concrete and will produce required finish surfaces. Use forms that do not require a release agent to prevent reaction with sealants.

H. Anchors and Subsystems:
   1. Stainless steel anchors and other attachment and connection materials: AISI Type 302/304, ASTM A666.
   2. Each GFRC unit is to be attached to the supporting concrete with a minimum of two anchors in the top horizontal plane (one anchor for every 2.5 SF of surface) and at uniform spacing.
   3. Weepholes Tubes: In accordance with Section 04100, "Mortar, Grout and Masonry Accessories".

2.3 FABRICATION

A. Fabricate GFRC warning strip units complying with manufacturing and testing procedures, quality control recommendations, and following dimensional tolerances, unless otherwise indicated.

B. Accurately construct forms mortar-tight of rigid materials that will result in finished GFRC warning strip units conforming to profiles, lines, and dimensional tolerances indicated, within specified fabrication tolerances.

C. Dimensional Tolerances of Finished Units: Overall height and width measured at face adjacent to mold at time of casting:
   1. Length and width of unit: Plus or minus 1/16 inch.
   2. Angular deviation of plane of mold: 1/16 inch total.
   3. Out of Square (difference in length of two diagonal measurements): 1/16 inch.
   4. Skin Thickness: Plus 1/4 inch or minus 0.
   5. Architectural Facing Thickness: Plus 1/8 inch or minus 0.
   6. Tolerances of other dimensions not otherwise indicated: Plus or minus 1/16 inch.

D. Fabricate units straight, smooth, and true to size and shape, with exposed edges and corners precise and square unless otherwise indicated.

E. GFRC concrete warning strip units that are warped, cracked, broken, spalled, stained, or otherwise defective will not be acceptable.

F. Provide loose stainless steel pins, anchors, and other miscellaneous anchors not provided by other trades, necessary for securing GFRC warning strip units to supporting and adjacent members.

G. Fabricate GFRC warning strip units and provide exposed surface finishes to match the Contracting Officer's control sample.

H. Curing: Ensure sufficient strength for removing units from form.
   1. After initial curing, remove panel from form and place in a controlled curing environment. Keep panels continuously moist for minimum 7 days in accordance with manufacturer's standard curing practice. Maintain temperature between 60 deg. F and 120 deg. F during this period.
2. Acrylic thermoplastic copolymer dispersion may be used as a curing admixture in lieu of moist curing. Use only copolymers shown to eliminate need for moist curing through published independent laboratory test data and in accordance with specifications in Appendix F of PCI/CONCRT MNL-128. Verify compatibility of alternate curing agent with sealant.

I. Mark each GFRC warning strip unit to correspond to identification mark on shop drawings. Mark each panel with casting date.

J. Source Quality Control: Establish a quality control program for manufacturing GFRC panels to monitor glass content, spray rate, unit rate of slurry, product physical properties, and shear strengths, curing period and conditions, flexural yield strength, and flexural ultimate strength in accordance with PCI/CONCRT MNL-117.

K. The GFRC panels shall meet or exceed the following requirements when dry tested:

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Ultimate Strength</td>
<td>2500 psi</td>
</tr>
<tr>
<td>Flexural Yield Strength</td>
<td>1500 psi</td>
</tr>
<tr>
<td>Tensile Ultimate Strength</td>
<td>1300 psi</td>
</tr>
<tr>
<td>Ultimate Compressive Strength</td>
<td>9000 psi</td>
</tr>
<tr>
<td>Glass Fiber Content</td>
<td>4.5 - 6% by weight</td>
</tr>
</tbody>
</table>

L. GFRC Skin: In no case shall the panel skin be less than 1 inch thick. Backup mixes shall have the same proportion of pigments as face mixes to eliminate the possibility of bleeding through a different colored backup.

M. Provide detectable warning pattern on walking surface of units to comply with ADAAG and TAS. Match Contracting Officer’s sample for color and pattern.

N. Architectural facing, if required, shall be no less than 1 1/8 inches thick, excluding detectable warning dome.

2.4 MORTAR SETTING BED

A. General: The GFRC manufacturer shall verify the compatibility of the mortar bed with the composition of the GFRC design mix. A three part mortar setting bed shall be used to adhere the GFRC warning strip units to the concrete grade beams.


C. Expansion Control: Provide expansion (sealant) joints between GFRC units as recommended by the mortar setting bed requirements at intervals not to exceed 20 feet on center. Joint design shall conform to Tile Council of America (TCA) Detail EJ 171.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine the areas and conditions under which GFRC units are to be installed, and make provisions for the proper and timely completion of work. Do not proceed with the work until unsatisfactory conditions have been corrected.

B. Provide and check setting diagrams, templates, instructions, and directions of embedded anchors as required for installation. Drill holes in the platform surface in which the GFRC will be installed at the proper template location. Check location of holes prior to drilling on each panel. Drilled holes shall be 1/2 inch larger than anchor diameter.

C. Do not install glass fiber reinforced concrete warning strip units until supporting concrete has attained minimum allowable design compressive strength.

D. Install GFRC warning strip units at true plane per contract drawings, and in alignment within PCI/CONCRT MNL-117 and specified limits of installation tolerances. Provide temporary supports, spacers, and bracing as required to maintain position, stability, and alignment as units are being permanently installed.
E. Maintain a perpendicular joint alignment, unless otherwise shown on drawings, and uniform joint width as erection progresses.

F. Install weepholes where shown.

G. Anchor units in final position by grouting setting bed and all joints, or as otherwise indicated. Remove temporary shims, wedges, and spacers as soon as possible after anchoring and grouting are completed.

H. Clean exposed facing to remove dirt and stains on units after installation and completion of joint treatments. Wash and rinse in accordance with GFRC manufacturer’s recommendations. Do not use cleaning materials or processes that could change the character of GFRC finishes.

I. Surface of each unit will be at designated elevation, tactile domes will extend above finished elevations shown on drawings.

3.2 INSTALLATION TOLERANCES

A. Install precast concrete warning strips so that the joints between units meet the following:

1. Face width of joints: plus or minus 1/16 inch.
2. Joint taper: 1/16 inch maximum in 3 feet.
4. Variation from true plane: run plus or minus 1/4 inch in 30 feet.
5. Variation from plumb: plus or minus 1/16 inch maximum in 3 feet.

B. Warning strips shall be placed within plus 1/4 inch of horizontal and vertical line and grade.

3.3 DEFECTIVE AND DAMAGED GFRC UNITS

A. Do not install units with surface imperfections such as air bubbles, joint lines, warpage, stains, and damages to any exposed sides or corners.

3.4 PERFORMANCE REQUIREMENTS

A. General:

1. Conduct inspections, perform testing, and make repairs or replace unsatisfactory GFRC warning strip units as required.

2. Develop procedures and techniques for corrective work to GFRC warning strip units during the early stages of production.

B. Limitations as to amount of corrective work which will be permitted is subject to acceptance of the Contracting Officer.

C. In-place GFRC warning strip units may be rejected for any one of the following:

1. Does not match mock-up.
2. Exceeding specified fabrication or installation tolerances.
3. Damage during construction operations.
4. Surface finish deficiencies and irregularities in exposed-to-view surfaces.
5. Visible stains on panel surface.
6. Visible differences between panel and approved sample.
7. Visible nonuniformity of textures or color.
8. Visible areas of backup concrete bleeding through the facing concrete.
9. Visible foreign material embedded in the face.
10. Visible repairs or cracks.
11. Visible reinforcement shadow lines.

3.5 INSPECTION

A. Materials furnished in this Contract shall be presented for inspection at the place of manufacture. The Contractor shall provide the Contracting Officer all necessary facilities to examine the work during its progress as well as the finished product to verify that the materials comply with these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Glass fiber reinforced concrete warning strip units will not be measured but will be paid for at the lump sum price.
SECTION 03490
GLASS-FIBER-REINFORCED PRECAST CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes plant-cast, glass-fiber reinforced concrete (GFRC) column covers, including embedded hardware, loose connection hardware and supplementary items necessary to complete their installation.

B. Elastomeric sealants and backings for sealing joints between panels is specified in Section 07900, "Joint Sealants".

1.2 REFERENCED STANDARDS

A. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code - Steel

2. AWS D1.3 - Structural Welding Code - Sheet Steel

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):


2. ASTM A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished


4. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

5. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

6. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength

7. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

8. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

9. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar


11. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

12. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete

13. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete

14. ASTM C947 - Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)

15. ASTM C948 - Standard Test Method for Dry and Wet Bulk Density, Water Absorption, and Apparent Porosity of Thin Sections of Glass-Fiber Reinforced Concrete

C. Precast/Prestressed Concrete Institute (PCI):

1. PCI/CONCRT MNL-117 - Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products

2. PCI/CONCRT MNL-128 - Recommended Practice for Glass Fiber Reinforced Concrete Panels

3. PCI/CONCRT MNL-130 - Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide GFRC panels, panel frames and anchors capable of withstanding gravity, wind, seismic, and erection design loads as well as the effects of thermal- and moisture-induced volume changes, according to load factors and combinations established in PCI/CONCRT MNL-128.

1. Design Loads: As indicated on drawings in "Building Summary" schedule.

2. Design framing systems to withstand design loads with lateral deflections no greater than 1/360 of the panel height.

B. Design panel framing to provide for movement of framing members without damage or over stressing, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient
1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include GFRC design mixes.

B. Shop Drawings: Detail fabrication and installation of GFRC panels, including the following:
   1. Signed and sealed by the qualified professional engineer responsible for its preparation and engineering.
   2. Panel elevations, sections, and dimensions.
   3. Thickness of facing, GFRC backing, and bonding pads.
   4. Finishes.
   5. Joint and connection details.
   7. Cold-formed metal framing layout and details.
   8. Location and details of connection hardware attached to structure.
   9. Size, location, and details of flex, gravity, and seismic anchors.
  10. Other items sprayed into panels.
  11. Sequence of erection for special conditions.
  12. Relationship to adjacent materials.
  13. Description of loose, cast-in, and field hardware.

C. Samples: Representative of finished exposed face of GFRC showing the full range of colors and textures expected, 12 by 12 inches and of appropriate thickness.

D. Welding Certificates: Copies of certificates for welding procedures and personnel.

E. Qualification Data: For manufacturing firms specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed GFRC panels similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Manufacturer Qualifications: A firm that complies with the following requirements and is experienced in manufacturing GFRC panels similar to those indicated for this Project and with a record of successful in-service performance.
   1. Assumes responsibility for engineering GFRC panels to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.

B. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in State of Texas and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of GFRC panels that are similar to those indicated for this Project in material, design, and extent.
   1. Participates in PCI's Plant Certification Program and is designated a PCI-Certified Plant for Group G, Glass Fiber Reinforced Concrete.
   2. Has sufficient production capacity to produce required units without delaying the Work.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M and AWS D1.3.

D. PCI Manuals: Comply with requirements and recommendations in PCI/CONCRT MNL-128 and PCI/CONCRT MNL-130, unless more stringent requirements are indicated:

E. Mockups: Before installing GFRC, build mockups for each form of construction and finish required to verify selections made under sample Submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for the completed Work:
   1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Contracting Officer.
F. Include sealant-filled GFRC joints complying with requirements in Section 07900, “Joint Sealants.”

1. Notify Contracting Officer seven days in advance of dates and times when mockups will be constructed.
2. Demonstrate the proposed range of aesthetic effects and workmanship.
3. In presence of Contracting Officer, damage part of an exposed-face surface and demonstrate materials and methods proposed for repair of surface blemishes.
4. Obtain Contracting Officer's approval of mockups before starting installation.
5. Maintain mockups during installation in an undisturbed condition as a standard for judging the completed Work.
6. Demolish and remove mockups when directed.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Handle and transport units to avoid excessive stresses or damage.

B. Store units to protect from contact with soil, staining, and physical damage.

PART 2 - PRODUCTS

2.1 MOLD MATERIALS

A. Molds: Rigid, dimensionally stable, nonabsorptive material, warp and buckle free, that will provide continuous and true GFRC surfaces; nonreactive with GFRC and capable of producing required finish surfaces.

1. Mold-Release Agent: Commercially produced liquid-release agent that will not bond with, stain, or adversely affect GFRC surfaces and will not impair subsequent surface treatments of GFRC.

B. Form Liners: Units of face design, texture, arrangement, and configuration to match approved sample. Provide solid backing and form supports to ensure that form liners remain in place during concreting. Furnish with manufacturer's recommended liquid-release agent that will not bond with, stain, or adversely affect GFRC surfaces and will not impair subsequent surface treatments of GFRC.

2.2 GFRC MATERIALS

A. Portland Cement: ASTM C150, Type I, color as required to match approved sample.

1. For surfaces exposed to view in finished structure, use of same type, brand, and source throughout GFRC production.

B. Glass Fibers: Alkali resistant, with a minimum zirconia content of 16 percent, 1 to 2 inches long, specifically produced for use in GFRC, and complying with PCI MNL 130.

C. Sand: Washed and dried silica, successfully used in GFRC production, complying with composition requirements of ASTM C144; passing No. 20 sieve with a maximum of 2 percent retained on No. 140 sieve.

D. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of GFRC and complying with chemical limits of PCI MNL 130.

E. Curing Admixture: Acrylic thermoplastic copolymer dispersion complying with PCI MNL 130.

F. Air-Entraining Admixture: ASTM C260, containing not more than 0.1 percent chloride ions.

G. Chemical Admixtures: ASTM C494/C494M, containing not more than 0.1 percent chloride ions.

2.3 ANCHORS AND SUBSYSTEMS

A. Carbon-Steel Shapes and Plates: ASTM A36/A36M.


C. Carbon-Steel Plate: ASTM A283/A283M.

D. Bolts: ASTM A307 or ASTM A325.

E. Finish: Zinc coated by hot-dip process according to ASTM A123/A123M, after fabrication, and ASTM A153, as applicable.

2.4 GFRC MIXES

A. GFRC Mix: Proportion backing mix of portland cement, glass fibers, sand, and selected admixtures to comply with design requirements, and as follows. Provide nominal glass-fiber content of not less than 5 percent.

1. Flexural Properties: Average yield strength of 900 psi, and average ultimate strength of 2200 psi at 28 days; ASTM C947.
2. Maximum Water-Cementitious Ratio: 0.35.

3. Curing Admixture: 4 to 5 percent of total mix volume.


5. Air Content: 3 to 10 percent; ASTM C231.

2.5 MOLD FABRICATION

A. Construct molds that will result in finished GFRC complying with profiles, dimensions, and tolerances indicated, without restraining shrinkage or damaging GFRC during stripping. Construct molds to prevent water leakage and loss of cement paste. Coat contact surfaces of molds with form-release agent.

B. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of liners during GFRC application. Coat form liner with form-release agent.

2.6 GFRC FABRICATION

A. Proportioning and Mixing: For backing mix, meter sand/cement slurry and glass fibers to spray head at rates to achieve desired mix proportion and glass content according to PCI MNL 130 procedures.

B. Spray Application: Comply with general procedures as follows:

1. Spray mist coat or face mix of matrix without glass fibers over molds to a thickness not exceeding 1/8 inch.

2. Proceed with spraying up backing mix skin before mist coat or face mix has set, using procedures that produce a uniform thickness and even distribution of glass fibers and matrix.

3. Consolidate backing mix by rolling or use another technique to achieve complete encapsulation of glass fibers and compaction.

4. Measure thickness with a pin gage or another acceptable method at least once for each 5 sq. ft. of panel surface. Take not less than six measurements per panel.

C. Hand form intricate details, incorporate formers or infill materials, and over spray before material reaches initial set to ensure complete bonding.

D. Attach panel frame to GFRC before initial set of GFRC backing, maintaining a minimum clearance of 1/2 inch from GFRC backing, and without anchors protruding into GFRC backing.

E. Build up homogeneous GFRC bonding pads over anchor legs, maintaining a minimum thickness of 1/2 inch over top of anchor foot, before initial set of GFRC backing.

F. Inserts and Embedments: Build up homogeneous GFRC bosses or bonding pads over inserts and embedments to provide sufficient anchorage and embedment to comply with design requirements.

G. Curing: Employ initial curing method that will ensure sufficient strength for removing units from mold.

1. After initial curing, remove panel from mold and place in a controlled curing environment.

2. Keep panels continuously moist for a minimum of seven days. Maintain temperature between 60 and 120 deg F during this period.

3. An acrylic thermoplastic copolymer dispersion may be used as a curing compound in lieu of moist curing. Use only copolymers shown, in published independent laboratory test data, to eliminate the need for moist curing of GFRC.

H. Panel Identification: Mark each GFRC panel to correspond with identification mark on Shop Drawings. Mark each panel with its casting date.

2.7 FABRICATION TOLERANCES

A. Manufacturing Tolerances: Manufacture GFRC units so each finished panel complies with the following basic dimensional tolerances. For additional dimensional tolerances not listed below, comply with PCI MNL 130.

1. Overall Height and Width of Units, Measured at the Face Adjacent to Mold:

   B. 10 feet or under, plus or minus 1/8 inch.

   C. More than 10 feet, plus or minus 1/8 inch per 10 feet; 1/4 inch maximum.

   1. Edge Return Thickness: Plus 1/2 inch, minus 0 inch.


4. Local Smoothness: 1/4 inch per 10 feet.

5. Bowing: Not to exceed L/240 unless unit meets erection tolerances using connection adjustments.

6. Length and Width of Block Outs and Openings within One Unit: Plus or minus 1/4 inch.

7. Location of Window Opening within Panel: Plus or minus 1/4 inch.

8. Maximum Permissible Warpage of One Corner out of the Plane of the Other Three: 1/16 inch per 12 inches of distance from nearest adjacent corner.

2.8 FINISHES

A. Finish exposed-face surfaces of GFRC units as follows to match design reference sample. Panel faces shall be free of joint marks, grain, or other obvious defects.

1. Typical: Smooth-Surface Finish: Provide free of pockets, sand streaks, and honeycombs, with uniform color and texture.

2. Where indicated: Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.

2.9 SOURCE QUALITY CONTROL

A. Quality-Control Testing: Establish and maintain a quality-control program for manufacturing GFRC panels according to PCI MNL 130.

1. Test and inspect GFRC production. Include material acceptance testing, preproduction testing, aggregate production testing, wet production testing, and production testing after curing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive GFRC units and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator's acceptance of installation conditions.

3.2 ERECTION

A. Install clips, hangers, and other accessories required for connecting GFRC units to supporting members and backup materials.

B. Lift GFRC units at lifting points established by manufacturer and install without damaging units.

C. Install GFRC units level, plumb, square, and in alignment. Provide temporary supports and bracing as required to maintain position, stability, and alignment of units until permanent connections are completed.

1. Maintain horizontal and vertical joint alignment and uniform joint width.

2. Remove projecting hoisting devices.

D. Anchor GFRC units in position by bolting or welding, or both, as indicated on Shop Drawings. Remove temporary shims, wedges, and spacers as soon as possible after anchoring is completed.

E. Welding: Comply with AWS D1.1/D1.1M and AWS D1.3 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.

1. Protect GFRC units from damage by field welding or cutting operations, and provide noncombustible shields as required.

F. At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.

3.3 ERECTION TOLERANCES

A. Plan Location from Building Grid Datum: Plus or minus 1/2 inch.

B. Top Elevation from Nominal Top Elevation: As follows:

1. Exposed Individual Panel: Plus or minus 1/4 inch.

2. Nonexposed Individual Panel: Plus or minus 1/2 inch.

3. Exposed Panel relative to Adjacent Panel: 1/4 inch.

4. Nonexposed Panel relative to Adjacent Panel: 1/2 inch.

C. Support Elevation from Nominal Elevation:

1. Maximum Low: 1/2 inch.

GLASS-FIBER-REINFORCED PRECAST CONCRETE

D. Maximum Plumb Variation over the Lesser of Height of Structure or 100 Feet: 1 inch.

E. Plumb in Any 10 Feet (3 m) of Element Height: 1/4 inch.

F. Maximum Jog in Alignment of Matching Edges: 1/4 inch.

G. Maximum Jog in Alignment of Matching Faces: 1/4 inch.

H. Face Width of Joint: (governs over joint taper):
   1. Panel Dimension 20 Feet or Less: Plus or minus 1/4 inch.


J. Joint Taper in 10 Feet: 1/4 inch.

K. Differential Bowing, as Erected, between Adjacent Members of Same Design: 1/4 inch.

3.4 REPAIRS

A. Repairs will be permitted provided structural adequacy of GFRC unit and appearance are not impaired, as approved by Contracting Officer.

B. Blend and mix patching materials and repair GFRC so cured patches match color, texture, and uniformity of adjacent exposed surfaces.

C. Prepare and repair damaged galvanized coatings on metal framing, anchors, and subsystems with galvanizing repair paint according to ASTM A780.

D. Remove and replace damaged GFRC units when repairs do not comply with requirements.

3.5 CLEANING AND PROTECTION

A. Perform cleaning procedures according to GFRC manufacturer’s written instructions. Clean soiled GFRC surfaces with detergent and water, using soft fiber brushes and sponges, and rinse with clean water. Prevent damage to GFRC surfaces and to adjacent materials.

B. Provide final protection and maintain conditions that ensure GFRC is without damage or deterioration at time of Substantial Completion.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for glass-fiber-reinforced precast concrete (GFRC) per location indicated wherein no measurement will be made.

END OF SECTION 03490
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the materials and procedures to repair concrete defects caused by spills, cracks, or delaminations. In no case does the inclusion of this specification imply that substandard work is acceptable and can be repaired to conform to contract drawings by the use of the materials and procedures included herein. The Authority reserves the right to reject any substandard or deficient product and require the Contractor to remove and replace the nonconforming product with one that conforms to the Contract Documents at no cost to the Authority.

B. The type of concrete repair specified herein include the following:

1. Minor Surface Repair
2. Surface Repair
3. Crack Repair

C. Repairs required beyond these described here may require a specialty contractor and a separate repair procedure and plan for each case.

1.2 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. ACI 224.1R - Causes, Evaluation and Repair of Cracks in Concrete Structures
2. ACI 503.2 - 503.4 - Three Epoxy Standards
   a. ACI 503.2 - Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive
   b. ACI 503.3 – Specification for Producing a Skid-Resistant Surface on Concrete by the Use of Epoxy and Aggregate
   c. ACI 503-4 – Standard Specification for Repairing Concrete with Epoxy Mortars

1.3 SUBMITTALS

A. Contractor shall submit the proposed repair procedure for each repair not covered under “Minor Surface Repair”. With the approval of the Contracting Officer’s inspector, repairs agreed to that qualify as “Minor Surface Repair” will not require a submitted procedure. Other repairs will require a repair procedure be submitted for approval, identifying, products, tools and procedures to be used and dimensional extents of repair.

B. Defective concrete, which by its extent, type, or location exceeds the repair procedures enclosed, herein, as determined by the Contracting Officer, will require a submittal detailing repair procedure, specialty contractors to be employed, materials to be used, tools to be used, location of repair and dimensions of said repair.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage and handling of products shall conform to each manufacturer’s recommendations.

B. Packages opened prior to its day of intended use shall be discarded and not used.

C. Do not exceed the shelf life of a product.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete: Conform to Section 03305 “Portland Cement Concrete”.

B. Epoxy: Low viscosity epoxy adhesive conforming to TxDOT Material Specification DMS-6100, Type IX.

C. Grout: Conform to Section 03305 “Portland Cement Concrete”.

PART 3 - EXECUTION

3.1 MINOR SURFACE REPAIR

A. A minor repair is defined as a spall or small area of section loss that does not expose any reinforcing and has a maximum of 1-1/2 inch depth of defective concrete.

B. Remove loose, delaminated, or honeycombed concrete to sound material. Feathered edges shall be eliminated by saw cutting or chiseling a vertical edge around the repair perimeter, a minimum of 1/4 inch, or as recommended by the material supplier.

C. If upon removing defective concrete, reinforcing is exposed, further preparations, as defined in article 3.2 Surface Repair, may be necessary, at the discretion of the Contracting Officer.

D. Once defective concrete is removed, and no reinforcing is exposed or cracks visible, the surface is to be cleaned by wire brush, oil-free air hose, or...
SURFACE REPAIR

A. Surface Repair: A surface repair is defined as an area of deficient concrete larger than the defined minor repair and/or exposes reinforcing steel. The Contracting Officer is to be notified immediately if an area of defective concrete will require a Surface Repair. The procedure for a surface repair is as follows:

B. Remove loose delaminated concrete to sound concrete. Feathered edges shall be eliminated by saw cutting around the repair perimeter a minimum of 1/4 inch. Care shall be taken not to damage any reinforcing during the concrete removal process. Where one-half of a reinforcing bar’s circumference is exposed, concrete, whether sound or delaminated, shall be sufficiently removed to provide a 1 inch clearance beyond the exposed reinforcing.

C. If after removing delaminated concrete, no reinforcing is visible, yet the removed concrete exceeds 1-1/2 inch in depth, anchors shall be drilled and epoxied into the sound concrete, extending into the patch material. Embedment into sound concrete shall be at least 3 inches and cover from the finished patch surface shall be at least 1/2 inch. Spacing of anchors shall not exceed 6 inch. Supplemental reinforcing consisting of reinforcing bars, welded wire fabric or other approved material may be required as directed by the Contracting Officer.

D. If after removing delaminated concrete visible cracks remain, they shall be epoxy injected per Article 3.3 of this specification, as directed by the Contracting Officer.

E. The surface of the area to be patched shall be cleaned by wire brush or other approved means, to remove loose particles, dirt, deteriorated concrete or other substance that would impede the bond of the patch material. Final cleaning shall be by an oil-free, high pressure, air blast.

F. Concrete surface to be patched shall then be saturated or coated with an approved bonding agent. If a proprietary patch material is used, preparation shall be in compliance with the manufacturer’s recommendations.

G. Concrete, similar to the damaged base material shall be used for the patch material. A proprietary patch material may be used in lieu of concrete, if approved by the Contracting Officer. Forming, if required, casting and curing shall be performed in compliance with these specifications for the intended use of the damaged element.

H. Verification of the bonding shall be done by sounding the patch and surrounding area with an inspector’s hammer. Areas sounding hollow shall be removed and repaired per this specification.

3.3 EPOXY INJECTION OF CRACKS

A. Epoxy Injection of Cracks: Cracks larger than 0.002 inch but less than 3/32 inch wide shall be injected with epoxy if approved by the Contracting Officer. Cracks greater than 3/32 inch will have to be reviewed by the Contracting Officer on a case-by-case basis. The sealing material shall be an epoxy adhesive capable of bonding to wet or dry surfaces and shall be gray in color. It shall have adequate strength and adhesion to confine the injection material in the cracks being injected until the injection material has cured.

B. Epoxy used for injection shall be a two-component epoxy conforming to TxDOT Materials Specification DMS 6100, Type IX or other material as approved by the Contracting Officer. The viscosity of the epoxy shall be adjusted as necessary to obtain penetration and retention into the cracks. Where there is considerable variation in crack widths, it may be necessary to use more than one epoxy formulation. The epoxy shall contain no solvents and no solvents shall be added at any time. The mixing ratio of the components in terms of volume and weight shall be clearly stated. Proprietary crack injection systems may be used subject to approval by the Contracting Officer.

C. Unless otherwise approved by the Contracting Officer, injection will not be permitted unless the concrete temperature is above 50 degrees F and the air temperature is above 50 degrees F and forecasted to remain above 50 degrees F for the duration of the application period.

D. Top surface of cracks to be injected shall be cleaned free of dust, dirt, oil, grease or other material that would interfere with the bond of the surface sealer. The interior of the cracks should also be cleaned as much as possible with compressed air prior to sealing. Entry ports for epoxy injection shall be provided, spaced far enough apart to assure that when the epoxy shows at the adjacent port, it has completely filled the crack to its full depth. Entry ports may be either surface mounted or drilled into the cracks.
shall be placed along cracks a maximum of 12 inches on center and usually determined by the tightness of the crack and the depth of penetration. Spacing is generally between 4 inches and 10 inches. When drilling cracks for port installation, care should be used to avoid over drilling the crack. There should be no evidence of any dust or debris remaining in the drilled holes, which would be detrimental to the injection process. The injection ports shall be epoxied in place with the surface seal epoxy being careful not to seal the ports from resin flow.

E. Epoxy shall be injected with automatic two-component proportioning and mixing equipment. The two components shall be mixed by the machine just prior to injection. The machine must be capable of proportioning the materials to within plus or minus 5 percent of the ratio stated by the epoxy supplier. The mixing head must be designed so that an intimate mix of the two components will be obtained. Dwell time in the mixing head shall not exceed 10 seconds.

F. Injection of the epoxy into a given crack shall, unless permitted by the Contracting Officer begin first at the lowest entry port and progress upward as the epoxy begins to flow out of the adjacent ports. Injection pressure shall be kept as low as possible and shall not exceed 30 psi. After injection at a given port has been completed, this port shall be sealed and injection started at the next adjacent port.

G. Before beginning injection, and at selected intervals during the injection work, a small sample of the mixed epoxy will be taken from the injection gun. Should these samples show any evidence of improper proportioning or mixing, injection work shall be suspended until the equipment or procedures are corrected.

H. Surface of the crack herein treated shall be finished flush with the adjacent concrete surfaces and show no indentations or evidence of port fittings.

3.4 QUALITY OF WORK

A. Overall quality of the work will be judged by the Contractor’s ability to achieve a repair with no voids remaining in the structure and full epoxy penetration into cracks.

B. In case of question as to the quality of the work, the Contracting Officer may have core samples taken from the completed work and assess the completeness of the patch and/or crack injection. The cores will be taken at locations determined by the Contracting Officer. The expense of taking and testing core samples will be borne by the Contractor.

C. In general, core samples indicating 90 percent or more epoxy penetration into the crack will signify acceptable work. Work not considered acceptable will not be paid for unless satisfactorily corrected by the Contractor. In evaluating core samples for compliance, the Contracting Officer will take into account the presence of foreign matter that was not amendable to removal by usual crack cleaning processes required herein.

D. Finishing of the surface shall match the surrounding concrete in color and texture. The final surface shall be as shown on the contract drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Work described in this section will not be measured or paid for separately if the work is being performed on concrete constructed as part of this Contract.

B. If the work specified under this section is being performed on preexisting structures then the work will be measured by and paid for at the following unit prices: Per square foot of surface for “minor surface repair” and for “surface repair” and per linear foot of crack for “epoxy injection”.

END OF SECTION 03905
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing mortar and accessories for unit masonry work, including brick masonry, concrete masonry units and stone. The installation of such material is specified in the various masonry sections.

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):
   1. ACI 530.1/ASCE 6/TMS 602 - Specification for Masonry Structures and Commentary

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
   3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   4. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
   5. ASTM A 1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   8. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar
   11. ASTM C270 - Standard Specification for Mortar for Unit Masonry
   12. ASTM C476 - Standard Specification for Grout for Masonry
   13. ASTM C780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
   14. ASTM C954 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs From 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness
   16. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications

C. Brick Institute of America (BIA):
   1. BIA - Technical Notes on Brick Construction.

1.3 SUBMITTALS

A. Product Data: Manufacturer's data: Recommendations for use of materials, preparation of substrate, limitations and special instructions for materials necessary to the work.

B. Samples: Three of each type of the following products used in the work:
   1. Mortars: Cured samples showing color of each type.
   2. Accessories: Representative samples of each type.

1.4 QUALITY ASSURANCE

A. Fire-rated Masonry: Wherever a fire - resistance classification is shown or scheduled for unit masonry construction (4-hour, 3-hour and similar designations), provide mortar as UL-listed for the particular construction.

B. Qualification: Do not change source and brands of masonry mortar materials during the course of the work.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products to Worksite in their original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type, and class as applicable.
MORTAR, GROUT AND MASONRY ACCESSORIES

B. Store products so as to prevent water intrusion, dampness, and deterioration. Store loose materials, sand, and aggregates, so as to prevent intrusion of foreign materials.

C. Handle products so as to prevent breakage of containers and damage to products.

1.6 JOB CONDITIONS

A. Environmental Requirements:

1. Do not use materials or aggregates that are covered with frost. Do not mix mortar when the temperature is below that specified for the related masonry work.

2. Provide protective covering and heat for cold weather work as specified for masonry work.

3. Perform work under environmental conditions consistent with manufacturer's recommendations for materials being used in the work.

4. Perform hot weather mortar work in accordance with requirements of ACI 530.1/ASCE 6/TMS 602.

4. Colored Pigmented Mortar: Comply with the requirements for brick masonry mortar specified herein, and proportion pigments with other ingredients to achieve required mortar color as follows:

1. Mix to match color as directed.

2. Cement and pigments, as applicable to produce required mortar color, factory proportioned, dry blended and packaged. Site proportioning and blending not permitted.

3. Pigment to cement ratio by weight and water to cement ratio of colored mortar mixes to be consistent and in compliance with instructions of the pigment manufacturer for required mortar color and with the requirements of this section. Do not exceed pigment to cement ratio of 1:7, except limit carbon black to ratio of 1:35.

C. Mortar Mixes for Concrete Masonry Unit: As specified for brick masonry, except color pigment not required unless otherwise noted.

D. Grout for Masonry Lintels and Other Reinforced Masonry: Comply with ASTM C476. Use non-shrink grout of consistency indicated or if not otherwise indicated, of consistency (fine or coarse) at time of placement which will completely fill all cells and spaces intended to receive grout, and fully surrounding the reinforcement. Use concrete fill specified in Section 04220, "Concrete Masonry Units", in lieu of grout where shown.

E. Grout: For setting steel lintels and similar items: Portland cement, clean sand and lime putty added to obtain quick set; proportioned as required to provide a 28 day minimum compressive strength of 3000 psi when tested in accordance with ASTM C109.

2.3 EMBEDDED FLASHING MATERIALS

A. Sheet Metal Flashing: Fabricate from following metal complying with requirements specified in Section 07600, "Flashings and Sheet Metal" and below:
1. Stainless Steel: ASTM A666, Type 302/304, 2D annealed finish, soft, 0.0156 inch (28 gage) thick.

2. Fabricate metal expansion joint strips from sheet metal indicated above, formed to shape indicated.

3. Application: Use where flashing is fully or partly concealed in masonry wall.

4. Provide end dams at flashing termination and back-up plates at control joints.

B. Sealant: Low modulus silicone sealant complying with requirements for joint sealants specified in Section 07900, “Seals and Sealants”.

2.4 JOINT REINFORCEMENT

A. Continuous horizontal wall reinforcement:

1. Prefabricated continuous reinforcing tie system of truss design fabricated of 9 gauge side and cross wire rods conforming to ASTM A82; flush welded diagonal rods.

2. Hot-dip galvanized after fabrication in accordance with ASTM A153/A153M, Class B2, 1.50 ounces for side and diagonal rods.

3. Provide for out to out dimension of side rods 2 inches less than nominal thickness of wall.

4. Intersecting wall reinforcement: Factory-prefabricated units for corners and butting and intersecting walls.

5. Cavity wall reinforcement: Provide 4 wire ladder design continuous reinforcing for cavity wall construction.

2.5 VENEER ANCHORS AND TIES

A. General: Provide two-piece assemblies that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall; for attachment over sheathing to metal studs; and with the following characteristics:


2. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A1008M cold-rolled, carbon-steel sheet hot-dip galvanized after fabrication to comply with ASTM A153/A153M.

3. Structural Performance Characteristics: Capable of withstanding a 100 lbf. load in both tension or compression without deforming, or developing play in excess of, 0.05 inch.

B. Anchor System: Heckman Building Products, Inc., POS-I-TIE Masonry Veneer Anchor System with 5 gage steel wire ties, hot-dipped galvanized per ASTM A153/A153M, Class B3, size as required to provide maximum bond.

1. Provide screw types for steel studs, concrete or masonry and structural steel.

2. Corrugated ties not allowed.

C. Veneer Wall Tie: Minimum 14 gage screw attached anchor plate with 3/16 inch wire ties, hot-dipped galvanized per ASTM A153/A153M, Class B2, size as required to provide 2 inch minimum bond.

1. Anchor Section: Sheet metal plate with screw holes top and bottom and with raised rib-stiffened strap stamped into center to provide a slot between strap and plate for connection of wire tie.

   a. Plate 1-1/4 inches wide by 6 inches long with strap 5/8 inch wide by 3-5/8 inches long; slot clearance formed between face of plate and back of strap shall not exceed diameter of wire tie by more than 1/32 inch.

2. Wire Tie Section: Triangular-shaped wire tie sized to extend at least halfway through veneer but with at least 5/8 inch cover on outside face.

   a. Corrugated ties not allowed.

3. Steel Drill Screws for Steel Studs: ASTM C954 except manufactured with hex washer head and neoprene washer, No. 10 diameter by length required to penetrate steel stud flange by not less than 3 exposed threads. Corrosion protective organic polymer coating with salt-spray resistance to red rust of more than 800 hours per ASTM B117.

4. Neoprene Gaskets: Anchor manufacturer’s standard closed cell neoprene gaskets manufactured to fit behind anchor plate and to prevent moisture from penetrating through screw holes to steel studs behind sheathing.

5. Acceptable Manufacturers and Products:

   a. Dur-O-Wal, Inc.: “D/A 210”

   b. Hohmann & Barnard, Inc., “DW-10HS”

   c. Masonry Reinforcing Corp. of America, “1004, Type III”

   d. Heckman Building Products, Inc., “315D”

   e. Or approved equal.
D. Dovetail anchors:

1. Flexible, adjustable dovetail anchors of 3/16 inch zinc alloy or mild steel galvanized after fabrication in accordance with ASTM A153/A153M, Class B3. To be installed every 16 inches vertically and at 36 inches on centers horizontally, maximum (unless shown otherwise).

2. Dovetail anchor slots: 22 gauge electro-galvanized steel with removable filler.

3. Section 03100, "Concrete Formwork".

E. Wall Plugs: Galvanized, corrugated metal, approximately 3 inches long and of standard manufacture, where necessary for attaching other work. Galvanize after fabrication, ASTM A153/A153M, Grade B3.

F. Z-type rigid steel anchors: Steel, ASTM A36/A36M, 1/4 inch thick by 1-1/4 inches wide by length as required, galvanized; with one 2 inch opposing 90-degree bend at each end. Galvanizing ASTM A153/A153M, Class B3.


2.6 ACCESSORIES

A. Weep holes for brickwork: Provide one of following:

1. Aluminum Weep Hole/Vent: One-piece, L-shaped units made from sheet aluminum, designed to fit into a head joint and consisting of a vertical channel with louvers stamped in web and with a top flap to keep mortar out of the head joint; painted to comply with Section 09970, "Coatings for Steel" before installation, in color approved by Architect to match that of mortar.

2. Plastic Weep Hole/Vent: One-piece, flexible extrusion made from UV-resistant polypropylene copolymer, designed to fill head joint with outside face held back 1/8 inch from exterior face of masonry, in color selected from manufacturer's standard.

3. Vinyl Weep Hole/Vent: One-piece, offset, T-shaped units made from flexible, injection-molded PVC, designed to fit into a head joint and consisting of a louvered vertical leg, flexible wings to seal against ends of masonry units, and a top flap to keep mortar out of the head joint; in color approved by Contracting Officer to match that of mortar.

B. Weep holes for stonework: 1/4 inch OD, nonstaining plastic tubes of lengths ensuring complete panel penetration.

C. Cavity Drainage Material:

1. Description: Proprietary product composed of either reticulated, nonabsorbent mesh made from polyethylene strands, or, polymer core geomatrix composed of woven nylon strands, molded and shaped in open weave configuration to maintain drainage at weep holes without being clogged by mortar droppings, size as required to extend across entire width of cavity.

2. Acceptable Manufacturers and Products:
   a. Advanced Building Products, Inc., "Mortar Maze".
   b. Mortar Net USA, Ltd., "Mortar Net Green".
   c. Polytite Manufacturing Corp., "Mortarstop".
   d. Or approved equal.

D. Rubberized Asphalt Flexible Flashing:

1. Polyethylene-sheet-backed rubberized asphalt membrane, 40 mils thick. Provide primer (VOC compliant) when recommended by membrane manufacturer.

2. Acceptable Manufacturers and Products:
   a. Carlisle Coatings and Waterproofing Inc., "CCW-705-TWF"
   b. W.R. Grace & Co., "Perm-A-Barrier" Wall Flashing,
   c. Hohman & Barnard, "TEXTROFLASH"
   d. Polyken Technologies, "Polyken 640 Underlayment Membrane"
e. Polyguard Products, Inc., “400 Membrane”

f. Protecto Wrap Co., “Thru Wall Flashing”

g. Or approved equal.

E. Bolts, straps, bars, rods, and angles of the type and size indicated, fabricated from not less than 16 gauge galvanized sheet metal or 3/8 inch diameter rod stock.


G. Masonry Flashing: Install flashings where shown.

H. Control Joint Filler: Rubber, factory-extruded solid key-section 60 to 80 “Shore A durometer” hardness, ASTM D2000, 2AA805, minimum shear strength 540 psi; Rapid Control Joint, “Dur-O-Wall” Incorporated, or approved equal.

I. Loose granular Insulation and preformed foam inserts for CMU cells as shown on Drawings (See Section 07210, “Building Insulation”).

PART 3 - EXECUTION

3.1 MIXING OF MORTAR

A. Mix mortar materials in a clean mechanical mixer, the drum of which is free from dirt and dried mortar, for at least three minutes.

B. Mortar which has stiffened beyond workability because of evaporation of water may be retempered by adding water as needed to restore necessary consistency. Use mortar within 2 hours of initial mixing. Do not use mortar which has begun to set.

C. Use clearly identifiable graduated containers for measuring materials for mortar that will control and accurately maintain specified proportions throughout the work. Shovel measure is prohibited. Measure sand in damp loose condition.

3.2 INSTALLATION OF ACCESSORIES

A. Install accessories as shown and in conformance with manufacturers installation recommendations.

B. Place anchors every 16 inches in height of wall at intersections of masonry walls and concrete, and for masonry furring of concrete. Dovetail slots are to be embedded in concrete vertically not more than 24 inches apart over centers.

3.3 TESTING

A. Mortar composition and properties shall be evaluated per ASTM C780.

B. Grout shall be sampled and tested for compressive strength per ASTM C1019.

C. Refer to Section 01450, "Quality Control", for further information and compliance.

D. Testing Frequency: Tests and evaluations listed in this article shall be performed during construction for each 5000 sq. ft. of wall area or portion thereof.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. No separate measurement will be made for the work specified in this section.

B. No separate payment will be made for the work specified in this section, but it shall be included under relevant sections of the Specifications in the cost of furnishing and installing the related work such as brick masonry, concrete masonry, stone, etc. for which the work described in this section will be required.

END OF SECTION 04100
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing brick masonry, as applicable and as shown.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C62 - Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)

2. ASTM C216 - Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)

3. ASTM C780 - Standard Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry

B. Brick Institute of America (BIA):

1. BIA - Technical Notes on Brick Construction.

1.3 SUBMITTALS

A. Product Data:

1. Submit manufacturer’s data for each material to be used in the work, showing compliance with the specified requirements. Include instructions for handling, storage, installation, and protection of each material.

2. Tests: Submit independent laboratory test reports and certificates on materials to show compliance of materials with specified requirements.

B. Samples:

1. Submit three units of each kind of brick (nine units if they range in color), with indication of locations for their use. Acceptance of color range is at the sole discretion of the Contracting Officer.

2. Review will be for size, color, and texture only.

C. Shop Drawings: Show reinforcement, anchors, flashing and accessories details where required.

D. Masonry Mock-up:

1. Construct a mock-up masonry panel of exposed brick masonry, for each type required, of size not less than 4 feet x 3 feet incorporating corner edge, stone base (if any), reinforcement, flashing, face brick and backup units.

2. Construct sample panels on Worksite, as required to demonstrate the construction required for the work.

3. If necessary to produce an acceptable standard of appearance and workmanship, construct additional panels until approved.

4. Use types of material, color, mortar, bond, thickness, and tooling of joints, method of laying and workmanship typical and standard for the installation. Clean sample panel as specified for finished work.

5. Maintain panels in good condition and protect from moisture penetration until completion of masonry work and removal is directed.

1.4 QUALITY ASSURANCE

A. Preparatory: Before constructing sample panels, meet with the affected trades and the Contracting Officer to review new work installation procedures, precautions, and coordination with other work. Discuss in detail the color matching requirements for restoration work; the testing of salvaged units; the mixing and application of mortar; and the setting and pointing of brick units.

B. Source Quality Control: Brick used in the work shall be from the same run, unless quantity of brick for the project requires more than one run production.

C. Certification: Submit signed certification that materials conform with specified requirements.

D. Construction Tolerances:

1. Variation from Plumb: For lines and surfaces of walls and arises do not exceed 1/4 inch in 10 feet, or 3/8 inch in a story height or 20 feet maximum, nor 1/2 inch in more than 40 feet. Except for external corners, expansion joints and other conspicuous lines, do not exceed 1/4 inch in any story or 20 feet maximum, nor 1/2 inch in more than 40 feet.
2. Variation from Level: For lines of exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines, do not exceed 1/4 inch in any bay or 20 feet maximum, nor 3/4 inch in more than 40 feet.

3. Variation of Linear Building Line: For position shown in plan and related portion of columns, walls and partitions, do not exceed 1/2 inch in any bay or 20 feet maximum, nor 3/4 inch in more than 40 feet.

4. Variation in Cross-Sectional Dimensions: For thickness of walls, from dimensions shown, do not exceed minus 1/4 inch nor plus 1/2 inch.

5. Variation in Face of Masonry: 1/16 inch from face of adjacent masonry unit.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the Worksite in good condition.

B. Keep products dry, protect from rain, snow, and ice, do not allow to become wet or damp, prevent contact with soil.

C. Handle products to prevent chipping and breaking.

1.6 JOB CONDITIONS

A. Environmental Requirements: The following are prohibited:

1. Use of products that are covered with frost.

2. Erection of masonry when temperature is below 40 deg. F or tending to fall below 40 deg. F, unless suitable fireproof protective covering and heat are provided to maintain work and materials above 40 deg. F.

PART 2 - PRODUCTS

2.1 FACE BRICK

A. Provide brick as follows:

1. ASTM C216, Grade SW.

2. Size 2-1/4 inches by 3-5/8 inches by 7-5/8 inches, unless shown otherwise.

3. Color and finish: As scheduled on drawings.

B. Special Shapes: 100 percent solid for the following locations, as applicable:

1. Flat header wall caps.

2. End units on rowlock header wall caps.

3. Comers of soldier courses.


5. Pierced screen walls.

6. Where construction would result in exposed cores.

7. Where shown.

2.2 COMMON BRICK (BACKING BRICK)

A. ASTM C62, Grade SW, wire-cut.

B. First quality, hard grade, same vertical dimensions as face brick.

2.3 MORTAR AND GROUT

A. Specified in Section 04100, "Mortar, Grout and Masonry Accessories".

2.4 CLEANING SOLUTION

A. Formulated for cleaning brick work, containing no acid.

B. Type which will not stain, discolor or otherwise adversely affect surfaces with which it comes into contact.

2.5 SEALANT AND BACKER ROD

A. Polyurethane based sealant and backer rod, as specified in Section 07900, "Seals and Sealants".

2.6 CONTROL JOINT FILLER

A. Section 04100, "Mortar, Grout and Masonry Accessories".

2.7 OTHER ACCESSORIES

A. Specified in Section 04100, "Mortar, Grout and Masonry Accessories".

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove dirt, debris, oil, grease, and other foreign matter from surfaces to receive brick masonry, in accordance with BIA instructions.
B. Follow manufacturers’ instructions regarding the proper preparation and use of materials.

C. Protection: Protect areas around and below work areas from mortar droppings.

D. Built-In Work:
   1. Verify locations of chases and openings for pipes, conduit, ducts, and locations of flashing and weep holes.
   2. Establish layout lines and verify proper setting of bucks and frames.

3.2 **ERECITION**

A. Erect masonry to conform to approved sample panels. Place units plumb, true to line, and with level courses.

B. Erect adjoining walls simultaneously. Do not erect walls more than 5 feet above adjoining walls. Tooothing is prohibited. Cover and protect tops of unfinished walls whenever work on wall is not in progress.

C. Plumb piers and walls. Level brick courses using uniform joint thickness. Use power driven, masonry saws for cutting material. Build external corners square, unless otherwise shown.

D. Provide structural and pattern bonding as shown.

E. Unless otherwise shown, provide common Flemish header courses in every sixth brick course when using concrete masonry backing.

F. Place reinforcement and build in openings for pipes, conduits, ducts, chases and other work as shown.

G. Grout and set in place steel lintels furnished by other trades for openings in masonry walls.

H. Install flashing and weep holes over brick shelf angles, lintels and where shown. Lap joints in flashing 4 inches minimum and bond with mastic. Install through-wall flashing from inside and outside faces of walls. Set flashing in full bed of mortar and trowel full bed of mortar to ensure complete contact. If not otherwise shown, install weep holes not more than 2 feet on centers, immediately above flashing, but end recessed from face of wall. Keep weep holes free of mortar with sash cord, removing cord, and rodding before mortar hardens.

I. When more than one run of brick is required, select face brick from various stock piles so that they may be mixed to prevent segregating color ranges. Use same color mortar proportions throughout work.

J. Prior to laying face brick, lay out work so that bond and design are maintained plumb and level and joints are of uniform width throughout the work.

K. Do not use segments of bricks less than one-half in size at corners and openings. Use same sizes of bricks or same sizes of brick segments in same course at each side of jambs of openings and piers.

L. Thoroughly soak brick with water just before laying; and allow water to soak in so there is no standing water on the bricks.

M. Cover brick uniformly with mortar, firmly lay into place, with no voids in wall joints, at window frames or at door frames.

N. Place units with full mortar coverage on head and bed joints. Provide sufficient mortar on ends of units to fill head joints. Butter faces of brick. Do not slush joints.

O. Where necessary to secure more accurate dimensions in the field, size brick by grinding or cutting with a diamond-tipped blade.

P. Adjust units to final location while mortar is soft and plastic. If units are displaced after mortar has stiffened, remove, clean joints and units of mortar and relay with fresh mortar.

Q. Do not drop excessive mortar in cavity space to ensure the function of the weep hole system.

R. Where dovetail anchors are required, provide anchors vertically at each slot, maximum 16 inches on center vertically and 36 inches on center maximum (unless otherwise shown) horizontally and solidly fill in joints against concrete with mortar. Ensure that joints at anchors and bond courses are filled.

S. Unless otherwise shown, use 3/8-inch concave joints, carefully tooled to form smooth dense surface. Avoid burns at intersections and mortar discoloration.

T. Lay face brick from exterior with bed joints, head joints and collar joints full and level, faces plumb, joints uniform, and bonds accurate.

U. Place continuous wall reinforcement in courses maximum 16 inches on center except as otherwise shown. Use specially fabricated sections at corners and intersections.
V. Masonry anchors and wall reinforcements: In accordance with Sections 04100, "Mortar, Grout and Masonry Accessories", and 04220, "Concrete Masonry Units".

W. As the work progresses, clean masonry with stiff brush before mortar sets.

3.3 CONTROL JOINTS AND EXPANSION JOINT

A. Provide control joints where shown.

B. Wherever control joints are placed, insert Control Joint Filler (Section 04100), pack with a backer rod and joint filler, and fill with sealant as specified in Section 07900, "Seals and Sealants".

C. Provide expansion and control joints in masonry walls as shown. Ensure that joints are straight and of the thickness shown. Ensure that clear joints are free of water, mortar and other obstructions. Leave continuous open joint for caulking and sealing in accordance with Section 07900, "Seals and Sealants".

3.4 REPAIR, POINTING, AND CLEANING

A. Repair and Pointing Procedure:

1. Remove and replace masonry units which are loose, chipped broken, stained, or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in fresh mortar or grout, pointed to eliminate evidence of replacement taking care not to discolor or damage mortar or brick.

2. Pointing: During the tooling of joints, enlarge any voids or holes, except weep holes, and completely fill with mortar. Point up all joints including comers, openings, and adjacent work to provide a neat, uniform appearance.

B. Cleaning:

1. Wet exposed brick masonry surfaces and clean with soap-and-water solution applied with stiff fiber brushes leaving masonry clean, free of mortar daubs and with tight mortar joints throughout. The use of acid is prohibited.

2. Allow masonry walls to cure at least three weeks in summer four weeks in spring and fall, and five weeks in winter before final cleaning.

3. Begin cleaning at top and work down.

4. Remove as much mortar from brick as is possible with scraper or wire brushes taking care not to discolor mortar or brick.

5. Dampen walls thoroughly with water to prevent loose materials from being drawn into pores of dry brick below and to prevent build-up of dry detergents.

6. Clean surfaces thoroughly with cleaning solution. Rinse and flush with clean water immediately after cleaning.

7. Leave work in uniformly clean condition, free from mortar stain or other defacement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Brick masonry described in this section will be paid for on a lump sum basis per location indicated wherein no measurement will be made.

END OF SECTION 04210
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing, and the installation of, concrete masonry units (CMU), and includes installation of glazed structural tile, and structural clay tile.

1.2 REFERENCED STANDARDS

A. American Concrete Institute (ACI):
   1. ACI 530.1/ASCE 6/TMS 602 - Specification for Masonry Structures

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A82 – Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
   2. ASTM 153 – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   3. ASTM A615 - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
   4. ASTM C33 - Standard Specification for Concrete Aggregates
   5. ASTM C55 - Standard Specification for Concrete Brick
   6. ASTM C90 - Standard Specification for Loadbearing Concrete Masonry Units
   7. ASTM C140 - Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
   9. ASTM C331 - Standard Specification for Lightweight Aggregates for Concrete Masonry Units

C. National Concrete Masonry Association (NCMA)
   1. Specifications for the Design and Construction of Concrete Masonry

D. Portland Cement Association (PCA)
   1. Concrete Masonry Handbook

1.3 SUBMITTALS

A. Product Data:
   1. General: Submit manufacturer's data for each type of concrete masonry unit required, including certified copies of laboratory test reports and other data as may be required to show compliance with the specified requirements.
   2. Fire-rated assemblies: Submit complete information on each fire-rated assembly to be used in the work. Include the assembly identification number or designation and all construction requirements and details; include certified test reports where applicable and the qualifications of the testing laboratory. Submit all components of the assembly in one, coordinated submittal.

B. Samples:
   1. Submit samples of each type of concrete block to be used. Select units to show the range of color and texture which will be used in the finished work for the Contracting Officer’s inspection and approval.
   2. Submit three of each type of the following products which will be used in the work:
      a. Concrete masonry units (CMU):
         1) Hollow.
         2) Solid.
         3) Special shapes.
      b. Precast lintels.
      c. CMU lintels.

C. Shop Drawings: Show reinforcement, anchors, flashing and accessories details where required. Take and indicate field-verified dimension and elevations. Show existing and new units at restoration locations and how restored areas are bonded to existing.
D. Masonry Sample Panel(s):

1. Construct sample panel(s) for exposed work only. Build panels not less than 4 feet square by 8 inches thick incorporating reinforcement and concrete masonry units. If sample panel is not constructed in accordance with specifications and drawings, and is not approved by the Contracting Officer, rebuild as necessary until approval is obtained.

2. Masonry Mock-up(s): Construct a Mock-up masonry panel of exposed CMU, for each type required, of size not less than 4 feet by 3 feet, incorporating corner edge, cast stone base (if any), reinforcement, flashing and backup structure if required.

3. Use types of material, color, mortar, bond, tooling of joints, method of laying and workmanship shown or specified.

4. Maintain panels in good condition and protect from moisture penetration until completion of masonry work and removal is directed.

E. Certification: Provide certification that UL fire rated units comply with requirements for ratings indicated.

1.4 QUALITY ASSURANCE

A. Concrete Unit Masonry Standard: Comply with recommendations of Portland Cement Association’s “Concrete Masonry Handbook”.

B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, through one source from a single manufacturer for each product required.

C. Preconstruction Testing Service: Engage a qualified independent testing agency to perform following preconstruction testing:

1. Concrete Masonry Unit Test: For each concrete masonry unit indicated, per ASTM C 140.

2. Prism Test: For each type of wall construction indicated, per ASTM C 1314.

3. Test results or certificates of conformance already on file with supplier may be used.

D. Fire-Resistance Ratings: Where indicated, provide materials and construction identical to those of assemblies with fire-resistance ratings determined per ASTM E 119 by a testing and inspecting agency, by equivalent concrete masonry thickness, or by another means, as acceptable to authorities having jurisdiction. Proof of tests may be procured from manufacturer and submitted as certificate of conformance; specific jobsite testing is not required.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store masonry units on elevated platforms, under cover, and in a dry location to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion, and other causes. If units become wet, do not install until they are in air-dried condition.

B. Store cementitious materials on elevated platforms, under cover, and in dry location.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Store masonry accessories including metal items to prevent corrosion and accumulation of dirt and oil.

1.6 PROJECT CONDITIONS

A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day’s work. Cover partially completed masonry when construction is not in progress.

B. Stain Prevention: Prevent grout, mortar, and soil from staining face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with masonry.

1. Protect base of walls from rain-splashed mud and mortar splatter using coverings spread on ground and over wall surface.

2. Protect sills, ledges, and projections from mortar droppings.

3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes from mortar droppings.

C. Hot and Cold-Weather Requirements: Comply with referenced concrete unit masonry standard.

PART 2 - PRODUCTS

2.1 CONCRETE MASONRY UNITS

A. Use products of a single manufacturer.

B. Nominal dimensions:


2. Thickness: As shown.
CONCRETE MASONRY UNITS

C. Color and Finish: Manufacturer's standard color with standard aggregate and ground finish unless shown otherwise.

D. For exposed work, provide units of uniform medium texture, free from defects and of uniform dimensions. Furnish special units as necessary.

E. Units having UL fire resistance ratings to achieve fire ratings for walls as required by local building codes and as shown.

F. Units free from iron and other substances that will stain plaster or paint.

G. Hollow and Solid Load Bearing Units: ASTM C90, normal weight, aggregate complying with ASTM C33 and dry net weight of not more than 125 pounds per cubic foot.

H. Curing: Cure units by autoclave treatment at a minimum temperature of 350 degrees F, and a minimum pressure of 125 psi. Limit moisture absorption to 25 percent of saturation during delivery and until time of installation.

2.2 CONCRETE FILL FOR MASONRY

A. Concrete fill for unit masonry bond beams and reinforced masonry unit cells: Class 3500; (3500 psi compressive strength) maximum aggregate size, 3/4 inch.

2.3 ANCHORS AND REINFORCEMENT

A. Anchoring Devices - Provide bolts, straps, bars, rods and angles, of the type and size indicated, but fabricated from not less than 16 gauge sheet metal zinc coated, conforming to ASTM A153, Class B2.

B. Reinforcing Bars - Steel reinforcing bars, complying with ASTM A615, Grade 60, size as indicated, joint reinforcement conforming to ASTM A82, free from mill scale and excess or loose rust deposits.

2.4 WALL CONTROL JOINT FILLER

A. Section 04100, "Mortar, Grout and Masonry Accessories".

2.5 ACCESSORIES

A. Section 04100, "Mortar, Grout and Masonry Accessories".

2.6 CLEANING SOLUTION

A. Mild household detergent (wash powder), in quantities recommended by manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean foreign substances which would affect bond of mortar from surfaces to receive unit masonry.

B. Built-In Work:

1. Verify locations of chases and openings for pipes, conduits and ducts.

2. Establish locations for walls and partitions; verify that door frames and other built-in work provided by others are or can be properly located.

3.2 ERECTION

A. Erect exposed unit masonry work to conform to approved sample panel.

B. Erect adjoining walls simultaneously. Do not erect walls more than 5 feet above adjoining walls. Tooothing is prohibited. Cover and protect the tops of unfinished walls.

C. Plumb piers, walls and partitions. Level courses using uniform joint thickness for interior work. Build external corners with square or bull nose units as indicated.

D. Place reinforcement and build in openings for pipes, conduits, ducts, chases, frames, and other work as shown.

E. Grout and set in place miscellaneous steel lintels furnished by other trades for openings in masonry walls.

F. As the work progresses, keep masonry clean by stiff brushing.

G. Do not wet units before laying up. Unless otherwise shown, lay units in running bond, with full mortar coverage of bottom and ends, tooled to tight concave joints.

H. Prevent smearing mortar on surface of exposed units. If mortar smears occur, remove while soft.

I. Carefully cut faces of units for electrical or other outlets and cut out backs for conduit and other piping. Where possible, use full size units. Do not use portions of units shorter than 4 inches. Perform cutting with power-driven masonry saws.

J. Build partitions plumb and true to lines and heights shown on contract drawings. Anchor partitions at junctions with masonry exterior walls using Z-type steel anchors, rigid or corrugated, Z-bar anchors vertically 24 inches on center maximum unless otherwise shown. Use dovetail anchors spaced not over 16 inches on vertical centers where partitions abut concrete walls or concrete columns and steel.
framing anchors where partitions abut steel columns.

K. Use unit masonry or precast lintels except where steel lintels are shown. Use precast lintels for 4 inch masonry partitions. For other masonry partitions and walls, use lintels fabricated at plant or at job site from masonry lintel units.

L. Fill cells of masonry with mortar adjacent to openings and around built-in and embedded items.

M. Place prefabricated continuous wall reinforcement in alternate horizontal joints above grade and each horizontal joint below grade. Terminate each side of expansion joints. Use specially fabricated sections at corners and intersections.

N. Fill cells solid with grout where vertical reinforcement is installed within unit masonry walls.
   1. Fill cells with granular insulation where shown on drawings.
   2. Fill heads and jambs of hollow metal frames solid with mortar, as laying of units progresses.

O. Installation of Masonry Accessories:
   1. Wall anchors:
      a. Space Z-type rigid steel anchors at intersections of load-bearing masonry walls and at control joints.
      b. Space corrugated steel anchors 16 inches on centers vertically at control joints located not more than 2 feet from intersections of masonry walls.
   2. Steel framing anchors: Install anchors to attach masonry walls to structural steel building frame at 16 inches on centers vertically and 36 inches horizontally (unless shown otherwise). Weld anchors to structural steel so as to achieve full strength of anchor system.
   3. Soldier course anchors: Install corrugated steel anchors in horizontal mortar joints of soldier coursing, except where continuous wall reinforcement is used. Space anchors 24 inches on centers horizontally.
   4. Flashing: Install flashing to provide positive keying to mortar.
   5. Weep holes: Install at 2 feet 8 inches on centers at terminations of through-wall flashing.

P. Bond Beams:
   1. Provide bond beams in walls where shown.
   2. Construct similar to unit masonry lintels, except beams to be continuous, except at control joints, and full bearing.

Q. Chases: Build chases and recesses as indicated and as may be required for work of other trades.

R. Construction Openings: Leave openings for equipment as indicated or required to be installed at later date. Complete masonry work after equipment is in place using materials identical with those immediately adjacent to opening.

S. Construction Joints: Step back unfinished work for joining with new work; toothing will not be permitted. Before new work is started, clean exposed surfaces of set masonry, and remove loose masonry units and mortar prior to laying fresh masonry.

T. Cutting Masonry Units: Use motor driven saw designed to cut masonry units with clean sharp corners. Cut units as required to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting wherever possible. Avoid the use of less than half size units at corners, jambs and wherever possible at other locations. Do not use chipped or broken units for exposed work.

3.3 CONSTRUCTION TOLERANCES

A. Comply with tolerances in ACI 530.1/ASCE 6/TMS 602 and the following:

1. Variation from Plumb: For Lines and surfaces of walls and arises do not exceed 1/4 inch in 10 feet, or 3/8 inch in a story height or 20 feet maximum, nor 1/2 inch maximum. Except for external corners, expansion joints and other conspicuous lines, do not exceed 1/4 inch in any story or 20 feet maximum, nor 1/2 inch maximum.

2. Variation from Level: For lines of exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines, do not exceed 1/4 inch in any bay or 20 feet maximum, nor 1/2 inch maximum.

3. Variation of Linear Building Line: For position shown in plan and related portion of columns, walls and partitions, do not exceed 1/2 inch in any bay or 20 feet maximum, nor 3/4 inch maximum. Variation in Cross-Sectional Dimensions: For thickness of walls, from dimensions shown, do not exceed minus 1/4 inch nor plus 1/2 inch.

4. Variation of Face of Masonry. 1/16 inch from face of adjacent masonry unit.

3.4 LAYING MASONRY WALLS AND PARTITIONS

A. Mortar Types General: Refer to Section 04100, "Mortar, Grout and Masonry Accessories" for masonry types and applications.
B. Bond: Use running bond for single-wythe masonry walls unless otherwise indicated.

C. Laying Procedure for Walls:
1. Shove masonry units into place with a full bed of mortar in both horizontal and vertical joints.
2. Lay-up walls plumb and true with courses level and accurately spaced and coordinated with other work.
3. Build bearing plates, masonry anchors, flashings, sleeves, door frames and other miscellaneous items into masonry as work progresses. Fill-in solid with masonry around built-in items. Fill hollow metal frames adjoining masonry work solidly with mortar.
4. Provide anchoring devices of the type indicated.
5. Do not grout between top of non-bearing walls and structural beams or slabs above. Provide firestopping material. At the top of the fire partitions also, seal through fireproofing all the gaps around penetration of ducts, conduits, pipes, cables, etc. (See Section 07840, “Firestopping”).

D. Joints:
1. Maintain uniform joint widths except for minor variations to maintain bond alignment.
2. Cut joints flush for masonry walls which are concealed or to be covered with other materials.
3. Tool exposed wall joints slightly concave, unless otherwise indicated.

E. Reinforcing:
1. At openings of more than 1 foot width, provide joint reinforcement both immediately above the lintel and immediately below the sill. Extend the reinforcing a minimum of 2 feet beyond the opening.

F. Grouting, General:
1. Use fine grout for filling spaces less than 4 inches in both horizontal directions.
2. Use coarse grout for filling spaces 4 inches or larger in both horizontal directions.

G. Grouting, low-lift techniques subject to the following requirements:
1. Place vertical reinforcing before grouting. Place reinforcement before or after laying masonry units, as required by job conditions. Support vertical reinforcing at intervals indicated. Where individual bars are placed after laying masonry, place wire loops extending into cells as masonry is laid and loosen before mortar sets. After insertion of reinforcing bar, pull loops and bar to proper position and tie free ends.
2. Prior to grouting, clean, and inspect grout spaces and close cleanout holes. Remove dust, dirt, mortar droppings, loose pieces of masonry, and other foreign materials from grout spaces. Clean reinforcing and adjust to proper positioning as required. Clean top surface of structural members supporting masonry to ensure bond. After final cleaning and inspection, close cleanout holes and brace closures as required to resist grout pressures.
3. Do not place grout until entire height of masonry to be grouted has attained sufficient strength to resist displacement of masonry units and breaking of mortar bond. Install shores and bracing, if required, before starting grouting operations.
4. Limit grout pours to sections which can be completed in one working day with not more than one hour interruptions of pouring operations. Place pour in lifts which do not exceed 4 feet. Allow not less than 30 minutes, nor more than one hour between lifts of a given pour. Rod or vibrate each grout lift during pouring operation.
5. When more than one pour is required to complete a given section of masonry, extend reinforcing beyond masonry as required for splicing. Pour grout to within 1-1/2 inches of top course of first pour. After grouted masonry is cured, lay masonry units and place reinforcing for second pour section before grouting. Repeat sequence if more pours are required.
6. Extend vertical reinforcing above elevation of maximum pour height as required to allow for splicing.
7. Lay masonry units to maximum pour height. Do not exceed 4 feet.
8. Pour grout using container with spout or chute. Rod or vibrate grout during pour.

3.5 LINTELS

A. Provide masonry lintels where openings of more than 12 inches are shown without structural steel or other supporting lintels. Provide either precast or formed-in-place masonry lintels as follows:
1. Provide precast lintels made from concrete matching concrete masonry units in color,
2. Provide prefabricated or built-in-place masonry lintels. Use specially formed bond beam units with reinforcing bars placed and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

3. Unless otherwise indicated, provide one reinforcing bar for each 4 inch thickness of wall, and use bars of a size number not less than the number of feet of opening width.

B. Provide minimum bearing of 8 inches at each jamb, unless otherwise indicated.

C. Steel: Install steel lintels and loose lintels of other materials where indicated.

3.6 CONTROL JOINTS / EXPANSION JOINTS

A. General: Install control/expansion joints in masonry walls where indicated. Rake out mortar in preparation for application of sealant.

B. Spacing: If control joint locations are not indicated, place joints vertically, spaced at each structural column, or joint between bays but in no case spaced more than 30 feet on center. Also, place vertical joints at points of natural weakness in the masonry work, including the following locations:

1. Above and below major openings, at one side of the jamb if opening is less than 6 feet wide and at both jambs if opening is over 6 feet wide. Joint should be located away from the opening, at least 2 feet beyond the end of the lintel beam.

2. At expansion or control joints in supporting structure.

3. Where end of masonry wall abuts supporting structure.

3.7 POINTING, CURING, AND CLEANING

A. Pointing: When approved by the Contracting Officer, enlarge and point holes in joints of exposed unit masonry surfaces by completely filling with pointing mortar (Section 04100, "Mortar, Grout and Masonry Accessories").

B. Curing: Allow masonry walls to cure at least three weeks in summer, four weeks in spring and fall, and five weeks in winter before final cleaning.

C. Cleaning:

1. After pointing, wet and clean exposed unit masonry surfaces with mild household detergent-and-water solution, applied with stiff fiber brushes leaving masonry clean, free of mortar daubs and with tight mortar joints throughout. The use of acid is prohibited.

2. Begin cleaning at top and work down.

3. Remove as much mortar from masonry as is possible with scraper or wire brushes taking care not to deface masonry units.

4. Clean surfaces thoroughly and carefully with cleaning solution.

5. Rinse and flush with clean water immediately after cleaning.

6. Leave work in clean condition, free from mortar stain or other defacement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Concrete masonry described in this section will be paid for on a lump sum basis per location indicated, wherein no measurement will be made. Unless designated in the contract as separate pay items, no separate measurement will be made for bond beams, unit cores, lintel beams, anchors and reinforcement as specified.

END OF SECTION 04220
PART 1 - GENERAL

1.1 DESCRIPTION

A. The extent of stonework (pavers and wall units) is shown on the drawings.

1.2 REFERENCED STANDARDS

A. American National Standards Institute (ANSI):
   1. ANSI A108.1 - Installation of Ceramic Tile
   2. ANSI A118.1 – Specifications for Dry-Set Portland Cement Mortar
   3. ANSI A118.4 – Specifications for Latex-Portland Cement Mortar
   4. ANSIA A118.6 – Specifications for Ceramic Tile Grouts

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar
   2. ASTM C150 - Standard Specification for Portland Cement
   3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   4. ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
   5. ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
   6. ASTM C97 – Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
   10. ASTM C270 - Standard Specification for Mortar for Unit Masonry

C. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC Paint 12 - Cold-Applied Asphalt Mastic (Extra Thick Film)

D. Tile Council of America (TCA):
   1. TCA Handbook for Ceramic Tile Installation

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s data for each material required and proposed for use in the work, showing compliance with the specified requirements. Include mortar, grout, and stone test results performed by testing laboratories, independent of the manufacturer, and instructions for handling, storage, installation, and protection of each material. For tests of mortars and grouts, use the prescribed mixes to achieve the specified properties.

B. Samples: Submit 3 sets of samples not less than 12 inches by 12 inches in size of each different color, grade, and finish of stonework required. Include in each set the full range of exposed color and texture to be expected in the completed work. Contracting Officer’s will review for color and texture only.

C. Shop Drawings: Submit cutting and setting drawings showing sizes, dimensions, sections, and profiles of stonework units; the arrangement and provisions for jointing; required anchoring and fastening supports and other necessary details for lifting devices and reception of other work. Indicate location of each stonework unit on the setting drawings with number designation corresponding to number marked on each unit.

1. Show location of inserts (for stone anchors and supports) which are to be built into concrete or masonry.
2. Locate lifting devices only on concealed surfaces.
3. Show large scale details of decorative surfaces and inscriptions.


1.4 QUALITY ASSURANCE

A. Source Quality Control:

1. Provide stone which complies with recommendations of the following, as applicable:
   a. Limestone: Indiana Limestone Institute.
   c. Marble: Marble Institute of America.

2. Obtain each type or color of stone from one quarry, with consistent color range and texture throughout the work, matching Contracting Officer's samples for the project.

3. Fabricator: Ensure that fabricator (manufacturer) of stonework is an individual or firm experienced in the fabrication of stonework of the type and quality shown and specified and who can provide required quantities. The fabricator and the quarry company are required to be one and the same firm, unless accepted otherwise by the Contracting Officer.

B. Stone Quality: Unacceptable defects in stone units and installations are as follows:

1. Irregular edges.
2. Exposed surfaces which have finish deficiencies.
3. Damaged surfaces.
4. Exceeding specified tolerances.

C. Allowable Tolerances: As recommended by the applicable stone association, unless more strict requirements are specified in sections relating to each type of stonework.

D. Sample Panel Installation: See requirements in sections relating to each type of stonework.

E. Pre-Construction Meeting: Before constructing sample panel installations, meet with affected trades and the Contracting Officers to review installation procedures, precautions, and coordination with other work. Discuss in detail the mixing and application of mortars and grouts, and the setting of stone.

F. Latex Admixture Manufacturer Qualification: Ensure that latex manufacturer has proven experience in formulating and manufacturing latex admixtures for stonework.

G. Workmanship: Use only journeymen stonecutters and journeymen stonesetters under the direction of a competent foreman to perform stonework.

H. Sample Panel:

1. Prior to installation of stonework, provide sample panels of stonework indicated with proposed range of color, texture, and workmanship to be expected in the completed work. Use stone, anchors and jointing, as shown and specified in accordance with final shop drawings.

2. Obtain Contracting Officer's acceptance of visual qualities of sample panels before start of stonework. Replace unsatisfactory sample panel work, as directed, until acceptable to the Contracting Officer.

3. If sealant primers, sealants, resin-adhesives, sealers, water repellents, and other compounds are required in the finished work, build sample panel and apply compounds in sufficient time to allow for final examination for staining or other deleterious effects from such applications.

4. Sample Panels will be used to approve procedures, the finished appearance of installations, and the qualification of installation personnel.

5. Initial Testing of Paver Installation Sample Panels (if any stone pavers):
   a. After at least 40 hours bond coat curing time, and before grouting pavers, test sample panel in presence of Contracting Officer. Test each paver by tapping with a 3/8 inch diameter steel rod, 36 inches long; and gently pry each paver sideways or upward.
   b. Mark with bright crayon or paint for immediate removal, pavers which are not firmly bedded, or which exhibit a hollow sound when tapped, or which are broken.
   c. Remove marked pavers, chip out bond coat, and set new paver in place of the removed unit, fully aligned with adjacent pavers.
d. Adjust setting technique to prevent probable causes of discovered failures.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Protect stone during storage and construction against wetting, soiling, staining and damage.

B. Handle stone to prevent chipping, breakage, soiling or other damage. Do not use pinch or wrecking bars without protecting edges of stone with wood or other rigid materials. Lift with wide-belt type slings wherever possible; do not use wire rope or ropes containing tar or other substances which might cause staining. If required, use wood rollers and provide cushion at end of wood slides.

C. Store stone on wood skids or pallets, covered with non-staining, waterproof membrane. Place and stack skids and stones to distribute weight evenly and to prevent breakage or cracking of stones. Protect stored stone from weather with waterproof, non-staining covers or enclosures, but allow air to circulate around stones.

D. Protect mortar materials and stonework accessories from weather, moisture, and contamination with earth and other foreign materials.

1.6 JOB CONDITIONS

A. Maintain a temperature of not less than 50 degrees F during stonework installation and for 7 days after completion.

B. Keep sand dry, so that mixes are not diluted with water.

C. During all seasons, protect partially completed stonework against inclement weather when work is not in progress. Cover top of walls with strong, waterproof, non-staining membrane extending at least 2 feet down both sides of walls and anchor securely in place.

D. Do not proceed with installation of sealants when ambient and substrate temperatures are outside the limits permitted by sealant manufacturer or below 40 degrees F., or when joint substrates are wet due to rain, frost, condensation or other causes.

E. Cold Weather Precautions:

1. Do not use frozen materials or materials mixed or coated with ice or frost. Do not use salt to thaw ice in anchor holes or slots. Do not lower the freezing point of mixes by use of admixtures or anti-freeze agents, and do not use calcium chloride in mixes.

2. Do not build on frozen work. Remove ice or snow formed on substrate surfaces, carefully applying heat until top surface is dry to the touch.

3. Remove and replace stonework which is frozen or damaged by frost or freezing condition.

1.7 EXTRA MATERIALS

A. Deliver extra materials to Owner at a location and time that is at Owner's convenience. Furnish extra materials matching products installed, packaged with protective covering for storage and identified with labels clearly describing contents.

1. Stone Cladding Units: Furnish quantity of full-size units for each shape and thickness equal to 2 percent of amount installed.

PART 2 - PRODUCTS

2.1 MARBLE

A. Pavers: ASTM C503, except as follows:

1. Water absorption: (0.06) percent by weight after 48 hours immersion, ASTM C97.

2. Compressive strength: 8,700 psi, ASTM C170.

3. Abrasive hardness: Coefficient of 15.0 or better, ASTM C241.

B. Trim Units and Wall Units: ASTM C503.

2.2 GRANITE

A. ASTM C615, architectural grade, free from starts, cracks, or seams which might impair its structural integrity or appearance.

B. Finish Classifications: Finishes for granite are defined as follows:

1. Split-face finish: Finish face mechanically split along a line parallel to the grain. Stones with exposed tooling or tool marks are not acceptable.

2. Saw-cut finish: Relatively plain surface with texture ranging from wire sawn, a close approximation of smooth lusterless rubbed finish, to shot sawn, with scorings 3/32 inch in depth.

3. Thermal finish: Plane sawn surfaces with flame finish applied by mechanically controlled means to ensure uniformity. Surface coarseness may vary depending upon grain structure. Stone on which the thermal pattern is directional is unacceptable.
4. Honed: Dull sheen, without reflections, approximate 80 to 100 grit finish.

5. Polished: Mirror gloss, with sharp reflections.

6. Shot-ground: Plane surface with pronounced circular markings or trails having no regular pattern.

7. Lewis Holes: Where stone thickness permits, provide Lewis holes for lifting stones weighing over 100 pounds. Do not provide Lewis holes closer than 2 inches from finished face of stone nor in exposed portions of stone.

2.3 LIMESTONE

A. Pavers: ASTM C568, Category III (high density).

B. Trim Units and Wall Units: ASTM C568, Category II (medium density) or Category III (high density).

2.4 SLATE

A. ASTM C629, Classification I (Exterior); hard, non-absorbing, non-fading, sound stock.

B. Finish Classifications:
   1. Natural Cleft (pronounced texture).
   2. Semi-Rubbed (partly rubbed to produce a level surface, but showing some of the natural cleft face).
   3. Sand-Rubbed (perfectly smooth, straight face).
   4. Honed (smoother than sand-rubbed, having some sheen).

2.5 BOND ADHESIVE

A. Two component epoxy resin designed specifically for bonding together units of stone or for bonding stone units to a substrate as recommended by manufacturer for intended use.

2.6 BITUMINOUS PAINT

A. Cold applied asphaltic mastic complying with SSPC Paint 12, formulated for 30 mils dry film thickness per coat and compatible with adjacent damproofing.

2.7 JOINT FILLER

A. Closed cell polyethylene or neoprene foam, not less than 3 psi for 25 percent compression resistance, free of tar, asphalt, or creosote, and highly resistant to petroleum oils and solvents. Provide filler of dimensions in width as required to compress firmly into joints; in any case not less than 1/4 inch greater than the width of joints. Refer to Section 07900, “Seals and Sealants” for installation.

2.8 SEALANT

A. Multi-component polyurethane sealant, as applicable, complying with Section 07900, “Seals and Sealants”.

2.9 BACKER ROD

A. See Section 07900, “Seal and Sealants”.

2.10 MORTAR AND GROUT MATERIALS

A. Cement: Provide Portland cement, ASTM C150, white, non-staining and non-air-entraining. Use Type I, except Type III may be used for setting stonework in cold weather. Do not use masonry cement.

B. Hydrated Lime: ASTM C207, Type S.

C. Sand: Measure and use sand in dry, loose consistency so that mixes are not diluted with water, and will have the specified properties, except as otherwise allowed in writing by the latex manufacturer and proven by the submitted test results.

   1. Mortar Sand: ASTM C144, except graded with 100 percent passing the No. 16 sieve and of white or colored aggregate as required to match Contracting Officer’s sample.
      a. White mortar aggregate: Natural white sand or ground white stone meeting the specified requirements.
      b. Colored mortar aggregate: Marble, granite, or other sound stone, meeting the specified requirements.

   2. Setting bed sand (course sand): ASTM C144, 100 percent passing the No. 8 sieve.

   3. Bond coat sand (fine sand): ASTM C144, bagged silica sand, with no particles larger than No. 30 sieve and no particles smaller than No. 60 sieve.

D. Grout: Prepackaged, factory colored, acid-resistant, sanded grout mix, without additives that would alter the properties of the latex admixture.

E. Pigment: Where required for use to match approved sample, provide commercial finely ground, integral coloring pigment of iron oxide, manganese dioxide, ultramarine blue, chromium oxide or carbon black which are fade proof, alkali-resistant; and compounded for use in mortar mixes and matching Contracting Officer’s sample. Do not exceed pigment-to-cement ratio (by weight) of 1-to-35 for carbon black and 1 to 7 for other pigments.
F. Stearate Additive for Back-Parging: Ammonium stearate, aluminum tristearate or calcium stearate.

G. Water: Clear and free of deleterious materials which would impair the work.

H. Latex Admixtures: Styrene butadiene latex, formulated to improve the adhesive, cohesive, compressive, and water resistant properties of the mortars, bond coats, and grouts to which they are added. Do not use acrylic latex, vinylidene chloride latex, or polyvinyl acetate latex. Mix properties are specified under Article 2.12, herein. Conform to the requirements of ANSI A118.1, A118.4, A118.6 and the TCA: Handbook for Ceramic Tile Installation, as applicable.

2.11 STONEWORK ACCESSORIES

A. Adjustable Inserts: Stainless steel, AISI Type 302/304, of the configuration and size shown or, if not shown, as required to support loading involved.

B. Dovetail Slots: Fabricate from not less than 24-gauge galvanized steel, unless otherwise indicated. Provide with filler strips. Supply dovetail slots to concrete installer.

C. Expansion Anchors: Type, size, and load capacity shown or, if not shown, as required to support loading involved.
   1. For anchoring into concrete, fabricate from hot-dipped galvanized A153 Class B3 steel.
   2. For anchoring into stone, fabricate from AISI Type 302/304 stainless steel.

D. Anchor Bolts, Nuts and Washers: Fabricate from AISI Type 302/304 stainless steel if in contact with stone; otherwise, provide regular low carbon steel bolts and nuts (ASTM A307, Grade A) hot-dip galvanized; complying with ASTM A153.

E. Stone Anchors: Type and size shown or, if not shown, as required to securely anchor and fasten stonework in place. Fabricate anchors and dowels from Type 302/304 stainless steel.

F. Setting Buttons: High-density, high-impact polyurethane of the thickness required for the joint size indicated, and of the size required to maintain uniform joint width.

G. Stonework Flashing: Provide concealed flashing, shown to be built into stonework, of AISI Type 302/304 stainless steel, 2D finish, fully annealed or dead-soft temper, in thicknesses indicated but not less than 0.0156 inch thick.

H. Cleavage Membrane: Minimum 4 mils thick polyethylene film, for use only where shown.

I. Setting Bed Reinforcement: 2 inch by 2 inch, 16/16 gauge welded wire mesh; ASTM A185, galvanized after fabrication. Use flat mats, not rolls. Cut mats to stop 1 inch short of control joint locations.

J. Metal Lath: 3.4 pounds per square yard expanded, self-furring, zinc coated metal lath; anchored by galvanized nails and 1/2 inch stainless steel washers 6 inches on center. Place metal lath in all vertical cement mortar (mud set) setting beds. Cut lath to stop at control joints.

K. Water Repellents for Limestone: Penetrating water repellent for vertical application. A monomeric compound containing approximately 20 percent alkyltrialkoxysilanes and meeting VOC/AIM regulations containing 3.3 lb./gal. VOCs or less.

2.12 MIXES

A. General: Use the following mixes for mortar and grout, as applicable, unless otherwise specified in sections relating to each type of stonework.

B. Setting Bed Mortar (Traffic Surfaces): Mixture of 1 part Portland cement to 3 parts setting bed sand by volume and liquid latex for mortar mixed complying with instructions of liquid latex manufacturer. Mixture consistency which will stick together on being molded into a ball by a slight pressure of the hands, will not exude liquid latex, but will leave hands damp, and when placed, be at the point of becoming plastic. Water or diluted liquid latex is not acceptable, except as otherwise instructed by liquid latex manufacturer. Provide weather resistant, frost resistant, shock resistant cured mortar, with the following physical properties:
   1. Compressive Strength: Minimum 5000 psi at 28 days.
   2. Water Absorption: Maximum 4 percent.
   3. Bond Strength: Minimum 500 psi.
   4. Ozone Resistant: No loss of strength after 200 hrs. exposure at 200 ppm.

C. Veneer Setting Mortar (Walls): Mixture of Portland cement, hydrated lime, mortar sand and liquid latex for mortar in-place of water complying with ASTM C270. Type S, except as otherwise indicated, mixed complying with instruction of liquid latex manufacturer. Provide mixture of workable consistency for the application. Water or diluted liquid latex is not acceptable, except as otherwise instructed by liquid latex manufacturer. Provide weather resistant, frost resistant, shock resistant cured mortar, with the following physical properties:
   1. Compressive Strength: Minimum 3000 psi at 28 days.
   2. Water Absorption: Maximum 4 percent.
   3. Bond Strength: Minimum 500 psi.

D. Bond Coat: Mixture of 1 part Portland cement to 1 part bond coat sand by volume and liquid latex for bond coat, mixed complying with instructions of liquid latex manufacturer. Provide mixture of a thick, creamy consistency. Water or diluted liquid latex is not acceptable, except as otherwise instructed by liquid latex manufacturer. Provide weather resistant, frost resistant, shock resistant, non-staining cured bond coat with the following physical properties:

1. Compressive Strength: Minimum 5000 psi at 28 days.
2. Water Absorption: Maximum 4 percent.
3. Bond Strength: Minimum 500 psi.
4. Ozone Resistance: No loss of strength after 200 hours exposure at 200 ppm.

E. Floor Grout: Mixture of proprietary floor grout pre-mixture and liquid for grout, mixed complying with instructions of manufacturers. Provide mixture of workable toothpaste consistency, which permits filling joints their full depth, without voids. Water or diluted liquid latex is not acceptable, except as otherwise instructed by liquid latex manufacturer. Provide weather resistant, frost resistant, shock resistant, resistant to promoting bacteria growth, non-shrink, non-staining cured grout, with acceptable color consistency between batches and the following physical properties:

1. Compressive Strength: Minimum 5000 psi at 28 days.
2. Water Absorption: Maximum 4 percent.
3. Bond Strength: Minimum 500 psi.
4. Ozone Resistance: No loss of strength after 200 hrs. exposure at 200 ppm.

F. Color Pigmented Veneer Setting Mortar: Comply with the requirements for veneer setting mortar specified herein, and proportion pigments with other ingredients to achieve required mortar color as follows:

1. Mix to match final sample.
2. Cement, and pigments, as applicable to produce required mortar color; factory proportioned, dry blended and packaged. Site proportioning and blending not permitted.
3. Pigment to cement ratio by weight and water to cement ratio of colored mortar mixes to be consistent and in compliance with instructions of the pigment manufacturer for required mortar color and with the requirements of this section. Do not exceed specified pigment to cement ratio.

2.13 FABRICATION

A. General: Fabricate as shown and as detailed on final shop drawings and in compliance with the recommendations of the applicable stone association. Provide holes and sinkages cut or drilled for anchors, fasteners, supports and lifting devices, as shown and as necessary to secure stone work in place. Cut and back-check as required for proper fit and clearance. Shape beds to fit supports.

B. Contiguous Work: Provide chases, reveals, reglets, openings, and similar spaces and features as required for contiguous work. Coordinate with drawings and approved shop drawings showing contiguous work.

C. Cut accurately to shape and dimensions shown on approved shop drawings, maintaining fabrication tolerances specified under Quality Assurance.

1. Dress joints (bed and vertical) straight and at 90 degree angle to face, unless otherwise indicated.
2. Provide quirk-mitered corner, unless otherwise shown or specified. Provide for cramp anchorage in top and bottom bed joints of corner units, unless otherwise shown or required to assure concealment of the anchorage.
3. Joint Width: Cut to provide joint widths as shown or specified; or, if not shown or specified, cut to allow for uniform 1/2 inch wide joints.
4. Remove rust and iron particles for sawn backs of stone units.

D. Thickness: Provide stone of the thickness shown or specified. Saw-cut back surfaces which will be fully concealed in the finished work.

E. Provide not less than 1 inch clearance between back face of units and structure framing (or fireproofing, if any).

F. Fabricate molded work to profiles shown, with arrises sharp and true and matched at joints between units.

G. Carve and cut decorative surfaces and inscriptions in accordance with the final shop drawings.

H. Cut flashing reglets, 5/8 inch wide by 3/4 inch deep, unless otherwise indicated.
I. Cut gasket reglets in edges of panels where gasketed joints are shown. Coordinate with profile of gaskets to be used in the work.

J. Fabricate saddles and thresholds to profiles and dimensions shown.

K. Fabricate saddles and thresholds of same width as jamb openings and 7/8 inch thick if flush, or 1-1/4 inch thick with rounded corners, if raised. Cope ends to fit profile of metal jambs and stops; extend ends under stops of wood jambs.

PART 3 - EXECUTION

3.1 INSPECTION

A. Require Installer (stonecutter and stonesetter) to examine supporting structure and all conditions under which the stonework is to be performed, to verify all critical dimensions, and to notify the Contracting Officer in writing of any conditions detrimental to proper installation or performance of the work.

B. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

C. Where indicated, dampproof concrete and masonry surfaces associated with or to be in direct contact with stone units prior to installation of stonework.

D. Do not use stone units with chips, cracks, voids, stains, discoloration, or other defects which might be visible or cause bad appearance in the finished work.

3.2 PREPARATION

A. Coordinate placement of inserts and flashing reglets which are to be used for anchoring and supporting and flashing of stonework. Furnish to installers of other adjacent work drawings or templates showing location of inserts for stone anchors and supports.

B. Remove debris, material droppings, and all other foreign matter from substrate surfaces before starting installation of stonework.

C. Clean stone before setting by thoroughly scrubbing with fiber brushes followed by a thorough drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh fillers or abrasives. If not thoroughly wet at time of setting, drench or sponge stone. Do not wet expansion or control joint surfaces.

3.3 INSTALLATION - GENERAL

A. Execute stonework by skilled stone cutters and stone setters at the site to do necessary field cutting as stone is set.
L. **Flashing:** Provide concealed flashing built into stonework where indicated. Prepare substrate surfaces smooth and free from projections and other items which might damage flashing. Seal flashing penetrations with sealant before covering.

1. Terminate flashing 1/2 inch from outside face of stonework, unless otherwise indicated.

2. Extend flashings beyond interior edge of lintels and sills at least 4 inches and turn up edge on sides to form pan to direct moisture to exterior.

3. Interlock end joints of flashing units by overlapping not less than 3 inches and seal lap with sealant.

M. **Expansion and Control Joints:** Provide expansion and control joints where indicated, but in no case less frequent than at abutting surfaces and directly over joints in substrate. Provide joint filler of applicable type for installation condition installed in continuous strips complying with Section 07900, “Seals and Sealants”. Do not fill joint space with mortar or grout. Ensure joint filler extends full width and depth of joint, including bedding material. Install joint filler to allow for installation of sealant and backer rod complying with Section 07900, “Seals and Sealants”.

3.4 **WALLS**

A. Erect walls plumb and true with joints uniform in width and accurately aligned. Set in full bed of mortar, unless otherwise indicated. Provide setting buttons as required to prevent extrusion of mortar. Do not set units above until mortar in courses below is set sufficiently to maintain alignment and prevent extrusion.

B. **Cavity Construction:** Where open space between back of stone units and back-up or framing is shown, keep cavity open; do not fill with mortar or grout. Ensure joint filler extends full width and depth of joint, including bedding material. Install joint filler to allow for installation of sealant and backer rod complying with Section 07900, “Seals and Sealants”.

3.5 **TRAFFIC SURFACES (FLOORS)**

A. Clean subbase to remove dirt, dust, debris, and loose particles.

B. Moisten concrete subbase with clean water about three hours before placing setting bed, until absorption from water-suction stops. About 1 hour prior to placing setting bed, remove all remaining surface water, allowing surface to dry. Omit water-moistening or modify procedure if so recommended by latex admixture manufacturer.

C. **Layout:** As indicated, or if not indicated, center paver field, both directions, in each major area to provide a symmetrical pattern which minimizes pavers less than half-size and cutting of pavers.

1. Set pavers with stone grain running all in the same direction, unless otherwise shown.

2. **Texture:** Locate pavers with shallow textures together, gradually making transition to pavers with deeper textures so the transition is imperceptible.

D. **Joint Width:** As indicated, or if not indicated, provide joints 1/2 inch wide, except as detailed for expansion joints.

E. **Bed Bond Coat:** Where setting bed mortar is to be placed directly on a concrete substrate, apply bond coat to substrate at approximately 1/16 inch thickness by trowel about 15 minutes prior to placing setting bed mortar. Limit area of bond coat application to avoid drying out prior to placement of mortar.

F. **Setting Bed:** Place setting bed mortar over prepared substrate, and spread, compact and screed to uniform thickness indicated, except for variations necessary to provide a true surface level in plane or uniformly sloped for drainage and to the required tolerances. Place only the amount of mortar which can be covered with pavers prior to
initial set of mortar. Replace setting bed mortar which has reached initial set prior to placing of paver.

1. About 15 minutes after placing bed bond coat, and before it takes its initial set, place half of the mortar bed.

2. Dry mix the mortar bed ingredients in a concrete mixer for at least three minutes. Then mix dry ingredients with latex additive, as approved, to form a stiff cohesive mortar.

3. Screed the mortar which has been placed in the setting bed to a level which is 3/4 of the required setting bed thickness and compact it to 1/2 the required setting bed thickness by rolling or by tamping with a hand tamper.

4. Place the welded wire reinforcement flat on the mortar, half-bed lapping the joints 4 inches and tie with galvanized wire for convenience. Cut reinforcement 1 inch back from control joints.

5. Screed the remainder of the mortar over the welded wire reinforcement and compact by roller or tamper until the required overall mortar bed thickness and slope is attained and the completed mortar bed;
   a. Shows a slight glaze of moisture when worked with a steel trowel.
   b. Is firm enough to support a person’s weight without showing the outline of footprints.

6. Set pavers before initial set of setting bed mortar.

G. Setting Units:

1. Apply the paver bond coat to the setting bed mortar with the flat edge of the trowel and work into the surface of the mortar bed. Then, comb the bond coat with coarsely notched trowel, leaving ample mortar standing up in ridges.

2. Apply paver bond coat to the back surface of pavers sufficient to fully cover the surface and to fill all recesses.

3. Total thickness of the paver bond coat mortar: 1/16 inch to 1/8 inch as needed to make up for variations in the level and trueness of the mortar setting bed. Place the paver before bond coat takes its initial set.

4. Level pavers to required elevation. Install entire bottom surface of pavers in contact with setting bed. Set and level each paver immediately. Do not set large areas of pavers and later level.

H. Cleavage Membrane: Where cleavage membrane is shown, install membrane flat, lapping edges three inches and taping to hold membrane secure and flat during placement of setting bed.

I. Grout: Grout joint spaces as indicated. Install grout after initial set of setting mortar and pavers are firm and securely in place.

1. Remove debris, dust, and spacers from joint spaces.

2. Force grout into grout spaces full width and depth. Place in layers as necessary and compact with the side of a rod-shaped tool to assure there are no voids down to bottom of joint.

3. Strike joints flush with surface of pavers and tool slightly concave (maximum 1/32 inch).

4. Remove grout spillage from faces of pavers as work progresses.

5. Cure grout complying with instructions of grout latex admixture manufacturer.

J. Control Joints (Sealant Joints):

1. Rake out joint down to substrate of bed before mortar is set.

2. Fill joint with filler, keeping filler recessed just far enough to allow for backer rod and sealant. Therefore, there will be more filler material at thicker parts of setting bed, and less filler material at thinner parts of bed.

3. Install backer rod and sealant. See Section 07900, “Seals and Sealants”.

K. Projection:

1. Do not permit traffic on pavers during setting and for at least 24 hours after grouting or pointing of joints.

2. Protect installation from precipitation for 2 days.

L. Testing:

1. Permit normal pedestrian and light, soft-wheeled cart traffic over installation after grouting has cured at least 1 week in order to reveal the presence of any unsound or improperly set pavers.

2. Test entire installation in the presence of the Contracting Officer. Test each paver by tapping with a 3/8 inch diameter steel rod, 36 inches long.
3. Mark with bright crayon or paint for removal, pavers which exhibit a hollow sound when tapped, or which are broken or discolored.

4. Remove marked pavers, chip out grout and bond coat, and set new paver grout and sealer in place of removed material, fully level, align, and color match to adjacent work.

3.6 ADJUSTMENTS AND CLEAN-UP

A. Remove and replace stone units which are broken, chipped, stained or otherwise damaged. Where directed, remove and replace units which do not match adjoining stonework. Provide new matching units, install as specified and point-up joints to eliminate evidence of replacement. Repoint defective and unsatisfactory joints as required to provide a neat, uniform appearance.

B. Clean stonework not less than 6 days after completion of work, using clean water, a mild household detergent, and stiff-bristle brushes. Do not use wire brushes, acid type cleaning agents or other cleaning compounds with caustic or harsh fillers.

C. Protect the stonework from collapse, deterioration, discoloration, or damage during subsequent construction and until acceptance of the work.

3.7 ALLOWABLE TOLERANCES FOR FINISHED INSTALLATIONS

A. General: Meet the following tolerances unless otherwise specified in sections relating to each type of stonework.

B. Walls:
   1. Variation from plumb: 1/4 inch maximum in 10 feet.
   2. Variation from level: 1/4 inch maximum in any bay or 20 feet.
   3. Variation from linear building line: 1/2 inch maximum in any bay or 20 feet.
   4. Variation in cross-sectional dimensions: For thickness of walls, minus 1/4 inch and plus 1/2 inch.

C. Face of Stone: 1/16 inch offset from adjacent stone.

D. Floors and Other Horizontal Surfaces:
   1. Horizontal surface: Maximum of 1/8 inch deviation in 10 feet, taken at any location and in any direction.
   2. Elevation: Within 1/8 inch of elevation shown.

E. Joint Widths:
   1. 1/4 inch joints: Plus or minus 1/16 inch.
   2. 3/8 inch joints: Plus or minus 1/16 inch.
   3. 1/2 inch joints: Plus or minus 1/8 inch.

F. Maximum Out-of-Square: 1/4 inch in 10 feet, measured diagonally.

3.8 WATER REPELLENTS FOR LIMESTONE

A. Examination:
   1. Examine substrates surfaces to receive water repellents and associated work and conditions under which work will be installed. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

B. Preparation:
   1. Clean substrate of substances that might interfere with penetration or performance of water repellents. Test for moisture content, according to repellent manufacturer’s written instructions, to ensure surface is sufficiently dry.
   2. Test for pH level, according to water repellent manufacturer’s written instructions, to ensure chemical bond to silicate minerals.
   3. Protect adjoining work, including sealant bond surfaces from spillage or blow-over of water repellent. Cover adjoining and nearby surfaces of aluminum and glass if there is the possibility of water repellent being deposited on surfaces. Cover live plants and grass.
   4. Coordination with Sealants: Do not apply water repellent until sealants for joints adjacent to surfaces receiving water-repellent treatment have been installed and cured.
      a. Water-repellent work may precede sealant application only if sealant adhesion and compatibility have been tested and verified using substrate, water repellent, and sealant materials identical to those used in the work.
   5. Test Application: Before performing water-repellent work, including bulk purchase and
delivery of products, prepare a small application in an unobtrusive location and in a manner approved by Contracting Officer to demonstrate the final effect (visual, physical, and chemical) of planned application. Proceed with work only after Contracting Officer approves test application or as otherwise directed.

C. Application:

1. Apply a heavy-saturation spray coating of water repellent on surfaces indicated for treatment using low-pressure spray equipment. Comply with manufacturer’s written instructions for using airless spraying procedure, unless otherwise indicated.

2. Apply a second saturation spray coating, repeating first application. Comply with manufacturer’s written instructions for limitations on drying time between coats and after rainstorm wetting of surfaces between coats. Consult manufacturer’s technical representative if written instructions are not applicable to Project conditions.

D. Field Quality Control:

1. Manufacturer’s Field Service: Provide services of a factory-authorized technical service representative to inspect and approve the substrate before application and to instruct the applicator on the product and application method to be used.

E. Cleaning:

1. Protective Coverings: Remove protective coverings from adjacent surfaces and other protected areas.

2. Immediately clean water repellent from adjoining surfaces and surfaces soiled or damaged by water-repellent application as work progresses. Repair damage caused by water-repellent application. Comply with manufacturer’s written cleaning instructions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis per location indicated wherein no measurement will be made.

END OF SECTION 04400
SECTION 04720
CAST STONE

PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes cast stone masonry and supplementary items necessary to complete their installation.

B. Precast concrete units are specified in Section 03450, “Architectural Precast Concrete”.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes
2. ASTM A615/A615M - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
3. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
4. ASTM A767/A767M - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
5. ASTM A775/A775M - Standard Specification for Epoxy-Coated Steel Reinforcing Bars
6. ASTM C33 - Standard Specification for Concrete Aggregates
7. ASTM C114 - Standard Test Methods for Chemical Analysis of Hydraulic Cement
10. ASTM C666 - Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
11. ASTM C979 - Standard Specification for Pigments for Integrally Colored Concrete

B. Brick Institute of America (BIA):

1. BIA - Technical Notes on Brick Construction.

1.3 DEFINITIONS

A. Cast Stone: Highly refined architectural precast concrete building stone manufactured from mixture of Portland cement and coarse and fine aggregates, to simulate natural stone and generally used as masonry product, as an architectural feature, trim, ornament, or facing for buildings and other structures.

1.4 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for cast stone units.

B. Shop Drawings: Show fabrication and installation details for cast stone units. Include dimensions; details of reinforcement and anchorages, if any; and indication of finished faces.

1. Include building elevations showing layout of units and locations of joints and anchors.

C. Stone Samples: For each color and texture of cast stone required, 10 inches square in size.

D. Full-Size Samples: For each type of cast stone unit required. Make available for Architect’s review at Project site before installing cast stone. Approved Samples may be installed in the Work.

E. Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of cast stone with requirements indicated.

1. Certificates: In lieu of agency test reports, submit certificates signed by manufacturer certifying that cast stone complies with requirements specified.

1.5 QUALITY ASSURANCE

A. Standards: Comply with provisions of Cast Stone Institute standard specification and technical bulletins.

B. Manufacturer Qualifications: A firm experienced in manufacturing cast stone units similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to manufacture required units.

C. Source Limitations for Cast Stone: Obtain cast stone units through one source from a single manufacturer.
1.6 DELIVERY, STORAGE, AND HANDLING

A. Pack, handle, and ship cast stone units in suitable packs or pallets.
   1. Lift with wide-belt slings; do not use wire rope or ropes that might cause staining. Move cast stone units, if required, using dollies with wood supports.
   2. Store cast stone units on wood skids or pallets with nonstaining, waterproof covers. Arrange to distribute weight evenly and to prevent damage to units. Ventilate under covers to prevent condensation.

PART 2 - PRODUCTS

2.1 CAST STONE MATERIALS

A. General: Comply with ASTM C1364 and the following:
   B. Portland Cement: ASTM C150, Type I, containing not more than 0.60 percent total alkali when tested according to ASTM C114. Color as required to produce finish specified.
   C. Coarse Aggregates: Granite, quartz, or limestone complying with ASTM C33; gradation and color as needed to produce required textures and finish.
   D. Fine Aggregates: Manufactured or natural sands complying with ASTM C33, gradation and color as needed to produce required textures and finish.
   E. Air-Entraining Admixture: ASTM C260, certified by the manufacturer to be compatible with other admixtures used.
       1. Add to mixes for units exposed to the exterior at manufacturer’s prescribed rate to result in an air content of 5 to 7 percent.
   F. Reinforcement: Deformed steel bars complying with ASTM A615, Grade 60.
   G. Embedded Anchors and Other Inserts: Fabricated from stainless steel complying with ASTM A276 or ASTM A666, Type 304.
   H. Color Pigments: ASTM C979, Inorganic (natural or synthetic) iron oxide pigments excluding use of carbon black pigment, and guaranteed by pigment manufacturer to be lime-proof. Amount of pigment shall not exceed 5 percent by weight of cement used.

2.2 CAST STONE UNITS

A. Provide cast stone units complying with ASTM C1364.
   1. Provide units that are resistant to freezing and thawing as determined by laboratory testing according to ASTM C666, Procedure A, as modified by ASTM C1364.
   B. Reinforce units as indicated and as required by ASTM C1364. Use galvanized or epoxy-coated reinforcement when covered with less than 1-1/2 inches of material.
   C. Fabricate units with sharp arris and details accurately reproduced with indicated texture on exposed surfaces, unless otherwise indicated.
       1. Slope exposed horizontal surfaces at least 1:12, unless otherwise indicated.
       2. Provide raised fillets at backs of sills and at ends indicated to be built into jambs.
       3. Provide drips on projecting elements, unless otherwise indicated.
   D. Cure and finish units as follows:
       1. Cure units in totally enclosed curing room under dense fog and water spray at 95 percent relative humidity for 24 hours.
       2. Yard cure units until the sum of the mean daily temperatures for each day equals or exceeds 350 deg F.
       3. Acid etch units to remove cement film from surfaces indicated to be finished.
   E. Color and Texture: Provide units with fine-grained texture and buff color resembling Indiana limestone.

2.3 MORTAR MATERIALS

A. Provide mortar materials that comply with Section 04100, “Mortar, Grout and Masonry Accessories”.

2.4 ACCESSORIES

A. Anchors: Type quantity and size required to support cast stone cladding and to sustain imposed loads, fabricated from stainless steel complying with ASTM A276 or ASTM A666, Type 304.
   B. Dowels: Round stainless steel bars complying with ASTM A276, Type 304, 1/2-inch diameter.
2.5 MORTAR MIXES

A. Comply with requirements in Section 04100, "Mortar, Grout and Masonry Accessories" for mortar mixes.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive cast stone and associated work and conditions under which stone will be installed. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator's acceptance of installation conditions.

3.2 INSTALLATION

A. Install cast stone units to comply with requirements specified in other Division 4 Unit Masonry Sections for installing stone units in walls with other masonry units.

B. Install anchors, supports, fasteners, and other attachments necessary to secure units in place. Set units accurately in locations indicated with edges and faces aligned according to established relationships with other masonry units and indicated tolerances.

C. Drench units with clear water just before setting.

D. Set units in full bed of mortar with full head joints, unless otherwise indicated. Build anchors and ties into mortar joints as units are set.
   1. Fill dowel holes and anchor slots with mortar.
   2. Fill collar joint solid as units are set.
   3. Build concealed flashing into mortar joints as units are set in accordance with other Division 4 Unit Masonry Sections.
   4. Leave head joints open in coping and other units with exposed horizontal surfaces. Keep joints clear of mortar, and rake out to receive sealant.

E. Rake out joints for pointing with mortar to depths of not less than 3/4 inch. Rake joints to uniform depths with square bottoms and clean sides. Scrub faces of units to remove excess mortar as joints are raked.

F. Point mortar joints by placing and compacting mortar in layers not greater than 3/8 inch. Compact each layer thoroughly and allow to become thumbprint hard before applying next layer.

G. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness, unless otherwise indicated.

H. Provide expansion, control, and pressure-relieving joints of widths and at locations indicated.
   1. Sealing joints is specified in Section 07900, "Seal and Sealants".
   2. Keep joints free of mortar and other rigid materials.

3.3 INSTALLATION TOLERANCES

A. Variation from Plumb: Do not exceed 1/8 inch in 10 feet or 1/4 inch in 20 feet or more.

B. Variation from Level: Do not exceed 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 3/8 inch maximum.

C. Variation in Joint Width: Do not vary joint thickness more than 1/8 inch in 36 inches or one-fourth of nominal joint width, whichever is less.

D. Variation in Plane between Adjacent Surfaces (Lipping): Do not exceed 1/16-inch difference between planes of adjacent units or adjacent surfaces indicated to be flush with units.

3.4 ADJUSTING AND CLEANING

A. Remove and replace stained and otherwise damaged units and units not matching approved Samples. Cast stone may be repaired if methods and results are approved by Contracting Officer.

B. Replace units in a manner that results in cast stone matching approved Samples, complying with other requirements, and showing no evidence of replacement.

C. In-Progress Cleaning: Clean cast stone as work progresses. Remove mortar fins and smears before tooling joints.

D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed cast stone as follows:
   1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Clean cast stone by bucket and brush hand-cleaning method described in BIA Technical Notes No. 20 Revised II, using job-mixed detergent solution.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified in this section will be paid for on a lump sum basis per location indicated wherein no measurement will be made. No separate measurement will be made for mortar and grout, and any other equipment or accessories specified for the work, as they are considered incidental to and integral part of the finished work.

END OF SECTION 04720
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies structural steel work for bridges and includes shop coating of steel.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO HB-17 - Standard Specification for Highway Bridges

2. AASHTO/AWS D1.5M/D1.5 - Bridge Welding Code

B. American Institute of Steel Construction (AISC):

1. AISC 303 - Code of Standard Practice for Steel Buildings and Bridges

2. AISC 348 - Specification for Structural Joints Using ASTM A325 or A490 Bolts

C. American Railway Engineering Association (AREMA):

1. AREMA Chapter 15 - Steel Structures Volume 2/Structures (Manual for Railway Engineering - Fixed Properties, Vol. 2)

D. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code - Steel

E. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A6/A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

2. ASTM A27/A27M - Standard Specification for Steel Castings, Carbon, for General Application

3. ASTM A36/A36M - Standard Specification for Carbon Structural Steel

4. ASTM A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished

5. ASTM A109/A109M - Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled


8. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

9. ASTM A242/A242M - Standard Specification for High-Strength Low-Alloy Structural Steel

10. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

11. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

12. ASTM A370 - Standard Test Methods and Definitions for Mechanical Testing of Steel Products

13. ASTM A449 - Standard Specification for Quenched and Tempered Steel Bolts and Studs


15. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts

16. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

17. ASTM A588/A588M - Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4-in. (100-mm) Thick

18. ASTM A668/A688M - Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use


20. ASTM A709/A709M - Standard Specification for Carbon and High-Strength Low-Alloy Structural Steel Shapes, Plates, and Bars and Quenched-and-Tempered Alloy Structural Steel Plates for Bridges

22. ASTM F436 - Standard Specification for Hardened Steel Washers

23. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

F. Military Specification (MIL):
1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).
2. MIL-PRF-26915 - Primer Coating, for Steel Surfaces.

G. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
1. SSPC Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic").
2. SSPC VIS 1 - Visual Standard for Abrasive Blast Cleaned Steel (Standard Reference Photographs)

1.3 SUBMITTALS

A. Shop Drawings:
1. General: Shop drawings shall not be the reproductions of the Contract drawings.
2. Structural details: Include the following:
   a. Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.
   b. Details of location, type, sizes of bolts, and welds and for welded structures details of welding as specified.
   c. Structural computations for designed work certified by a Professional Engineer licensed in the State of Texas.
3. Match marks: Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.
4. Welding:
   a. Complete shop details of qualification test specimens.

B. Manufacturer's Data and Samples: Prior to the start of any shop painting work submit to the Contracting Officer for approval, the following:
1. Complete Data Sheets of the shop coating material to be used, identified by the manufacturer, brand name and product number, color, and batch number.
2. Written procedures for compliance with this specification, covering storage, handling, surface preparation, application, curing, repair, and inspection.

C. Certifications:
1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.
2. Certified quality assurance testing and inspection reports.
3. Submit certification verifying that welding personnel have been qualified in accordance with AASHTO/AWS D1.5M/D1.5, for the required positions and techniques utilized.
4. Manufacturer's certification that bolts meet approved testing.
5. Submit certifications for both the inspection and testing personnel who will inspect the welding showing they comply with requirements of AASHTO/AWS D1.5M/D1.5.

1.4 QUALITY ASSURANCE

A. Source Quality Control:

1. The Contracting Officer will have the authority to reject any material or work which does not meet the requirements of these specifications.

2. Testing and inspection:

a. Nondestructive test requirements for welded members: Perform the following:

1) Tension butt welds in fracture-critical non-redundant members and member components of structures subject to repetitive dynamic loading: 100 percent of welds inspected by radiographic examination and as specified in AASHTO/AWS D1.5M/D1.5.

2) Groove welds of flange material for compression and tension splices: 100 percent of welds inspected by radiographic examination.

3) Groove welds for web splices beginning at point of maximum stress: 40 percent of welds inspected by radiographic examination.

4) Fillet welds connecting web plates to flange plates: 25 percent of welds inspected by magnetic particle inspection.

5) For other fillet weld connections: 10 percent of welds inspected by magnetic particle inspection.

6) Visual inspection of welds for conformance to details shown on shop drawings and quality.

7) When testing, examination, and inspection as specified or scheduled herein reveals faulty welds, joints of the same type will be checked until the integrity of the welds is assured before resuming the specified schedule.

b. Mill Testing:

1) For identified stock materials provide three specimens from each heat number, one for tension test, one for bend test, and one for Charpy V-notch impact test.

2) Cut, machine and test specimens in accordance with ASTM A370.

3) Mill test reports shall reflect the following:

a) Specification to which material is provided.

b) Heat number of material.

c) Chemical and physical properties of material.

d) Impact test data when required.

4) Perform Charpy V-notch impact test on materials used for tension flanges and other tension components in accordance with ASTM A588, Zone 1 (Minimum service temperature, 0 degrees F and above). Sampling and testing procedures in accordance with ASTM A673 using the (H) frequency of heat testing.

5) Subject the fracture-critical members (FCM’s) to the further requirements set forth in the AASHTO/AWS D1.5M/D1.5.

a) FCM’s are defined as those tension members and components thereof whose failure would be expected to result in collapse of the bridge. Any component that is welded to a fracture critical member is considered part of that member and therefore, shall be
b) Fracture-critical members are specifically designated in the plans with the designation FCM.

c. Bolts: The Contracting Officer will randomly select at least five bolts for test purposes from each bin of bolts furnished. Not less than three bolt, nut and washer assemblies from each lot supplied shall be tested in a tension measuring device to demonstrate that the bolts and nuts, when used together, can develop the specified tension requirements.

d. Painting:

1) Inspect and test each phase of the shop prime painting work, and unacceptable conditions corrected and reinspected until approved, before transporting to job site.

2) Provide the following items to the Contracting Officer so that he may perform inspection and testing.

a) Air temperature thermometer 30 degrees F to 120 degrees F.

b) Surface temperature thermometer 0 degrees F to 250 degrees F.

c) Sling psychrometer 30 degrees F to 110 degrees F or continuous recording hygrometer.

d) Pictorial surface preparation standards SSPC VIS 1.

e) Surface profile measuring device Keane-Tator, Clemtex or Testex.

f) Wet film thickness gauge 0.5 to 20 mils.

g) Magnetic dry film thickness gauge Mikrotest 102/FIM or approved equal.

B. Qualification of Welding Personnel and Procedures:

1. Prior to qualifying welding personnel and welding procedures, submit and obtain approval from the Contracting Officer for procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment. Refer also to Section 01450, “Quality Control”, for further information and compliance.

2. Employ welding personnel whose qualification is certified in accordance with AASHTO/AWS D1.5M/D1.5. Such certification is to remain in force for the duration of the welding operations under this Contract.

3. Do not start fabrication until qualification has been successfully completed and procedures approved.

C. Qualification of Nondestructive Testing Personnel:

1. Conduct nondestructive testing of fracture-critical members, by personnel qualified as NDT Level II or Level III or ASNT-TC1A Level II or III, in accordance with AASHTO HB-17 Guide Specifications.

2. Supervise Level II technicians with Level III personnel.

3. Visual inspections will be performed by an AWS CW1.

D. Qualification of Fabrication Plants:

1. Fabricate members or member components in “Fracture Critical Members” (FCM) category by plants certified under AISC Quality Certification Program, Category III Major Steel Bridges.

2. Use experienced, knowledgeable personnel, procedures and equipment.

E. Stock Material:

1. For qualification of welding personnel and procedures and for quality assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.

2. Material Identification:

a. Inform the Contracting Officer at least 10 days in advance of commencing fabrication to permit
sampling and testing. Select identified material from as few heats as possible.

b. Use stock material that can be identified by heat number and mill test report.

c. The Contractor’s system of assembly-marking individual pieces, and the issuance of cutting instructions to the shop shall be such as to maintain identity of the original piece.

d. Use a marking system (color codes, stencils, etc.) which will identify the source of structural steel by heat number. Loss of positive identification will require testing to establish acceptability. Testing shall be performed by a commercial agency at the Contractor’s expense.

e. Each approved type of steel shall be identified by a color code in accordance with ASTM A6. The color “white” shall be used for ASTM A36 steel.

F. Comply with AWS: D1.1/D1.1M, except as follows:

1. For welding of structural steel, AASHTO/AWS D1.5M/D1.5.

2. For welding of “Fracture Critical” members; AASHTO/AWS D1.5M/D1.5.

G. Welder’s Identification Mark:

1. Assign each welder and welding operator an identification mark to stamp on pieces he has welded.

2. Have welder or welding operator place his identification mark by metal die stamp in letters 3/8 inch high in position that identification of welder or operator will appear adjacent to each of his welds in finally assembled members for ready reference to radiographic films and for identification by the Contracting Officer.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. General:

1. Load, transport, unload, and store structural materials to keep them clean and free from damage.

2. Store material above ground on platforms, skids, or non-abrasive supports and ensure proper drainage and protection from corrosion or damage to the coating.

3. Use acceptable methods to lift materials to protect coatings.

B. Steelwork:

1. Handle and store girders and beams in upright position. Properly brace and support to prevent damage from torsional, vertical or lateral deflections.

2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material.

3. Members suspected of damage during handling, transporting, or storing subject to non-destructive tests as directed by Contracting Officer.

4. Replace pieces bent or damaged unless repair is approved. Repair scraped or gouged pieces by grinding or filing.

5. Indicate weight on members weighing more than three tons by means of paint contrasting with shop coat.

6. Mark structural members in accordance with approved erection plans.

7. Store prime coated steel off the ground on nonabrasive supports and stacked on nonabrasive separators. Use acceptable methods to lift coated steel where the use of chains or steel cable would damage the coating.

C. Bolts and Nuts:

1. Ship small parts such as bolts, nuts, washers, pins, fillers and small connecting plates or angles in boxes, crates or barrels.

2. Pack separately bolts of each length and diameter and loose nuts or washers of each size.

3. List and describe contents of each box, crate, keg, or barrel on the outside of each package.

D. Coating Materials:

1. Receive and store coating materials in the manufacturer’s original, unopened containers bearing a legible product designation, batch number, and date of manufacture on the side of each container. Do not open containers except for immediate use.

2. Store coating materials according to the manufacturer’s latest printed instructions and protect from damage, moisture, direct
PART 2 - PRODUCTS

2.1 MATERIALS

A. General Requirements For Rolled Steel Plates, Shapes, And Bars: ASTM A6.

B. Structural Steel for Bridges: ASTM A709, grade as specified on design plans.

C. Low-Carbon Steel Bolts and Nuts: ASTM A307, Grade A or B for bolts. ASTM A563, Grade A for nuts.

D. High-Strength Bolts, Nuts, and Washers for Structural Joints: ASTM A325, Type as specified on plans for bolts. ASTM A563, Grade as recommended in Table X1.1, in ASTM A563, for nuts.

E. Circular, Clipped, and Beveled Washers:
   1. ASTM F436.
   2. Make beveled washers square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
   3. Diameter of hole in square beveled and circular washers as follows:
      a. For bolts less than 1 inch diameter: 1/16 inch larger than bolt size.
      b. For bolts larger than 1 inch diameter: 1/8 inch larger than bolt size.

F. Carbon Steel Forgings: ASTM A668.

G. Alloy Steel Forgings: ASTM A668.


I. Carbon Steel Castings: ASTM A27

J. Shear Connectors:
   1. Cold-rolled carbon-steel strip.
   2. Stud welding fasteners with upset head developing tensile strength of 65,000 psi minimum and yield strength of 52,000 psi minimum.

3. Complying otherwise to the following: Cold-finished bars, Grade 1015, Grade 1018 or Grade 1020, semi-killed or fully killed: ASTM A108.

4. Stud welding conforming to AASHTO/AWS D1.5M/D1.5.

5. Sizes and shapes: As shown.

6. Lengths to be after-weld lengths.

7. Studs arc-welded to parent metal as shown.

8. Before welding, parent metal surface to be free from rust, oil, paint, plating, and other foreign matter.

9. Heat treat parent metal where needed to develop full weld strength.

2.2 MISCELLANEOUS STEEL

A. Steel Plates and Shapes: Steel, ASTM A709, grade as shown on drawings.

B. Welded Headed Studs: ASTM A108, Grade 1015 or 1020, cold finished carbon steel headed studs.

C. Anchor Bolts: ASTM F1554, Grade 55, unless noted otherwise on drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers.

D. Galvanized Steel: ASTM A153/A153M.

E. Bearing: In accordance with Items 434 and 435 of the TxDOT Standard Specifications for Construction of Highways, Streets, and Bridges.

F. Dowels: As shown.

2.3 GALVANIZING

A. Steel products specified as galvanized. Hot-dip galvanized after fabrication, in accordance with the following:

1. Zinc coating on products fabricated from rolled, dressed and forged steel shapes, plates, and strips: ASTM A123.


B. Galvanizing Repair Paint:
   1. For Concealed or Top Coated Surfaces:
      a. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
         1) ASTM A780.
2. For Surfaces to be Left Exposed:
   a. In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
      1) MIL-P-21035.
      2) MIL-PRF-26915.
   b. Basis-of-Design: Brite Products "Brite Zinc".

2.4 PAINT

A. Primer: As specified in Section 09970, "Coatings for Steel" Paint and Coating System No. 1. Use make as selected for finish coating.

B. The following removable rust preventatives are acceptable for coating machined surfaces:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashland Petroleum Co.</td>
<td>Tectyl 890</td>
</tr>
<tr>
<td>Daubert Chemical Co.</td>
<td>Nox Rust 501 LS</td>
</tr>
<tr>
<td>Houghton Chemical Co.</td>
<td>Cosmoline 1062</td>
</tr>
<tr>
<td>Or approved equal</td>
<td></td>
</tr>
</tbody>
</table>

C. Products for erection marking shall be verified to be compatible with the selected painting system.

2.5 FABRICATION

A. Accomplish workmanship and finish to standards referenced in Section 01450, "Quality Control". For railroad structures, shop workmanship and fabrication procedures shall be accordance with Chapter 15 of the latest AREMA Specification.

B. Camber girders for dead load as shown on plans. Girders require shop assembly, reaming, and matchmarking of connections. The Contractor shall submit a detailed procedure to the Engineer for approval prior to heat curving or cambering any beam or girder.

C. Straightening Material:
   1. Use rolled material that, before being laid off or worked, is straight within tolerances specified in ASTM A6.
   2. Perform straightening where necessary by approved methods approved by the Contracting Officer which will not overstress material.

D. Tolerances are as follows:
   1. Flanges of completed girders shall not depart from straightness or the specified camber by more than 1/8 inch in any ten feet along the flange.
   2. The plane of bearing area of beams and girders shall be perpendicular to the vertical axis of the beam within 1/16 inch.
   3. The plane of the bearings supporting a box girder shall be perpendicular to the vertical axis of the girder within 1/16 inch and true to each other, in that plane, to 1/16 inch. Each bearing shall be true to 1/32 inch across its entire width in the short direction.
   4. The plane of the beam supports on box girders are bearing areas and shall be true to the box girder bearings to 1/16 inch in the short direction and true to the vertical axis of the nesting beams/girders to 1/16 inch.

E. Cutting:
   1. Flame cut edges of members subject to dynamic loading by mechanically guided torch or by hand, when approved. Remove nicks by grinding to depth not exceeding 1/4 inch.
   2. Shape re-entrant corners notch-free to radius of 3/4 inch minimum.
   3. Perform flame cutting so that metal does not carry stress during cutting operation.
   4. Direct flame so that remaining material is not damaged.
   5. Except as otherwise permitted on the plans, steel plates for main members shall be cut and fabricated so that primary direction of rolling is parallel to the direction of the main tensile and/or compressive stress.
   6. Edges of main members which are sheared or oxygen cut, and other exposed edges to be painted, shall be rounded or chamfered.
to an approximate 1/16 inch radius by grinding.

**F. Planing and Facing:**

1. Plane to depth of 1/4 inch sheared edges of plates more than 5/8 inch thick which will carry calculated stress.

2. Face and bring abutting joints to even bearing where shown.

3. Fabricate floor beams, stringers, and girders having end connection angles to length back to back of connection angles.

4. For compression joints depending on contact, prepare bearing surfaces to a common plane by milling, sawing, or other approved means.

5. Where end connections are faced, ensure that finished thickness of angle is not less than that shown.

6. The milled surface of bearing stiffeners shall meet ANSI surface roughness of 500, and provide an even bearing against the flange.

**G. Bolt Holes:**

1. Punch or drill holes for bolts.

2. Pitch and edge distance not shown on the plans shall be in accordance with the latest edition of the AASHTO HB-17.

3. Subpunch or subdrill and ream assemblies. Use a steel template for alignment of connections as necessary. Flame cutting is prohibited.

4. Subdrill or subpunch holes 3/16 inch less than nominal diameter of bolt; after assembly ream holes 1/16 inch greater than nominal diameter of bolt or drill from the solid to 1/16 inch greater than nominal diameter of bolt.

5. Holes in field splices of main box girders, continuous beams, and plate girders shall be subpunched (or subdrilled) and reamed assembled, or drilled full size assembled, to correct position in the finished structure due to grade, camber, or curvature. Layout shall be as shown on the shop drawings and shall be approved by the Contracting Officer before reaming or drilling is done by the fabricator.

6. Holes for floor beams and stringer end connections shall be subpunched and reamed to a steel template.

7. Holes for secondary members such as diaphragms and laterals may be punched full size.

**H. Connections:**

1. Except where welded or ASTM A307 bolted connections are shown, use ASTM A325 bolts for shop connections.

2. Unless otherwise shown, bolt field connections using ASTM A325 bolts in accordance with AISC Manual of Steel Construction.

3. Use of ASTM A490 bolts for dynamic or fluctuating loadings is prohibited.

**I. Plates:**

1. Bent plates: For load carrying cold-bent plates, use identified stock, and arrange direction of bending at right angles to direction of rolling. Ensure radius of bend, measured on concave face of metal, is not less and preferably more than the following:

<table>
<thead>
<tr>
<th>Plate Thickness</th>
<th>(t) Minimum Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to ½ inch</td>
<td>2.0t</td>
</tr>
<tr>
<td>Over ½ to 1 inch</td>
<td>2.5t</td>
</tr>
<tr>
<td>Over 1 to 1½ inches</td>
<td>3.0t</td>
</tr>
<tr>
<td>Over 1½ to 2½ inches</td>
<td>3.5t</td>
</tr>
<tr>
<td>Over 2½ to 4 inches</td>
<td>4.0t</td>
</tr>
</tbody>
</table>

J. Before bending, the corners of the plate shall be rounded to a minimum radius of 1/16 inch throughout the portion of the plate at which bending is to occur.

**K. Sheared plates:** For gusset plates or connection plates, use sheared plates designed to resist applied loads in more than one direction in plane of plate.

**2.6 SHOP WELDING**

**A.** Perform welding in accordance with AASHTO/AWS D1.5M/D1.5.

**B.** Perform procedure and sequence of welding so as to avoid needless distortion and to minimize stresses. Straighten transverse warpage of flanges, if necessary, by controlled heating along outside face.

**C.** Make allowance in shop for expected weld shrinkage in laying out and assembling members. Trim members to size when most or all of welding has been completed.

**D.** Complete butt welds in flange joints before flanges are assembled on web. Use extension blocks on such joints when making ends of butt welds
removing extension blocks only upon completion and cooling of weld. Ensure ends of welds are finished smooth and flush with edges of abutting parts. Use double-V- flange butt welds, unless otherwise shown.

E. Make welds in web plates where shown.

F. Fabricate built-up members by welding.

G. Prior to ultrasonic or radiographic testing of butt welds of flanges and webs, grind, or machine weld reinforcement of joint to remove irregularities of weld surface so that it merges smoothly with base surface; one side for ultrasonic testing and both sides for radiographic testing.

H. Ensure that welded joints which are to be radiographed are free of paint, scale, and grease. Grind off welded ripples and surface irregularities on both sides of joint. Grind perpendicular to length of weld and to such a degree that resulting radiographic contrast due to remaining irregularities cannot mask or be confused with that of objectionable defect and so that weld surface will merge smoothly into adjoining surface.

I. Repair defective welds by chipping or melting out such defects from one or both sides of joint removing no more weld metal than necessary to correct defect. Reweld and have weld retested radiographically.

J. Welded Structures Subjected to Dynamic Loads:

1. Do not use backup bars for fracture-critical non-redundant members or member components. Refer to AASHTO/AWS D1.5M/D1.5 for requirements for the construction of fracture critical members.

2. Avoid use of backup bars elsewhere, unless explicitly permitted by original design.

3. When use of backup bars is unavoidable because of practicality but not explicitly permitted by original design, remove backup bar after welding is completed and affected surfaces of weld metal and base metal is ground flush. Ensure roughness of ground surfaces are similar to that of surrounding unaffected plate surface.

4. Do not use gas shielded metal arc, flux cored arc, electroslag, or electrogas welding processes for fabrication of fracture critical members.

5. Fully automatic submerged arc welding is required for this project.

K. Do not field weld unless specifically indicated on the plans or approved by the Contracting Officer.

2.7 SHOP ASSEMBLY

A. Undertake complete or progressive shop assembly of continuous plate and box girders, before reaming is started. Obtain approval of progressive shop assembly procedure.

B. Assembly of main span girders and box girders prior to reaming or drilling shall include at least three sections and each assembly thereafter shall include at least one adjacent section which has been reamed with a previous assembly. Assemblies shall be set to correct geometric position prior to reaming or drilling.

C. Clean surfaces of metals in contact with each other before assembling.

D. Assemble parts to line and fit; drill or ream bolt holes while assembled. Hand reaming is prohibited unless approved.

E. Assemble beams and girders of short structures in line assembly with a minimum length assembled of one complete span, from bearing to bearing.

F. Show camber and curvature offsets on shop drawings at approximately 10 foot intervals, measured along girder.

G. Permissible variation in specified sweep for horizontally curved beams and girders, measured in inches: 1/8 inch by 0.1 by (the number of feet from the end bearing), but not to exceed 1/2 inch.

2.8 SHOP COATING OF STEEL

A. Shop prime steel surfaces, except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.

2. Surfaces to be field welded.

3. Surfaces to be high-strength bolted with slip-critical connections, if primer does not meet the specified AISC slip coefficient.

4. Items indicated to be galvanized.

B. Prepare steel surfaces and apply shop primer as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 1 and as specified below:

1. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

2. Stripe paint corners, crevices, bolts, welds, and sharp edges.

3. Apply two coats of shop primer to surfaces that are inaccessible after assembly or
erection. Change color of second coat to distinguish it from first.

C. Machined Surfaces: Wipe machined surfaces clean with solvent, free of foreign matter before coating with rust preventative.

D. Field Coats: For finish coat of paint, see Section 09970, "Coatings for Steel" Paint and Coating System No. 1.

PART 3 - EXECUTION

3.1 ERECTION

A. Falsework:

1. Furnish, place, and upon completion of erection, remove any required staging, and/or falsework.

2. Use temporary bracing to support loads to which structure may be subjected including erection equipment, materials, and their operations. Remove bracing when no longer required.

B. Erection of Superstructure:

1. Follow methods, procedures, and sequences shown on the approved erection drawings. Report immediately to Contracting Officer errors in shop fabrication and, if any, damages resulting from handling or transportation.

2. Erect reamed connections, match-marked in the shop during shop assembly, in accordance with those match-marks. Do not interchange or revise reamed connections from those shown on erection diagrams.

3. Support plate girders, box girders, and continuous I-beams to maintain required camber.

4. Provide fit-up bolts of the same nominal diameter as the design connection bolts, and drift pins not less than 1/32 inch larger than the connection bolts to provide a driving fit.
   - a. Place fit-up bolts in a symmetrical pattern.
   - b. Do not use fit-up bolts in final construction.
   - c. Ensure that holes are not enlarged and that metal in vicinity of holes is not disturbed by drifting during assembly. Drift only as necessary to bring parts into correct alignment and position.

5. Enlargement of holes to accept bolts is prohibited unless approved by the Contracting Officer. If approved, enlarge by reaming; burning is prohibited. Avoid hand reaming.

6. Field welding is prohibited, unless specifically shown on plans or if directed by the Contracting Officer. When field welding is directed, submit in advance the work and safety plan for approval and implement the approved measures during field welding. Welding and inspecting/testing personnel must submit proper certification prior to commencing their work.

7. Install anchor bolts accurately in positions shown on the plans.

8. If anchor bolts are set during construction of substructure units, ensure that the bolts are accurately located and held firmly in a rigid template elevated to span the concrete surface with sufficient clearance to permit proper finishing of concrete surface. Remove template only after concrete has set.

9. If anchor bolts are set in preformed holes or in drilled holes, the following requirements apply:
   - a. Drill in exact location, to required depth, perpendicular to the plane of the bridge seat, just prior to time of setting anchors.
   - b. Do not drill holes smaller in diameter than the diameter of the holes in the steel base plate.
   - c. Grout with structural non-shrink grout as specified in Section 03305, “Portland Cement Concrete”.

10. Bearing assemblies shall be placed upon lead plates or preformed fabric pads which shall be approximately 1/8 inch thick and 1/2 inch greater in length and width than the bottom bearing (masonry) plate under which they are placed.
   - a. Lead plates shall weigh approximately 8 pounds per square foot.
   - b. Fabric pads shall consist of fabric and rubber body made from new unvulcanized rubber and unused fabric fibers in proper proportion to maintain strength and stability. Type A shore durometer surface hardness of the vulcanized and cured pad shall be 70 - 90 and shall be capable of withstanding compressive loads of
not less than 7000 pounds per square inch.

c. Shop drawings are not required for lead plates or fabric pads.

3.2 FIELD BOLTING

A. Provide connections using high-strength steel bolts in accordance with AASHTO HB-17 Division I and Division II using ASTM A325 bolts.

B. Assemble high-strength bolted parts so that they fit solidly together when assembled. Do not use gaskets or other compressible materials. Use of lubricants on friction threaded bolts and nuts is prohibited.

C. Remove scale, dirt, burrs, and other defects likely to prevent proper seating when assembling joint surfaces, including those adjacent to washers.

D. Remove oil, paint, lacquer, and galvanizing from contact surfaces of friction joints.

E. Tightening Bolts:

1. Tighten A325 bolts to bolt tension not less than proof load given in AASHTO HB-17 Division II, Section 11.

2. Tighten by means of properly calibrated torque wrenches or turn-of-nut method. Alternatively tension indicating washers may be used to determine tension.

3. When tightening, place hardened washer under turned element (nut or bolt head), depending on which element is turned in tightening operation.

4. Calibrate torque wrenches by tightening bolt assembly in device capable of indicating actual bolt tension.

a. Set wrenches such as to induce a bolt tension 5 percent to 10 percent in excess of the specified value.

b. Recalibrate wrenches at least once each day by tightening, in a device capable of indicating actual bolt tension, not less than three bolts of each diameter from the bolts to be installed.

5. Measure torque when nuts or bolts are in tightening motion.

6. Adjust power wrenches, if used, to cut out or stall at required tension.

7. When tightening, do not allow rotation of the part not being turned by the wrench.

F. Arrange bolts so that heads show in areas exposed to public view.

3.3 ADJUSTING AND CLEANING

A. Galvanized Surfaces:

1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

B. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint shall be completed to blend with the adjacent surfaces. Such touch up work shall be done in accordance with manufacturer’s instructions as specified in Section 09970, “Coatings for Steel”.

3.4 QUALITY CONTROL

A. In accordance with Section 01450, “Quality Control”.

B. Inspection: Contracting Officer shall be notified and given the opportunity to observe installation and tightening of bolts to determine that the selected tightening procedure is properly used and that bolts are tightened, including shop and field bolts, tested in place.

1. When the calibrated wrench method of tightening is used, the Contracting Officer shall be given full opportunity to witness the calibration tests prescribed in a. herein.

2. The Contractor, in the presence of the Contracting Officer, shall use an inspected wrench that can be accurately adjusted in accordance with the requirements of a. herein.

3. When the inspection wrench is a torque wrench, each calibration test bolt shall be tightened in the calibration device to the minimum tension specified for its size in 3. herein. The inspecting wrench shall then be applied to the tightened bolt, and the torque necessary to turn the nut or bolt head 5 degrees (approximately 1 inch at 12 inch radius) in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job-inspecting torque.

4. When the inspecting wrench is a power wrench, it shall be adjusted so that it will tighten each calibration test bolt to a tension of at least 5 but not more than 10 percent greater than the minimum tension specified for its size in 3. herein. This setting of the wrench shall be taken as the job-inspecting torque.
5. Bolts represented by the sample prescribed in a. herein that have been tightened in the structure shall be inspected in the presence of the Contracting Officer by applying, in the tightening direction, the inspecting wrench and its job-inspecting torque to 10 percent of the bolts, but not fewer than two bolts, selected at a random in each connection. If no nut or bolt head is turned by this application of the job-inspecting torque, the connection will be accepted as properly tightened. If any nut or bolt head is turned by the application of the job-inspecting torque, the torque shall be applied to bolts in the connection. Bolts whose nut or head is turned by the job-inspecting torque shall be tightened and reinspected, or the bolts in the connection may be retightened and the connection resubmitted for the specified inspection.

6. Inspection of installations using tension-indicating washers will normally be accomplished by checking the residual gap with a metal feeler gage. Installations will be considered satisfactory if the average gap per bolt installation does not exceed 0.015 inch for a tension-indicating washer installed under the bolt head, or 0.010 inch for a tension-indicating washer installed in conjunction with a hardened, flat washer, or if the gap has been reduced to zero at any point around the indicator.

7. The Contracting Officer may verify, by calibrated wrench, that the work conforms to the specified tightening requirements regardless of the method of installation.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Structural steel shall be measured for payment in units of pounds by class such as carbon steel, low alloy steel, etc., and based upon computed weights from approved shop drawings. No allowance is made for erection bolts, excess field rivets or similar items, or the weight of paint, galvanizing, or weld material.

B. Increases in size or weights of members made at the Contractor’s convenience, even though approved by the Contracting Officer, will not be measured for payment, but measurement will be based upon approved Shop Drawings.

C. Deductions will be made for cuts, copes, perforations, and holes except bolt and rivet holes.

D. Weights of steel bolts are included for payment on the basis of the following weights per 100 bolts:

- 3/4 inch diameter - 65 pounds.
- 7/8 inch diameter - 95 pounds.
SECTION 05124
OVERHEAD CONTACT SYSTEM STEEL POLES – WIDE FLANGE

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section includes providing and delivering new wide flange steel poles and installation by the Contractor, as part of the Overhead Contact System (OCS) shown on the Contract Drawings and specified herein.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers International (ASME)

B. American Institute of Steel Construction, Inc. (AISC)
   1. Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings
   2. Code of Standard Practice for Steel Buildings and Bridges

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM 123/A 123M - Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   2. ASTM 143/A 143M - Safeguarding Against Embrittlement of Hot-Dip Galvanized Steel Products and Procedure
   3. ASTM A153 / 153 M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   4. ASTM A194/A194M - Specifications for Carbon and Alloy Steel Nuts
   5. ASTM A283 - Low and Intermediate Tensile Strength Carbon Steel Plates
   6. ASTM A307 - Carbon Steel Externally Threaded Standard Fasteners
   7. ASTM A370 - Methods and Definitions for Mechanical Testing of Steel Products
   8. ASTM A384 - Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
   9. ASTM F436 - Specifications for Hardened Steel Washers
   10. ASTM A500 - Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   11. ASTM A501 - Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
   12. ASTM A563 - Carbon and Alloy Steel Nuts
   13. ASTM A572 - High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality
   15. ASTM B6 – Standard Specification for Zinc
   16. ASTM E1316 - Standard Definitions of Terms Relating to Magnetic Particle Examination
   17. ASTM E709 - Standard Recommended Practice for Magnetic Particle Examination
   18. ASTM F593 - Stainless Steel Bolts, Hex Cap Screws, and Studs

D. American Welding Society (AWS)
   1. AWS D1.1/D1.1M;2004 - Structural Welding Code, Steel
   2. AWS WI Ch 12 - Computerization of Welding Inspection and Quality

E. Department of Defense Specifications (DOD)
   1. DOD-P-21035A   Paint, High Zinc Dust Content, Galvanizing Repair

F. Military Standard
   1. NAVY MIL DTL 24441/20A - Primer coating, zinc dust-zinc oxide (for galvanized surfaces)

G. Federal, State and Local Authorities
   1. All applicable codes and regulations

H. Corps of Engineers Publications
   1. CRD-C588 Non-shrink Grout

1.3 SUBMITTALS

A. Refer to these Specifications for submittal procedures.

B. Within 45 days of commencing Work, the Contractor shall submit shop drawings for review giving complete information required for fabrication of the poles. The shop drawings shall be to scale and shall indicate all
fitting, holes and accessories, and the locations, sizes and types of all welds.

C. Shop drawings shall be prepared under the signature and seal of a Licensed Texas Professional Engineer.

D. Within 45 days of commencing welding Work, the Contractor shall submit for acceptance:

1. Specifications for welding procedures in accordance with AWS D1.1.

2. Certificates of qualifications of welders, welding operators and tackers in accordance with AWS W1 CH12.

3. Certificate of qualification of welding inspectors in accordance with AWS W1 CH12.

E. Before commencing fabrication, the Contractor shall submit for review the manufacturer's certificates of compliance, or certified laboratory test reports demonstrating the compliance of all raw materials and fabricated products with paragraph 2.2, "Fabrication," of this Section. Included shall be a listing of the ASTM standards designated by the manufacturer, as indicated.

F. Six copies of certified laboratory test reports shall be submitted prior to delivery of poles.

1.4 QUALITY ASSURANCE

A. The Contractor shall perform the Work included in this Section in strict accordance with the requirements of the Authority approved Contractor Quality Control Program.

B. The Contractor shall comply with the requirements of these Specifications and the codes and regulations of jurisdictional authorities.

C. The Contractor’s Quality Control Program shall include the following requirements:

1. Material qualification testing and certification for acceptance of materials, components and assemblies.

2. Job control testing of in-progress work being performed in shops, factories and on-site.

3. On-site inspection of specified work elements.

1.5 POLE TESTING AND INSPECTION

A. Material Testing

1. The chemical compositions and required mechanical properties of all materials used shall be determined, either by obtaining manufacturer's certificates of compliance or by laboratory testing at a facility acceptable to the Authority.

B. Embrittlement

1. Fabrication shall conform to ASTM A143 to prevent embrittlement of the steel.

C. Weld Testing

1. The services of an AWS Certified Welding Inspector shall be provided by the pole fabricator:

   a. Inspect Fabrication Operations

   b. Inspect Welding Procedures

   c. Inspect Welding Personnel Qualifications

   d. Perform Ultrasonic and Magnetic Particle Testing

2. A visual inspection of all welds shall be performed in conformance with the AWS Code.

3. Weld testing shall be performed on a sample number of each type of pole, selected at random by the Authority, comprising five percent of the total number of poles. All poles selected for testing shall be tested by the ultrasonic and magnetic particle methods.

4. Equipment, procedures and personnel for weld testing, and test reports, shall conform to the requirements of AWS D1.1, Section 6 - Inspection.

5. Weld testing shall consist of:

   a. Ultrasonic testing conforming to the AWS D1.1, Section 6 requirements.

   b. Magnetic particle testing conforming to the ASTM E709 requirements.

6. Ultrasonic testing shall be performed on the complete penetration welds between the pole shaft and base.

7. For each tested pole that is found to be unacceptable, weld testing shall be performed on a further sample of two poles, selected at random by the Authority from the remaining untested pole population.

8. Results of weld testing shall be deemed acceptable or unacceptable in accordance with AWS D1.1, Sections 8, 9, or 10.

9. Welds found to be unacceptable shall be repaired in accordance with AWS D1.1, Section 3, and retested.

D. Galvanizing Testing
1. All galvanized items shall be inspected for conformance with the requirements of the following ASTM Specifications, as applicable:
   a. Galvanizing Compliance: A123 or A153
   b. Embrittlement: A143
   c. Distortion: A384

E. Impact testing:

1. Structural steel materials for base plates and pole shafts shall be tested for impact toughness in accordance with the Charpy V-notch test as specified in ASTM A370. The minimum energy value shall be 15 feet-pounds at 0 degrees F.

F. Inspection

1. Provisions shall be made for inspection of the fabrication and testing by the Authority. The Contractor shall provide two weeks advance notice for the Authority inspection. Inspection by the Authority at the point of manufacture shall not constitute acceptance of the work as specified.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. During fabrication and delivery, the poles shall be handled and transported in a manner to preclude damage to either the structural steel or the zinc coating.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wide Flange Poles

1. Wide Flange Pole shaft and components (base plates, stiffeners, bracket arms) shall be fabricated using ASTM A992 steel. The pole shaft shall be fabricated from one piece (no splicing).

B. Weld Filler

1. Weld filler metal shall be selected in compliance with the welding procedures of AWS D1.1.

C. Zinc

1. Zinc used for hot-galvanized coating shall be Prime Western Grade, or approved equal, conforming to ASTM B6.

D. Zinc rich paint shall conform to Federal Specification TT-P-641, Type II; and shall be Tnemec-Zinc Series 90-93 as manufactured by Tnemec Co., Inc.; Carbo-

Zinc SP81 as manufactured by Carbole; or approved equal.

E. Galvanizing repair compound shall conform to Federal Specification No. DOD-P-21035A, Galvalloy by Metalloy Products Co., Hardhat 2165 by Rust-Oleum, ZRC by ZRC Chemical Products, or approved equal.

2.2 FABRICATION

A. Poles, fittings, and accessories shall be fabricated to the dimensions shown on the Contract Drawings.

B. Methods and Tolerances

1. Poles, fittings, and accessories shall be fabricated by methods and within tolerances conforming to the AISC Specifications, except as specified herein.

C. Wide Flange base plates tolerances:

1. Bolt Circle +/- 1/16 inch.
2. Hole Diameter + 1/16, - 0 inch
3. Location of Holes + 1/16 inch in each direction.

D. Welding Procedures

1. Welding procedures, welders, welding operations and tackers shall conform to the provisions of AWS D1.1, Section 2, Design of Welded Connections; Section 3, Workmanship; Section 4, Technique; and Sections 8, 9, and 10.

E. Weld Repair

1. Welds found to be unacceptable shall be repaired in conformance with the provisions of AWS D1.1, Section 3, Workmanship.

F. Surface Grinding

1. Before galvanizing, all penetration welds shall be ground flush with base metal to eliminate surface cracks. All other welds and cut edges shall be ground to eliminate sharp edges and burrs.

G. Pole Straightening

1. Before galvanizing, the poles shall be straightened as required to conform to the specified requirements. Straightening methods shall not require heating of the poles.

H. Galvanizing

1. After fabrication, the poles, fittings and accessories shall be hot-dip galvanized inside
and out, in conformance with ASTM A123 or ASTM A153, as required. All pole fabrications shall be galvanized for their entire length, at one time, in a single hot-dip galvanizing bath. Galvanizing by successive dippings of partial pole lengths shall not be permitted.

I. Pole Identification Plate

1. A stainless steel pole identification plate shall be attached to each pole at 24 inches above the base plate. The plate shall show the pole type, structure number, and the manufacturer's name and date of manufacture. The identification plate shall be 4 inches by 1.5 inches and embossed with 0.75 inch high letters and numbers. The plate design, style of lettering and method of attachment shall be Authority approved.

J. Pole Type Assembly Mark

1. Pole type assembly number shall be hard marked with a minimum height of 3/4 inch and a minimum indentation of 1/16 inch. The hard mark shall be stamped on the top of the base plate and shall be visible after painting.

PART 3 - EXECUTION

3.1 DELIVERY AND STORAGE

A. Poles shall be delivered complete with associated fittings and accessories, properly packed and protected against damage and loss of parts. Poles shall be protected from damage during storage and handling, and during moving from the storage facility to the installation sites.

3.2 FIELD QUALITY CONTROL

A. Delivered poles, fittings, and accessories shall be inspected for conformance with requirements of this Section. Poles not acceptable will be removed and replaced at no additional expense to the Authority.

3.3 POLE SETTINGS

A. General

1. Wide flange steel poles shall be installed where shown on the Contract Drawings. Anchor bolts, nuts, and washers shown as cast-in-place will be provided and installed by the Contractor. Additional provisions prior to installation of the poles are as follows:

a. The Contractor shall inspect each OCS pole foundation for suitability of installing the designed pole. Any deficiencies with the OCS foundation shall be corrected by the Contractor at no additional cost to the Authority.

b. Perform any preparatory work required to install the pole such as chipping of concrete and cleaning of bolt threads. Cleaning of the bolt threads will generally require the use of the required chaser. Caution shall be exercised to prevent damage to the anchor bolts.

1) The Contractor shall repair the damage incurred at no extra cost to the Authority.

c. Straighten bent anchor bolts and or replace damaged ones as directed by the Authority. The Contractor shall be required to straighten or replace all bent or broken OCS foundation anchor bolts at no additional cost to the Authority.

d. The Contractor shall submit for Authority approval a procedure for straightening or replacing bent anchor bolts. The Contractor shall obtain Authority approval prior to commencing Work.

B. Pole Installation

1. All catenary poles shall be raked and/or adjusted to a plumb condition to compensate for the static load deflection induced by the wire and equipment. The final erected pole plumb (perpendicular) position shall not exceed one in 50 of true vertical with the pole fully loaded as measured within eight feet of its base and corrected for taper where applicable. Any pole lean shall be against the direction of the static loads.

2. The poles shall be raked in the unloaded position by adjusting the double nuts provided with the foundation. A minimum of two full threads shall protrude above the nut. The bottom nut shall clear the top of concrete a minimum of 3/4 inch and a maximum of 2-1/2 inches. All nuts shall be tightened by applying the required torque with a wrench.

C. Pole Fittings

1. The Contractor shall provide and install all fittings required for the specific installation, including, but not limited to, the following items:

a. Counterweight Holes

b. Brackets for Down Guys

D. Feeder Poles (Wide Flange Poles)

1. Wide flange feeder poles shall be fitted with cable support clamps as shown on the Contract Drawings. The Contractor shall
verify that any stiffener plates used on the feeder poles are installed in such a manner to allow correct routing of the feeder conduit risers.

E. Bracket Arms

1. Bracket arms shall be installed at the locations shown on the Contract Drawings. Installation shall conform to the following requirements:
   a. OCS support bracket arms shall be mounted and adjusted so that the contact wire can be installed at the wire heights, and within the tolerance limits, specified in this Specification.
   b. Bracket arm installation shall allow for pole rake and deflection caused by applied dead loads and wire tension loads. After overhead contact systems are installed and fully adjusted to the specified tensions, bracket arms and mountings shall be inspected, and readjusted as required.

F. Grounding and Bonding

1. All steel poles installed by the Contractor shall be electrically bonded to the foundation ground, or as shown on the Contract Drawings. Damage to the steel pole base plate galvanized coating shall be repaired in accordance with Paragraph 3.4, “Touch-Up,” of this Section.

G. Additional Requirements

1. If original foundations are replaced before poles are set, the poles shall be set not less than seven days after foundations are installed, and loaded to design requirements either not less than twenty-eight days after foundations are installed or until required concrete strength verified by test has been attained.

2. The Contractor shall exercise care during erection of poles to prevent damage and disfigurement. Nylon slings and chokers or other non-marking material shall be used for handling of poles. All imperfections on the steel poles shall be repaired as required to restore poles to a condition acceptable to the Authority. Damage to galvanized coatings shall be touched up as specified in Paragraph 3.4.

3. Caution is advised during steel pole erection to prevent contact with other overhead, and possibly energized, utilities.

3.4 TOUCH-UP

A. Areas of damaged galvanizing shall be coated with a compound such as Galvalloy by Metalloy Products Co., Hardhat 2185 by Rust-Oleum, ZRC by ZRC Chemical Products, or Authority approved equal.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the Work specified under Section 16371 “Overhead Contact System.”

END OF SECTION 05124
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section includes the following:

1. Design, fabrication and installation of metal fabrications for pole attachments, tunnel roof supports and over bridge supports required to secure the Overhead Contact System (OCS), as shown on the Contract Drawings and specified herein.

2. The fabricated items specified herein consist of steel and iron shapes, plates, bars, pipes, tubes, casting and roll-formed shapes, hot-dip galvanized after fabrication, which are not a part of an overall system specified in other sections of these Specifications.

3. Pole attachments and over bridge supports shall be fabricated as complete units, and hot-dip or electro-galvanized after fabrication in order to avoid the need for field painting, or for any finishing at the work site except for touch-up of damaged surfaces. Each unit shall be delivered complete with anchorage devices, ready for installation as specified in these Specifications, without requiring cutting or drilling at the work site. Units shall be protected against damage during shipment and handling.

1.2 REFERENCE STANDARDS

A. American Hot-Dip Galvanizers Association, Inc. (AHDGA)

1. Inspection Manual for Hot-Dip Galvanized Products

B. American Institute of Steel Construction (AISC)

1. AISC - Design, Fabrication and Erection of Structural Steel for Buildings

2. AISC - Code of Standard Practice for Steel Buildings and Bridges

C. American Iron and Steel Institute (AISI)

1. AISI - Stainless Steel Cold-Formed Structural Design Manual

2. AISI - Specifications for the Design, Fabrication and Erection of Structural Members

3. AISI - Design of Cold Formed Steel Structural Members

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

1. ASTM A6/A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

2. ASTM A 29/A 29M - Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for

3. ASTM 36 - Standard Specification for Carbon Structural Steel


5. ASTM A 48/ A 48M - Standard Specification for Gray Iron Castings

6. ASTM A 53/A 53M REV A - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

7. ASTM 108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished


9. ASTM A 143/ A 143M - Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

10. ASTM A153/A 153M - Zinc Coating (Hot-Dip) on Iron and Steel Hardware

11. ASTM A283/A 283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

12. ASTM A 325 REV B - High Strength Bolts for Structural Steel Joints, including Suitable Nuts and Plain Hardened Washers

13. ASTM A 384/A 384M - Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies

14. ASTM A 385 - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)

15. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

16. ASTM A563 REV A - Carbon and Alloy Steel Nuts
17. ASTM A 569/ A 569M - Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial
18. ASTM A 568/ A 568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
19. ASTM A575 - Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
20. ASTM 576 REV B - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality
22. ASTM D2092 - Preparation of Zinc-Coated Steel Surfaces for Painting

E. American Railway Engineering and Maintenance-of-Way Association (AREMA)
F. American Welding Society (AWS)
1. AWS D1.1/D1.1M - Structural Welding Code
2. AWS W1 CH12 - Qualifications of Welders and Welding Operators

G. The Society of Protective Coating (SSPC)
1. SSPC - Systems and Specifications, Steel Structures Painting Manual, Volume 2

1.3 SUBMITTALS
A. Refer to these Specifications, for submittal procedures.
B. Within 45 days of commencing Work, submit Shop Drawings for the fabrication and erection of assemblies of metal work that are not completely shown by manufacturer's data sheets. Include plan elevations at not less than 1 inch to 1-foot scale, and include details of sections and connections at not less than 3-inch to 1-foot scale. Show anchorage and accessory items.
C. Shop drawings shall be prepared under the signature and seal of a Licensed Texas Professional Engineer.
D. Within 45 days of commencing Work, submit manufacturer's product data, load tables, dimension diagrams, and anchor details indicating compliance with the Contract Specifications and Drawings requirements, and for products installation instructions to be used in the metal work fabrication, including paint products.
E. Within 45 days of commencing Work, submit welder certifications and qualifications, as required by AWS W1 CH12.

1.4 QUALITY CONTROL
A. The Contractor shall perform the Work included in this Specification in strict accordance with the requirements of the Contractor's Quality Control Program as Authority approved. The Contractor shall comply with the requirements of these Specifications.
B. The Contractor shall perform the following in accordance with these Specifications:
1. Material qualification testing and certification for acceptance of materials, components and assemblies.
2. Job control testing of in-progress work being performed in shops, factories and work site.
3. On-site inspection of specified work elements.
C. Qualifications: Provide major items of work fabricated by a firm that has been specializing in custom type metal fabrication for a minimum of five years on work of similar scope. Employ experienced workers for both fabrication and installation, who are capable of producing work of the highest standards of quality in the industry.
D. Inspection and Tests:
1. Inspections, tests, and samples shall conform to listed ASTM Specifications and Standards.
2. Inspection rights and privileges, procedures, and acceptance or rejection of galvanized steel materials shall conform to ASTM A123.
3. Inspection and tests include the following:
   a. Visual examination of samples and finished products.
   b. Tests to determine weight or mass of zinc coating per square foot of steel surface.
   c. Tests to determine distribution and uniformity of zinc coating.
   d. Tests to determine thread fittings of units, washers to bolts.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Packaging
1. Shall be of the type to prevent damage to galvanized surfaces and distortion of steel materials and components.
B. Handling and Storage:
1. Conform to ASTM A123.
2. Protect galvanized materials from damage to zinc coating.

3. To avoid humid storage stain, space surfaces of galvanized materials to permit free circulation of air.

C. Damaged Materials:
1. Repair material showing evidence of damage to zinc coating.
2. If not repairable, material with damaged coating will be subject to rejection.

PART 2 - PRODUCTS

2.1 FASTENERS AND ANCHORAGE MATERIALS

A. Fasteners shall be stainless steel or epoxy-coated to prevent rusting or staining.

B. Items listed below are indicated for minimum general conditions, and may be superseded by Section 2.2 A.

3. Expansion Anchor Bolts: Toothed steel or lead shield expansion devices to the type and size indicated, with galvanized bolts, except do not use lead shield type anchor bolts for overhead anchorage.
4. Lag Bolts: FS FF-B-561, type and grade as required.
5. Through Bolts or Eye Bolts, ASTM A193, Grade B7.
7. Washers: Carbon steel; plain, round complying with FS FF-W-92; locking, helical spring complying with FS FF-W-84, all galvanized.
8. Concrete Inserts: Unit-type inserts of the type and size indicated, of hot-dip zinc-coated steel.
9. Non-shrink, Nonferrous Grout: POR-ROK Anchoring Cement, Lehn & Fink Industrial Products, Division of Sterling Drug, or Authority approved equal.

2.2 FABRICATION, GENERAL

A. For the fabrication of metal work which will be exposed to view, use only materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, grinding, or by welding and grinding, prior to cleaning, treating and application of finishes including zinc coatings.

B. Use materials of the size and thicknesses indicated, or if not indicated, of the required sizes and thickness to produce adequate strength and durability in the finished product for the intended use. Work to the dimensions shown or accepted on shop drawings, using proven details of fabrication and support. Use the type of materials indicated or specified for the various components of work.

C. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Ease exposed edges to a radius of approximately 1/32 inch unless otherwise indicated. Form bent-metal corners to the smallest radius possible without causing grain separation or otherwise impairing the Work.

D. Verify dimensions by accurate field measurement before fabrication, wherever work adjoins other work that precedes it in construction. However, do not delay job progress; allow for trimming and fitting of metal work wherever the taking of field measurements before fabrication might delay the work. On shop drawings, note which dimensions have been verified by field measurement.

E. Weld corners and seams continuously and in accordance with the recommendations of AWS D1.1. Grind exposed welds smooth and flush to match and blend with adjoining surfaces.

F. Form exposed connections with hairline joints that are flush and smooth, using concealed fasteners wherever possible. Use exposed fasteners of the type indicated, or if not indicated, use Phillips flathead (countersunk) screws or bolts.

G. Pre-drill bolt holes and tapped holes for screws as indicated as required for attachment of metal work and for the attachment of adjacent materials.

H. Provide inserts and anchoring devices that must be set in concrete for the installation of metal work. Coordinate delivery of such devices with other work to avoid delay.

I. Provide for anchorage of the type indicated. Fabricate and space anchoring devices as indicated and as required to provide adequate support for the intended use of the work.

J. Cut, reinforce, drill and tap metal work as may be required to receive finish hardware and similar items of work.

K. Use hot-rolled steel bar for work fabricated from bar stock, unless work is indicated or specified to be fabricated from cold-finished or cold-rolled stock.

L. Pre-assemble work at shop to the greatest extent possible to minimize field splicing assembly of units at
OVERHEAD CONTACT SYSTEM FABRICATED METAL SUPPORTS

the work site. Disassemble units to the extent required to comply with shipping limitations. Mark all units clearly for reassembly and proper installation.

M. Where indicated as galvanized, complete the shop fabrication prior to application of the coating. Remove mill scale and rust, clean and pickle the units as required for coating. Apply hot-dip zinc coating of 2 ounces in accordance with ASTM A123.

2.3 GALVANIZING

A. Steel members, fabrication, and assemblies shall be galvanized after fabrication:

1. Method: Hot-dip process in accordance with ASTM A123.

2. Weight of zinc coating to conform to requirements specified under "Weight of Coating" in ASTM A123, as applicable.

B. Safeguard against steel embrittlement in conformance with ASTM A143.

C. Safeguard against warpage or distortion of steel members to conform to ASTM A384. Notify the Authority of potential warpage problems that may require modification in design before proceeding with steel fabrications.

D. Finish and uniformity of zinc coating and adherence of coating shall conform to ASTM A153.

E. Passivating: Galvanizing materials subject to extended periods of storage in open, exterior locations shall be given passivating treatment or light oiling to prevent humid storage stain; treatment, solution and process shall be subject to review and acceptance by the Authority.

F. Preservative Oils: Do not treat freshly galvanized or passivated surfaces with oils, grease, or chemicals that might interfere with adhesions of subsequent paint primers and coatings.

G. Field Inspection: Visually inspect galvanized materials, fabrications, and assemblies for conformity with applicable requirements of AHDGA, Inspection Manual for Hot-Dip Galvanized Products.

1. Steel for timber screw spikes shall be heat-treated to a minimum of 150,000 psi tensile strength.

2. Timber screw spike head shall be square headed or match equal drive sockets for installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set metalwork accurately in location, alignment and elevation, plumb, level, true and free of rack, measured from established lines and levels. Temporarily embrace or anchor in formwork where Work is to be built into concrete.

B. Fit exposed connections accurately together to form tight, hairline joints. Weld connections that are not to be left as exposed joints, but cannot be shop welded because of shipping size limitations. Grind joints smooth, and touch-up shop paint coat. Do not weld, cut or abrade the surfaces of exterior units which have been hot-dip galvanized after fabrication, and are intended for bolted or screwed field connections.

C. Anchor securely as shown or as required for the intended use, using concealed anchors wherever possible.

D. Grout with non-shrinking, nonferrous cement grout, or pack with lead wool and caulk where pipe sleeves are used to support metal Work. Provide galvanized steel pipe on pipe sleeves not less than 6 inches long and having an inside diameter not less than 1/2 inch greater than outside diameter of insert.

E. Install insulating devices or butyl tapes in between dissimilar metals.

3.2 TOUCH-UP

A. Immediately after erection, any areas of paint damaged by field installation, including field welding, shall be thoroughly cleaned to bare metal.

B. Paint those areas with the same material as used for shop coating.

C. Coat areas of damaged galvanizing with a compound such as Galvalloy by Metalloy Products Co., Hardhat 2185 by Rust-oleum, or ZRC by ZRC Chemical Products, or approved equal.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the Work specified under Section 16371 “Overhead Contact System.”

END OF SECTION 05125
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work described in this Section includes providing and delivering new steel poles, and their installation by the Contractor as part of the Overhead Contact System (OCS) as shown on the Contract Drawings and as Specified herein.

1.2 REFERENCE STANDARDS

A. American Institute of Steel Construction, Inc. (AISC)
   1. Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings
   2. Code of Standard Practice for Steel Buildings and Bridges

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A53/A53M REV A - Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless
   3. ASTM A123/A123M - Zinc Coating on products fabricated from rolled, pressed and forged steel shapes, plates, bars and strips
   4. ASTM 143/A143M - Safeguarding Against Embrittlement of Hot-Dip Galvanized Steel Products and Procedure
   5. ASTM A153/A153M - Zinc Coating (Hot Dip) on iron and steel hardware
   6. ASTM A283/A283M - Low and intermediate Tensile Strength Carbon Steel Plates
   7. ASTM A325 REV B - High Strength Bolts for Structural Steel joints, Including Suitable Nuts and Plain Hardened Washers
   8. ASTM A370 - Methods and Definitions for Mechanical Testing of Steel Products
   9. ASTM A384 - Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
   10. ASTM A572/ A572M - High-Strength, Low-Alloy Columbium-Vanadium Steels of Structural Quality
   11. ASTM A588/ A588M – High-Strength Low-Alloy Structural Steel
   12. ASTM A595 REV A - Steel Tubes, Low Carbon, Tapered for Structural Use
   13. ASTM E709 - Standard Guide for Magnetic Particle Examination
   15. ASTM F593 - Stainless Steel Bolts, Hex Cap Screws, and Studs

C. American Welding Society, Inc. (AWS)
   1. AWS D1.1/D1.1M - Structural Welding Code, Steel
   2. AWS W1 CH 12 - Qualifications of Welders and Welding Operators

1.3 SUBMITTALS

A. Shop Drawings: Within 45 days of commencing Work, submit shop drawings giving complete information required for the fabrication of the poles. The shop drawings shall be to scale and shall indicate all fittings, holes and accessories and all locations, types and sizes of all welds.
   1. Shop drawings shall be prepared under the seal of a Licensed Texas Professional Engineer.
   2. Indicate welded connections using standard AWS welding symbols, indicating net weld lengths.

B. Welding: Within 45 days of commencing Work, submit:
   1. Specifications for welding procedures in accordance with AWS D1.1/D1.1M.
   2. Certificates of qualifications of welders, welding operators and tackers in accordance with AWS W1 CH12.
   3. Certificates of qualifications of welding inspectors in accordance with AWS W1 CH12.

C. Certificates of compliance for components
   1. Before commencing fabrication provide a certification verifying that the material has been designed, manufactured, inspected and tested in accordance with the applicable portion of the referenced standards and these specifications.
   2. Test Reports: Provide copies of reports of all factory tests as required by these specifications and referenced standards.
D. Test Reports: Six copies of certified laboratory test reports shall be submitted within five days of each test, or series of tests.

E. Material and components manufactured to applicable foreign standards, including metric standards, are acceptable, provided that the Contractor submits written evidence in the English language, that they are equal or superior to those complying with the standards listed above, or after written approval is obtained from the Authority.

1.4 QUALITY ASSURANCE

A. The Contractor shall perform the work included in this Section in strict accordance with the requirements of the Contractor’s Quality Control Program as Authority approved.

B. The Contractor shall perform the following in accordance with these Specifications:
   1. Material qualification testing and certification for acceptance of materials, components and assemblies.
   2. Job control testing of in-progress work being performed in shops, factories and on-site.
   3. On-site inspection of specified work elements.

1.5 POLE TESTING AND INSPECTION

A. Material Testing:
   1. The chemical compositions and required mechanical properties of all materials used shall be determined, either by obtaining manufacturer’s certificates of compliance or by laboratory testing at a facility acceptable to the Authority.

B. Embrittlement:
   1. Fabrication shall conform to ASTM A143 to prevent embrittlement of the steel.

C. Weld Testing:
   1. The services of an AWS Certified Welding Inspector shall be provided by the pole manufacturer to:
      a. Inspect fabrication operations
      b. Inspect welding procedures
      c. Inspect welding personnel
      d. Perform ultrasonic and magnetic particle testing
   2. A visual inspection of all welds shall be performed in accordance with the AWS Code.
   3. Weld testing shall be performed on a sample number of each type of pole, selected at random by the Authority. All poles selected for testing shall be tested by the ultrasonic and magnetic particle methods.
   4. Equipment, procedures and personnel for weld testing, and test reports, shall conform to the requirements of AWS D1.1/D1.1M, Section 6 – Inspection.
   5. Weld testing shall consist of:
      a. Ultrasonic testing conforming to the requirements of AWS D1.1/D1.1M Section 6.
      b. Magnetic particle testing conforming to the requirements of ASTM E709.
   6. Ultrasonic or radiographic testing shall be performed on the complete penetration welds between the pole shaft and the pole base, and at any circumferential welds in the pole shaft at splice locations (if any), for each pole being tested. Magnetic particle testing shall be performed on all other welds including longitudinal seam welds at handholes.
   7. For each tested pole that is tested and found to be unacceptable, weld testing shall be performed on a further sample of two poles, selected at random by the Authority from the remaining untested pole population.
   8. Results of weld testing shall be deemed acceptable or unacceptable in accordance with AWS D1.1/D1.1M, Sections 8, 9, or 10.
   9. Welds found to be unacceptable shall be repaired in accordance with AWS D1.1/D1.1M, Section 3, and retested.

D. Galvanizing Testing:
   1. All galvanized items shall be inspected for conformance with the requirements of the following ASTM Specifications, as applicable:
      a. Galvanizing Compliance: A123 or A153
      b. Embrittlement: A143
      c. Distortion: A384

E. Impact testing:
   1. Structural steel materials for base plates and pole shafts shall be tested for impact toughness in accordance with the Charpy V-notch test as specified in ASTM A370. The minimum energy value shall be 15 foot-pounds at 0 degrees F.
OVERHEAD CONTACT SYSTEM STEEL TUBULAR POLES

F. Inspection:

1. Provisions shall be made for inspection of the fabrication and testing by the Authority or authorized representative. Contractor shall provide two weeks advance notice to the Authority. Inspection by the Authority or the authorized representative at the point of manufacture shall not constitute acceptance of the work as specified.

1.6 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall ensure that all materials provided are suitably packaged and protected against damage during delivery and transportation.

B. The Contractor shall store all products in accordance with the manufacturer’s instructions, to ensure that all material is protected from damage. Poles shall not be stored directly on the soil or earth.

C. Poles shall be prepared and shipped in a manner to prevent damage to the painted surfaces.

D. Any damage to the material shall be the Contractor’s responsibility, and repairs and replacements shall be accomplished by the Contractor in accordance with the manufacturer’s instructions and at the Contractor’s expense.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General

1. Tapered tubular poles shall be installed at locations as indicated in the plans.

B. Poles

1. Pole shafts shall be fabricated from one piece (no splicing) and from one structural steel material conforming to ASTM A595 REV A Grade A (55ksi FY).

2. Pole shafts shall be single ply.

3. Subject to Authority approval, other materials and fabrication methods may be used for the poles. Consideration shall not be given to press formed poles and wide flange poles will not be considered.

4. Taper tubular poles shall be designed for and selected so as not to exceed a maximum deflection due to operating loads of 2 inches at contact wire level (18 feet – 0 inches).

5. The maximum total deflection for the tubular poles, measured at the pole top shall not exceed 2.5 percent of the total pole length due to static and live loads combined. Poles shall not exhibit any permanent deflection or damage as a result of the defined system operating or non-operating loads.

C. Base plates shall be fabricated from structural steel conforming to the requirements of ASTM A572.

D. Handholes shall be fabricated from steel of the same type as the pole shafts specified.

E. Pole caps shall be fabricated from steel compatible with the pole shaft, fitted with a minimum of three stainless steel set screws.

F. Handhole cover screws shall be stainless hex, cap screws.

G. Feeder spouts shall be standard steel pipe conforming to ASTM A53/53M REV A, Type S, Grade A or B.

H. Weld filler metal shall conform to AWS D1.1/D1.1M.

I. Pole finish for painted poles and attachments shall be as specified in these Specifications. Color shall be as indicated on the Contract Drawings.

J. Poles that in the Contract Drawings are not indicated to be painted shall be hot dipped galvanized in accordance with ASTM A123/ A123M or A153/ A153M as required.

2.2 FABRICATION

A. General:

1. Poles, fittings, accessories and base plates shall be fabricated to the dimensions indicated in the approved shop drawings.

B. Methods and Tolerances:

1. Poles, fittings, accessories and base plates shall be fabricated by methods and within tolerances conforming to the AISC Specifications except as specified herein.

C. Tolerances:

1. Pole Diameter: Pole diameter shall be within +/- 1/8 inches of the design diameter. Round poles shall be within +/- 1/8 inches of perfect round.

2. Pole Wall Thickness: Pole wall thickness, exclusive of the weld area shall be within plus 10 percent or minus 2 percent of the design wall thickness.

3. Pole Taper: On taper tubular poles the pole taper shall be between 0.135 inches and 0.145 inches change in diameter per foot of length and constant for the length of the pole.
a. When pole length is over 32 feet, the pole taper rate may be between 0.075 inches and 0.145 inches change in diameter per foot.

4. Pole Straightness: Pole straightness shall be within 1/8 inch per 5 feet of length (1:480) and constant for the length of the pole.

5. Tolerances for Base Plate shall be as follows:
   a. Bolt Circle: +/- 1/16 inches
   b. Hole Diameter: + 1/16 inches, - zero inches
   c. Location of Holes: +/- 1/16 inches in each direction.

D. Welding Procedures:
   1. Welding procedures, welders, welding operations and tackers shall conform to the provisions of AWS D1.1/D1.1M, Section 2, Design of Welded Connections; Section 3, Workmanship; Section 4, Technique; and Sections 8, 9 or 10. All welds shall be ground smooth.

E. Weld Repairs:
   1. Welds found to be unacceptable shall be repaired in conformance with the provisions of AWS D1.1/D1.1M, Section 3, Workmanship.

F. Surface Grinding
   1. Before galvanizing, all penetration welds shall be ground flush with base metal to eliminate surface cracks. All other welds and cut edges shall be ground to eliminate sharp edges and burrs.

G. Pole Straightening
   1. Before galvanizing, the poles shall be straightened as required to conform to the specified requirements. Straightening methods shall not require heating of the poles.

H. Galvanizing
   1. After fabrication, the poles, fittings and accessories shall be hot-dip galvanized inside and out, in conformance with ASTM A123 or ASTM A153, as required. All pole fabrications shall be galvanized for their entire length, at one time, in a single hot-dip galvanizing bath. Galvanizing by successive dippings of partial pole lengths shall not be permitted.

I. Pole Identification Plate
   1. A stainless steel pole identification plate shall be attached to each pole at 24 inches above the base plate. The plate shall show the pole type, structure number, and the manufacturer's name and date of manufacture. The plate design, style of lettering and method of attachment shall be Authority approved.

J. Pole Type Assembly Mark:
   1. Pole type assembly number shall be hard marked with a minimum height of 3/4 inch and a minimum indentation of 1/16 inches. The hard mark shall be stamped on the top of the base plate and shall be visible after painting.

PART 3 - EXECUTION

3.1 DELIVERY
   A. Poles complete with base plates shall be delivered complete with associated fittings and accessories properly packed against damage and loss of parts.

3.2 INSTALLATION/ERECTION
   A. Erect structural steel in accordance with the AISC Specification for structural steel erection or in accordance with the manufacturer's recommended instructions.

   B. All catenary poles shall be raked and/or adjusted to a plumb condition to compensate for the static load deflection induced by the wire and equipment. The final erected pole plumb (perpendicular) position shall not exceed one in 50 of true vertical with the pole fully loaded measured within eight feet of its base corrected for taper where applicable. Any pole lean shall be against the direction of the static loads.

   C. Catenary Poles: Catenary poles shall be erected on foundations, using anchor bolts that have been cast into the concrete bases. The catenary pole erection crew shall maintain a quantity of leveling nuts and washers in the required sizes so that each pole erected will have the correct number of nuts and washers. Anchor bolts, nuts and washers are to be galvanized steel, and the Contractor shall take care to avoid damaging the galvanized surfaces. When poles have been erected to their final rake and alignment, the leveling nuts shall be in full contact with the base plate washers and shall be tightened to 50 foot-pounds torque. Two full threads shall protrude above the nut. The bottom nut shall clear the top of the concrete by 3/4 inch.

   D. Pole Fittings: The Contractor shall install all fittings required for the specific installation including, but not limited to the following items:
      1. Handholes
      2. Pole caps
      3. Feeder spouts
E. Grounding and Bonding: All steel poles installed by the Contractor shall be bonded to the foundation ground rod as shown on the Contract Drawings.

F. Additional Requirements:

1. Pole caps shall be installed on all poles prior to setting of the pole.

2. Contractor shall exercise care during erection of the poles to prevent subjection of the poles to abuse and damage. All imperfections on the steel poles shall be repaired by the Contractor as required to restore the pole to a condition acceptable to the Authority.

3. Caution is mandated during erection of the steel poles to prevent possible contact with overhead lines and other possible energized utilities.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the Work specified under Section 16371 “Overhead Contact System.”

END OF SECTION 05126
SECTION 05130
STRUCTURAL STEEL - BUILDINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies structural steelwork for structures other than bridges and includes shop coating of steel.

B. For additional requirements for Architecturally Exposed Structural Steel (AESS), see Section 05135, "Architecturally Exposed Structural Steel".

1.2 REFERENCE STANDARDS

A. American Institute of Steel Construction (AISC):
   1. AISC 303 - Code of Standard Practice for Steel Buildings and Bridges
   2. AISC 348 - Specification for Structural Joints Using ASTM A325 or A490 Bolts

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel

C. ASME International (ASME):
   1. ASME B18.2.2 - Square and Hex Nuts (Inch Series)

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A6/A6M - Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
   2. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   3. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   4. ASTM A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
   5. ASTM A109/A109M - Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled
   8. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   9. ASTM A194/A194M - Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
   10. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
   11. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat-Treated, 120/105 ksi Minimum Tensile Strength
   12. ASTM A435/A435M - Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates
   14. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
   15. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
   17. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
   18. ASTM A668/A688M - Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
22. ASTM A992/A992M - Standard Specification for Structural Steel Shapes

23. ASTM D610 - Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces

24. ASTM E164 - Standard Practice for Ultrasonic Contact Examination of Weldments

25. ASTM E709 - Standard Guide for Magnetic Particle Examination

26. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

E. Military Specifications (MIL):

1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).

2. MIL-PRF-26915 - Primer Coating, for Steel Surfaces

F. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

1. SSPC Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic").

1.3 SUBMITTALS

A. Shop Drawings:

1. General: Shop drawings shall not be the reproductions of the Contract drawings. Provide shop drawings prepared under supervision of a licensed engineer to include complete layout of work. Take and incorporate field verified dimensions as required.

2. Structural details: Include the following:

   a. Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.

   b. Details of location, type, sizes of bolts, and welds and for welded structures details of welding as specified.

   c. Structural computations for designed work certified by a Professional Engineer licensed in the State of Texas.

3. Match marks: Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.

4. Welding:

   a. Complete shop details of qualification test specimens.

   b. Include information on specimen identification, number of pieces, and welding procedure specification, type of material, sizes of pieces, and welds and other variables affecting detail or tests.

5. Erection.

6. Manufacturer’s test procedures for bolts: Details of methods of erection proposed to be used, including calculated stresses for proposed erection certified by a Professional Engineer registered in the State of Texas. Do not proceed until approval has been received.

B. Manufacturer’s Data and Samples: At least two weeks before start of any shop painting work submit to the Contracting Officer for approval the following:

1. Complete Data Sheets of the coating materials to be used, identified by the manufacturer, brand name, and product number.

2. Written procedures for compliance with this specification, covering storage, handling, surface preparation, application, curing, repair, and inspection.

3. Comply with paint manufacturer’s instruction for preparation of substrate. Submit procedure for review and approval. Submit 6 inch X 6 inch sample of prepared piece of metal if required by Contracting Officer.

C. Certifications:

1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.

2. Certified quality assurance testing and inspection reports.

3. Submit certification verifying that welding and inspection/testing personnel have been qualified in accordance with AWS D1.1/D1.1M.
4. Manufacturer's certification that bolts meet approved testing.

1.4 QUALITY ASSURANCE

A. Qualification of Welding Personnel and Procedures:
   1. Prior to qualifying welding personnel and welding procedures, submit and obtain approval from the Contracting Officer for procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment. See also Section 01450, "Quality Control".
   e. Each approved type of steel shall be identified by a color code in accordance with ASTM A6/A6M. The color “white” shall be used for ASTM A36/A36M steel.

2. Submit certifications for the welding and testing personnel in accordance with AWS D1.1/D1.1M within the previous 12 months prior to start of fabrication and erection. Such certification is to remain in force for the duration of the welding operations under this Contract.
   a. Do not start fabrication until qualification has been successfully completed and procedures approved.

B. Stock Material:
   1. For qualification of welding personnel and procedures and for quality assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.

   2. Material Identification:
      a. When stock material is proposed, inform the Contracting Officer at least 10 days in advance of commencing fabrication to permit sampling and testing. Select identified material from as few heats as possible.
      c. The Contractor's system of assembly-marking individual pieces, and the issuance of cutting instructions to the shop shall be such as to maintain identity of the original piece.
      d. Use a marking system (color codes, stencils, etc.) which will identify the source of structural steel by heat number. Loss of positive identification will require testing to establish acceptability. Testing shall be performed by a commercial agency at the Contractor's expense.

   b. Use stock material that can be identified by heat number and mill test report.

   c. The Contractor's system of assembly-marking individual pieces, and the issuance of cutting instructions to the shop shall be such as to maintain identity of the original piece.

   1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. General:
   1. Load, transport, unload, and store structural materials to keep them clean and free from damage.

   2. Store material on platforms, skids, or other non-abrasive supports above the ground and ensure proper drainage and protection from corrosion.

B. Steelwork:
   1. When handling and shipping steelwork, prevent bending, scraping, or overstressing members.

   2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material.

   3. Replace pieces bent, scraped, gouged, or damaged unless repair is approved.
4. Indicate weight on members weighing more than three tons by means of paint contrasting with shop coat.

5. Mark all structural members in accordance with approved erection plans.

C. Bolts and Nuts:
1. Ship small parts such as bolts, nuts, washers, pins, fillers, and small connecting plates or angles in boxes, crates, or barrels.

2. Pack separately bolts of each length and diameter and loose nuts or washers of each size.

D. Coating Materials:
1. Receive and store coating materials in the manufacturer’s original, unopened containers bearing a legible product designation, batch number, and date of manufacture on the side of each container. Do not open containers except for immediate use.

2. Store coating materials according to the manufacturer’s latest printed instructions and protect from damage, moisture, direct sunlight, and temperatures below 40 deg. F and above 105 deg. F.

3. Do not use coating materials that exceed the manufacturer’s shelf life without prior written permission from the Manufacturer. Do not use containers damaged to the point of jeopardizing the contents.

E. Coated Steel: Store coated steel off the ground on nonabrasive supports and stacked on nonabrasive separators. Use fabric slings or chokers to lift coated steel where the use of chains or steel cable would damage the coating.

1.6 SHOP CONDITIONS

A. Welding:
1. When welding during cold weather, avoid chilling weld metal within zone of welding influence and avoid restraining manual functions of welder or welding operator.

2. When temperature where steel is stored is more than 20 deg. F different from that of welding shop, move steel to be welded into shop sufficiently in advance of welding to allow it to attain shop temperature prior to welding.

3. Steel to be free of moisture. Dry as necessary by application of heat not exceeding 100 deg. F.

4. Do not weld when shop temperature is below 40 deg. F, unless otherwise required or permitted by AWS D1.1/D1.1M.

B. Painting:
1. Apply paint when temperature of steel and paint is within the temperatures recommended by the paint manufacturer and temperature is forecast to remain within that manufacturer’s recommendation until paint has dried.

2. Painting steel at a temperature which can cause blistering, porosity, or conditions otherwise detrimental to life of paint is prohibited. When paint is applied in hot weather or thinned in cold weather, ensure that specified thickness of paint coating is obtained.

3. Application of paint when steel surface temperature is below dew point is prohibited, unless otherwise approved. Follow manufacturer’s instruction for application temperature and allowable humidity level. If painting in damp or cold weather is unavoidable, provide protective covering and heat steel and surrounding air to 40 deg. F minimum. Maintain this temperature until weather conditions permit discontinuance.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General Requirements for Rolled Steel Plates, Shapes, and Bars: ASTM A6/A6M.

B. Carbon Steel Plates, Shapes, and Bars: ASTM A36/A36M.

C. High-Strength Structural Steel Shapes, Plates, and Bars: ASTM A572.

D. High-Strength Structural Steel “W” Shapes: ASTM A992.

E. Low-Carbon Steel Bolts and Nuts:
1. ASTM A307, Grade A regular low-carbon steel bolts with hexagonal heads.

2. ASTM A563, Grade A hexagon nuts.
F. High-Strength Carbon-Steel Bolts, Nuts and Washers For Structural Joints:
   1. ASTM A325; Type 1, heavy hexagon structural bolts.
   2. ASTM A563, Grade DH or ASTM A194, Grade 2H hot formed heavy hexagon nuts.
   3. Washers having a hardness of Rockwell C26 to C45.

G. Round Washers Other Than Those In Contact With High-Strength Bolt Heads and Nuts: ASME B18.2.2.

H. Anchor Bolts, Nuts and Washers: ASTM F1554, Grade 55, unless noted otherwise on drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers. Galvanized per ASTM A153/A153M

I. Beveled Washers:
   1. Square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
   2. Diameter of hole in square beveled washers, 1/16 inch larger than bolt size.

J. Structural Steel Tubing:
   1. ASTM A500, Grade B, 46,000 psi yield point, unless otherwise specified.
   2. ASTM A501, 36,000 psi yield point.

K. Steel Pipe: ASTM A53, Type E or S, Grade B; Black except where indicated to be galvanized.

L. Stud Connectors:
   1. Cold-finished bars, ASTM A108, Grade 1015, Grade 1018 or Grade 1020, semi-killed or fully killed, complying with AWSD1.1/D1.1M.
   2. Sizes and shapes: As shown.
   3. Lengths to be after-weld lengths.

M. Galvanizing: Steel products specified as galvanized. Hot-dip galvanized after fabrication, in accordance with the following:
   1. Zinc coating on products fabricated from rolled, dressed and forged steel shapes, plates and strips: ASTM A123/A123M.
   2. Zinc coating on iron and steel hardware: ASTM A153/A153M.

3. Galvanizing Repair Paint:
   a. For Concealed or Top Coated Surfaces:
      1) Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
         a) ASTM A780.
         b) SSPC Paint 20.
   b. For Surfaces to be Left Exposed:
      1) In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
         a) MIL-P-21035.
         b) MIL-PRF-26915.
      2) Basis-of-Design: Brite Products “Brite Zinc”.

N. Paint:
   1. Primer: As specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2B. Use make as selected for finish coating.

2.2 FABRICATION

A. General: Accomplish workmanship and finish to standards referenced in Quality Control paragraph of these specifications.

B. Straightening Material:
   1. Use rolled material that, before being laid off or worked, is straight within tolerances specified in ASTM A6.
   2. Perform straightening where necessary by approved methods which will not overstress material.
   3. Achieve fabrication tolerances which will result in full bearing.
   4. In bearing assemblies, perform straightening and planing as necessary to provide full bearing assemblies and bearing areas.
5. Steel Wall Framing:
   a. Select members which are true and straight for fabrication of steel wall framing. Straighten as required to provide uniform, square and true members in completed wall framing.
   b. The as-fabricated straightness tolerances for the steel wall framing members are one-half the standard camber and sweep tolerances for rolled shape in ASTM A6.

C. Cutting:
   1. Shape re-entrant corners notch-free to radius of 1/2 inch minimum.
   2. Perform flame cutting so that metal does not carry stress during cutting operation.
   3. Direct flame so that remaining material is not damaged.
   4. Edges of main members which are sheared or oxygen cut, and all other exposed edges to be painted, shall be rounded or chamfered to an approximate 1/16 inch radius by grinding.

D. Planing and Facing:
   1. Face and bring abutting joints to even bearing where shown.
   2. For compression joints depending on contact, prepare bearing surfaces to a common plane by milling, sawing or other approved means.
   3. Plane to depth of 1/4 inch sheared edges of plates more than 5/8 inch thick which will carry calculated stress.

E. Bolt Holes:
   1. Punch or drill holes for bolts.
   2. Subpunch or subdrill and ream assemblies using steel template for alignment of connections as necessary. Flame cutting is prohibited. Subdrill or subpunch holes 3/16 inch less than nominal diameter of bolt; drill or ream holes 1/16 inch greater than nominal diameter of bolt.
   3. Drill or punch holes required to secure other work to structural steel.

F. Connections:
   1. Weld or bolt shop connections.
   2. Unless otherwise shown, bolt field connections.
   3. To minimize the amount of field welding, shop assembled components shall be the largest size possible commensurate with transportation and handling limitations. Shop connections may be bolted with high-strength bolts or welded.

G. Welding:
   1. Perform welding in accordance with AWS D1.1/D1.1M. Weld exposed joints continuously and grind smooth. Fillet welds are not required to be ground when a smooth appearance is provided.
   2. Perform procedure and sequence of welding so as to avoid needless distortion and to minimize stresses. Straighten transverse warpage of flanges, if necessary, by controlled heating along outside face.
   3. Make allowance in shop for expected weld shrinkage in laying out and assembling members. Trim members to size when most or all of welding has been completed.
   4. Complete butt welds in flange joints before flanges are assembled on web. Use extension blocks on such joints when making ends of butt welds removing extension blocks only upon completion and cooling of weld. Finish ends of welds smooth and flush with edges of abutting parts. Use prequalified welding procedures, unless otherwise shown.
   5. Make welds in web plates where shown.
   6. Prior to ultrasonic or radiographic testing of butt welds of flanges and webs, grind or machine weld reinforcement of joint to remove irregularities of weld surface so that it merges smoothly with base surface; one side for ultrasonic testing and both sides for radiographic testing.
   7. Ensure that welded joints which are to be radiographed are free of paint, scale, and grease. Grind off welded ripples and surface irregularities on both sides of joint. Grind perpendicular to length of weld and to such a degree that resulting radiographic contrast due to remaining irregularities cannot mask or be confused with that of...
objectionable defect and so that weld surface will merge smoothly into adjoining surface.

8. Repair defective welds by chipping or melting out such defects from one or both sides of joint removing no more weld metal than necessary to correct defect. Reweld and have weld retested radiographically.

9. Welded Construction Subjected to Dynamic Loads: Comply with AWS D1.1/D1.1M, Section 9, rules for dynamically loaded structures, when welding crane girders, elevator framing or frames for reciprocally loaded structures.

H. Bolting:

1. Provide connections using high-strength steel bolts in accordance with AISC Specifications for Structural Joints using ASTM A325 bolts and washers except where ASTM A307 bolts are shown or permitted.

2. Assemble high-strength bolted parts so that they fit solidly together when assembled. Do not use gaskets or other compressible materials.

3. Remove scale, dirt, burrs, and other items likely to prevent proper seating when assembling joint surfaces, including those adjacent to washers.

4. Tightening Bolts:

   a. Tighten A325 bolts to provide fully pretensioned connections unless otherwise approved in writing by the Contracting Officer.

   b. When tightening, place hardened washer under turned element (nut or bolt head), depending on which element is turned in tightening operation.

   c. Calibrate torque wrenches by tightening bolt assembly in device capable of indicating actual bolt tension.

   d. Test three bolts minimum from each lot.

   e. Measure torque when nuts or bolts are in tightening motion.

   f. Adjust power wrenches to cut out or stall at required tension.

5. Arrange bolts so that heads show in areas exposed to public view.

6. Unless noted otherwise, Bolted connections shall be made with minimum 3/4 inch diameter H.S. ASTM, A325 bolts in bearing type, with the threads included in the shear plane.

2.3 SHOP PAINTING

A. Shop prime steel surfaces, except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.

2. Surfaces to be field welded.

3. Surfaces to be high-strength bolted with slip-critical connections, if primer does not meet the specified AISC slip coefficient.

4. Items indicated to be galvanized.

5. Surfaces which are to receive sprayed-on fireproofing.

6. Top surface of crane rails.

B. Prepare steel surfaces and apply shop primer as specified in Section 09970, "Coatings for Steel" Paint and Coating System No. 1 and as specified below:

1. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

2. Stripe paint corners, crevices, bolts, welds, and sharp edges.

3. Apply two coats of paint to surfaces which are inaccessible after assembly or erection. Change color of second coat to distinguish it from the first.

C. Shop painting requirements for Architecturally Exposed Structural Steel (AESS), see Section 05135, "Architecturally Exposed Structural Steel".

2.4 GALVANIZING

A. Hot-dip galvanize steel work and fasteners, where indicated, after fabrication. Conform to ASTM A123 and ASTM A153 as applicable. Plug vent holes with lead or silicone sealant after galvanizing.
2.5 **SOURCE QUALITY CONTROL**

**A.** Comply with quality control requirements specified in Paragraph 3.3 of this section and Section 01450, "Quality Control".

**B.** Materials and fabrication procedures are subject to inspection and tests in mill, shop, and field, conducted by a qualified inspection agency.

1. Such inspections and tests will not relieve Contractor of responsibility for providing materials and fabricated components in compliance with specified requirements.

2. Promptly remove and replace materials or fabricated components which do not comply.

PART 3 - EXECUTION

### 3.1 EXAMINATION

**A.** Verification of Conditions: Examine the areas and conditions under which structural steelwork is to be installed, and make provisions as necessary for the proper and timely completion of work. Do not proceed with the work until unsatisfactory conditions have been corrected. Modifications of structural materials must not proceed until accepted by the Contracting Officer.

### 3.2 ERECTION

**A.** General:


2. Immediately upon completion of erection of steel and prior to placing or applying all other materials, certify that the location of structural steel meets specified tolerances for plumbness, level and alignment. The Contracting Officer may verify placement prior to start of work by other trades. Immediately correct all deviations from specified requirements.

**B.** Surveys: Employ a Professional Engineer or Land Surveyor, licensed in the State of Texas, as required by Section 01722, "Field Engineering - Surveying", for accurate erection of structural steelwork. Check elevations of concrete and masonry bearing surfaces, and locations of anchor bolts and similar devices, before erection work proceeds. Report discrepancies to Contracting Officer. Do not proceed with erection until corrections have been made, or until compensating adjustments to structural steelwork have been agreed upon with the Contracting Officer.

**C.** Temporary Shoring and Bracing: Provide temporary shoring and bracing members with connections of sufficient strength to sustain imposed loads. Provide temporary guy lines to achieve proper alignment of structures as erection proceeds. Where floors and roofs are supported by steel framing, the framing should be considered to be unstable until floors and roofs are in place and properly secured. Remove temporary bracing members and connections when permanent members are in place and final connections are made. Do not use finish materials for erection or temporary purposes.

**D.** Temporary Connections: When the framing system requires connections with bolts common to several members, temporarily support all framing members affected by removal of bolts for installation of additional members.

**E.** Temporary Planking: Provide temporary planking and working platforms as necessary to effectively complete work.

**F.** Anchor Bolts: Furnish anchor bolts and other connectors required for securing structural steel to foundations and other in-place work. Furnish templates and other devices as necessary for presetting bolts and other anchors to maintain accurate locations during installation of concrete.

**G.** Setting Bases and Bearing Plates:


2. Set loose and attached base plates and bearing plates for structural members on steel shims, wedges or other adjusting devices.

3. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of base or bearing plate prior to packing with grout.

**H.** Grout beneath base plates using structural nonshrink grout as specified in Section 03305, "Portland Cement Concrete".

**I.** Bearing Devices: Install bearing devices in accordance with manufacturer's recommendations.
Field Assembly: Set structural frames accurately to lines and elevations indicated. Align and adjust various members forming part of complete frame or structure before permanently fastening. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure within specified AISC tolerances.
2. Establish required leveling and plumbing measurements on mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structures will be when completed and in service.
3. Plumb columns adjacent to elevator shafts to meet specified AISC tolerance at elevator shafts.
4. Splice members only where shown or specified.
5. Install high-strength threaded fasteners in accordance with AISC 348. Tension bolts with full pretension load.
6. On exposed welded construction, remove erection bolts, fill holes with plug welds and grind smooth at exposed surfaces.
7. Comply with AISC Specifications for bearing, adequacy of temporary connections, alignment, and removal of paint on surfaces adjacent to field welds.
8. Do not enlarge unfair holes in members by burning or by use of drift pins, except in secondary bracing members. Ream holes that must be enlarged to admit bolts.
9. Do not interchange parts which have been reamed or drilled in assembled position.
10. Handle material so that no parts will be bent, broken or otherwise damaged.

Crane Runways: Install runways complete with columns, girders, beams, bracing, rails, crane stops and other required items. Stagger joint locations in opposite rails to avoid crane girder joints. Provide flush joints at tip of crane rails. Set and adjust gauge alignment and elevation of crane rails and girders to tolerances as follows: gauge plus or minus 1/4 inch; horizontal alignment plus or minus 1/4 inch per 50’ length, 1/2 inch max. total; vertical alignment plus or minus 1/4 inch per 50’ length, 1/2 inch max. total; center of crane rail on girder web plus or minus 0.75 times the girder web thickness.

Stud Connectors:
1. Prepare steel surfaces as recommended by the manufacturer of the stud connectors. Weld only on clean, dry surfaces. Use automatic end welding of stud connectors in accordance with the manufacturer’s printed instructions.
2. Weld stud connectors, spaced as shown, to beams and girders through decking units. Do not weld through two layers (lapped ends) of decking units.

Field Cutting: Do not use gas cutting torches in field for correcting fabrication errors in structural framing.

ADJUSTING AND CLEANING

Touch-Up Painting: Immediately after erection, cleaning and touch-up painting of field welds, bolted connections, and abraded areas of shop paint shall be completed to blend with the adjacent surfaces. Such touch up work shall be done in accordance with manufacturer’s instructions as specified in Section 09970, “Coatings for Steel”.

Galvanized Surfaces:
1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.
2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

QUALITY CONTROL

Following provisions of this paragraph will complement Section 01450, "Quality Control".

Retain an independent testing and inspection agency approved by the Authority to inspect bolts and stud connectors, high-strength bolted connections, and welded connections, including stud welds, and perform tests and prepare test reports.

Testing Agency will conduct and interpret tests and state in each report whether test specimens comply with requirements, and specifically state any deviations therefrom.
D. Inspection of welded fabrication shall be done by AWS Certified Welding Inspectors with certification of Level II or III in accordance with the requirements of the American Society of Non-destructive Testing Certification SNT-TC-1A.

E. Provide access for Testing Agency to places where structural steelwork is being fabricated or produced so that required inspection and testing can be accomplished.

F. Correct deficiencies in structural steelwork which inspections and laboratory test reports have indicated as not in compliance with requirements. In accordance with Section 01450, "Quality Control", perform additional tests, at Contractor's expense, as may be necessary to reconfirm any non-compliance of original work, and as may be necessary to show compliance of corrected work.

G. Bolts: After receipt of bolts by the fabricator or erector, the Testing Agency shall test four bolts, selected at random, from each shipment to the fabricator or erector of a particular diameter and length using a bolt-tension calibrator. Bolts will be tested by being torqued to produce a tension of 105 percent of AISC 348 minimum fastener tension.

H. Bolted Connections:
   1. The Testing Agency shall visually inspect bolted connections to verify installation of specified bolt types and sizes in proper connections. Testing Agency will observe bolting installation and report conformance and non-conformance with AISC 348.
   2. When disagreement occurs relating to installation of bolts in connections requiring full pretensioning, arbitration inspection procedures conforming to AISC 348 will be used, except that a minimum of 25 percent of the bolts per connection will be checked.

I. Welded Connections: For each operator and each days work, the Testing Agency will perform nondestructive testing of field and shop welds, including stud welds, in accordance with provisions of the AWS Code and the following schedule:
   1. Partial Penetration Groove and Fillet Welds (Excluding Tubular Joints): Magnetic particle inspection in accordance with ASTM E709. Cracks or zones of incomplete fusion are not acceptable.
   2. Full Penetration Welds and Welds for Tubular Joints: Ultrasonic examination in accordance with ASTM E164, minimum quality level 2-2T.
      a. 1 out of 5 (full length) for thickness equal to or less than 3/4 inch welded in field.
      b. 1 out of 10 (full length) for thickness equal to or less than 3/4 inch welded in shop.
      c. 100 percent (full length) for thickness greater than 3/4 inch.
      d. 100 percent (full perimeter) for tubular butt welds of any thickness.
   3. Tubular "T", "K" and "Y" type connections:
      a. Verification of edge preparation: For 20 percent of joints of each type connection, verify that member ends are accurately cut to fit member joined and that edges are prepared in accordance with AWS D1.1/D1.1M to provide prequalified welds.
      b. Verification of weld integrity: Magnetic particle inspection in accordance with ASTM E709:
         1) 1 out of 5 joints for full perimeter when branch member thickness is 3/4 inch.
         2) 100 percent of joints for full perimeter when branch member thickness is greater than 3/4 inch.
   4. Weldments or Connections Subject to Lamellar Tearing: Ultrasonic inspection made 48 to 72 hours after welding at locations on weldments or connections subject to high restraint in order to check for lamellar tearing. The exact location of the areas to be inspected shall be determined by the Contractor and the Contracting Officer at the time of fabrication. This inspection shall be made according to the following schedule unless conditions of tearing indicate that more are required:
      a. 1 out of 10 for thickness equal to or less than 3/4 inch.
      b. 1 out of 5 for thickness greater than 3/4 inch and equal to or less than 1-1/4 inches.
c. 1 out of 2 for thickness greater than 1-1/4 inches.

d. If lamellar tearing should occur, modify material, procedures, or details to alleviate the problem before proceeding with further fabrication of like units.

e. For tubular "T", "K", and "Y" joints, inspect the continuous member for a distance of 2 feet each way beyond center of joint after the welding of all branch members.

5. Weldments Subjected to Ultrasonic Inspection: One or more radiographic examinations made as soon as possible after start of ultrasonic inspection as necessary to verify quality of ultrasonic inspection.

6. Stud Welds: Test studs in accordance with AWS requirements. In addition to the requirements of AWS D1.1/D1.1M, strike studs with a 15 pound hammer except, this requirement may be modified when approved in writing when temperatures below 50 deg. F are anticipated. Straighten studs after testing; except, on composite beams, studs bent toward mid-span need not be straightened. Replace studs that crack in the weld, base metal, or shank under testing or subsequent straightening.

7. Welds of any type, not tested by other means, shall be visually inspected and documented.

J. When testing, examination, and inspection as specified or scheduled herein reveals faulty welds, joints of the same type will be checked until the integrity of the welds is assured before resuming the specified schedule.

K. After faulty welds have been corrected or repaired, re-examine each in the manner specified for the original joint.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for structural steel - buildings per location indicated wherein no measurement will be made.
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SECTION 05135
ARCHITECTURAL EXPOSED STRUCTURAL STEEL

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies requirements regarding the appearance and surface preparation of Architecturally Exposed Structural Steel (AESS). Refer to Section 05130, "Structural Steel - Buildings" for other requirements regarding steel work not included in this Section.

B. This section applies to members noted on Architectural and Structural drawings as AESS and in the areas defined as AESS below.

1.2 REFERENCE STANDARDS

A. American Institute of Steel Construction (AISC):
   1. AISC 303 - Code of Standard Practice for Steel Buildings and Bridges

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel

1.3 DEFINITIONS

A. Architecturally Exposed Structural Steel (AESS): Structural steel that is exposed to view on or in completed structure or building and that requires special finishes to obtain specified architectural appearance.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Comply with Section 05130, "Structural Steel - Buildings" as amended below.


2.2 PAINT

A. Primer as specified in Section 09970, "Coatings for Steel" Paint and Coating System No. 1. Use make as selected for finish coat.

2.3 FABRICATION

A. Fabricate and assemble AESS in the shop to the greatest extent possible. Locate field joints in AESS assemblies at concealed locations or as approved by the Contracting Officer. Detail AESS assemblies to minimize field handling and expedite erection.

B. Fabricate AESS with exposed surfaces smooth, square and of surface quality consistent with the approved mock up. Use special care in handling and shipping of AESS both before and after shop painting.

C. In addition to special care used to handle and fabricate AESS, employ the following fabrication techniques:

1. Fabrication Tolerance: Fabricate steel to one half the normal tolerance as specified in AISC 303 Section 10.

2. Welds ground smooth: Fabricator shall grind welds of AESS smooth. For groove welds, the weld shall be made flush to the surfaces each side and be within plus 1/16 inch, minus 0 inches of plate thickness.

3. Contouring and blending of welds: Where fillet welds are indicated to be ground contoured, or blended, oversize welds as required and grind to provide a smooth transition and match profile on approved mock-up.

4. Continuous Welds: Where welding is noted on the drawings, provide continuous welds of a uniform size and profile.

5. Minimize Weld Show Through: At locations where welding on the far side of an exposed connection occurs, grind distortion and marking of the steel to a smooth profile with adjacent material.

6. Coping and Blocking Tolerance: Maintain a uniform gap of 1/8 inch plus or minus 1/32 at copes and blocks.

7. Joint Gap Tolerance: Maintain a uniform gap of 1/8 inch plus or minus 1/32.

8. Piece Marks Hidden: Fabricate such that piece marks are fully hidden in the final structure or made with such media to permit full removal after erection.

9. Mill Mark Removal: Deliver steel with no mill marks (stenciled, stamped, raised etc) in exposed locations. Mill marks shall be omitted by cutting of mill material to appropriate lengths where possible. Where not possible, the fabricator may fill and/or grind to a surface finish consistent with the approved mock up.

10. Grinding of Sheared Edges: Grind edges of sheared, punched or flame cut steel to match approved mockup.
11. Rolled Members: Member specified to be rolled to a final curved shape shall be fully shaped in the shop and tied during shipping to prevent stress relieving. Distortion of the web or stem and of outstanding flanges or legs of angles shall be visibly acceptable to the Contracting Officer from a distance of 20 feet under any lighting condition determined by the Contracting Officer. Tolerances for the vertical and horizontal walls of rectangular HSS members after rolling shall be the specified dimension plus or minus 1/2 inch.

12. Seal Welds: Seal weld open ends of round and rectangular hollow structural section with 3/8 inch closure plates. Provide continuous, sealed welds at angle to gusset plate connections and similar locations where AESS is exposed to weather.

### 2.4 SHOP CONNECTIONS

A. Bolted Connections: Make in accordance with Section 05130, "Structural Steel - Buildings". Provide bolt type and finish as noted herein and align bolt heads as indicated on the approved shop erection drawings.

B. Weld Connections: Comply with AWS D1.1/D1.1M and Section 05130, "Structural Steel - Buildings". Appearance and quality of welds shall be consistent with the mock up. Assemble and weld built-up sections by methods that will maintain alignment of members without warp exceeding the tolerance of this section.

### 2.5 SHOP PRIMING

A. Shop prime steel surfaces, except the following:
   1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
   2. Surfaces to be field welded.
   3. Surfaces to be high-strength bolted with slip-critical connections, if primer does not meet the specified AISC slip coefficient.

B. Prepare steel surfaces and apply shop primer as specified in Section 09970, "Coatings for Steel" Paint and Coating System No. 1 and as specified below:
   1. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.
   2. Stripe paint corners, crevices, bolts, welds, and sharp edges.
   3. Apply two coats of shop primer to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

### 3.1 EXAMINATION

A. The erector shall check AESS members upon delivery for twist, kinks, gouges or other imperfections which may result in rejection of the appearance of the member. Coordinate remedial action with fabricator prior to erecting steel.

### 3.2 PREPARATION

A. Provide connections for temporary shoring, bracing and supports only where noted on the approved shop drawings. Temporary connections not shown shall be made at locations not exposed to view in the final structure or as approved by the Contracting Officer. Handle, lift and align pieces using padded slings and/or other protection required to maintain the appearance of the AESS through the process of erection.

### 3.3 ERECTION

A. Set AESS accurately in locations and to elevations indicated and according to AISC specifications referenced in this Section.

B. In addition to the special care used to handle and erect AESS, employ the following erection techniques:
   1. AESS Erection Tolerances: Erection Tolerances shall meet the requirements of Chapter 10 of the AISC 303.
   2. Welds ground smooth: Erector shall grind welds smooth in the connections of AESS members. For groove welds, the weld shall be made flush to the surfaces each side and be within plus 1/16 inch, minus 0 inches of plate thickness.
   3. Contouring and blending of welds: Where fillet welds are indicated to be ground contoured, or blended, oversize welds as required and grind to provide a smooth transition and match profile on approved mock-up.
   4. Continuous Welds: Where noted on the drawings, provide continuous welds of a uniform size and profile.
   5. Minimize Weld Show Through: At locations where welding on the far side of an exposed connection occurs, grind distortion...
and marking of the steel to a smooth profile with adjacent material.

6. Bolt Head Orientation: Bolt heads shall be oriented as indicated on the contract documents. Where bolt head alignment is specified, the orientation shall be noted for each connection on the erection drawings. Where not noted, the bolt heads in a given connection shall be oriented to one side.

7. Removal of field connection aids: Run out tabs, erection bolts and other steel members added to connections to allow for alignment, fit-up, and welding in the field shall be removed from the structure. Field groove welds shall be selected to eliminate the need for backing bars or to permit their removal after welding. Welds at run out tabs shall be removed to match adjacent surfaces and ground smooth. Holes for erection bolts shall be plug welded and ground smooth.

8. Filling of weld access holes: Where holes must be cut in the web at the intersection with flanges on W shapes and structural tees to permit field welding of the flanges, they shall be filled. Filling shall be executed with proper procedures to minimize restraint and address thermal stresses in group 4 and 5 shapes.

C. Field Welding: Weld profile, quality, and finish shall be consistent with mock-ups approved prior to fabrication.

D. Splice members only where indicated.

E. Obtain permission for any torch cutting or field fabrication from the Contracting Officer. Finish sections thermally cut during erection to a surface appearance consistent with the mock up.

F. Do not enlarge unfair holes in members by burning or by using drift pins. Ream holes that must be enlarged to admit bolts. Replace connection plates that are misaligned where holes cannot be aligned with acceptable final appearance.

3.4 FIELD CONNECTIONS

A. Bolted Connections: Install bolts of the specified type and finish in accordance with Section 05130, “Structural Steel - Buildings”.

B. Welded Connections: Comply with AWS D1.1/D1.1M for procedures, and appearance. Refer to Section 05130, "Structural Steel - Buildings" for other requirements.

1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without warp. Verify that weld sizes, fabrication sequence, and equipment used for AESS will limit distortions to allowable tolerances.

2. Obtain Contracting Officer’s approval for appearance of welds in repaired or field modified work.

3.5 FIELD QUALITY CONTROL

A. Structural requirements: The Contractor shall engage an independent testing and inspecting agency to perform field inspections and tests and to prepare test reports. Refer to Section 05130, “Structural Steel - Buildings” for detailed bolt and weld testing requirements.

B. AESS acceptance: The Contracting Officer will observe the AESS steel in place and determine acceptability based on the mockup. The Testing Agency shall have no responsibility for enforcing the requirements of this section.

3.6 ADJUSTING AND CLEANING

A. Touchup Painting: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint shall be completed to blend with the adjacent surfaces of AESS. Such touch up work shall be done in accordance with manufacturer's instructions as specified in Section 09970, “Coatings for Steel”.

3.7 SCHEDULE OF ARCHITECTURALLY EXPOSED STRUCTURAL STEEL (AESS) ITEMS

A. Canopies

B. Other items indicated on Architectural or Structural drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for architecturally exposed structural steel per location indicated wherein no measurement will be made.
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies structural metal roof decking.

B. Metal decking described in this section required for roof construction at crew room, light rail station, canopy, or any other building shall be included in the metal work.

1.2 REFERENCE STANDARDS

A. American Iron and Steel Institute (AISI):
   1. AISI SG02-1 - North American Specification for the Design of Cold-Formed Steel Structural Members

B. American Welding Society (AWS):
   1. AWS D1.3 - Structural Welding Code - Sheet Steel

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   2. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
   3. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   4. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

D. Military Specification (MIL):
   1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).
   2. MIL-PRF-26915 - Primer Coating, for Steel Surfaces

E. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic").

F. Steel Deck Institute (SDI):
   1. SDI Specifications and Commentary for Steel Roof Deck.

1.3 PERFORMANCE REQUIREMENTS

A. Shear Diaphragm Loads: Roof deck units are part of the lateral load resisting system. Use deck configuration and fasteners which will provide the minimum pounds per linear foot diaphragm shear strength shown.

B. Uplift Loading: Proportion deck units and anchorage to resist, unless noted otherwise, gross uplift loading of 45 lbs. per sq. ft. at eaves overhang and 30 lbs. per sq. ft. for other roof areas.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Provide drawing to show complete layout of work, under supervision of a licensed engineer, include details of fabrication and erection including materials, material thicknesses, dimensions, methods of joining, welding, accessories, fastenings, openings through decking, and protective coatings. Take and include any required field dimension(s).
   2. Include manufacturer's printed instructions.

B. Samples:
   1. Welding Sample: Prepare and submit three samples of each type of deck welding specified and shown. Resubmit samples not approved as required to provide an acceptable sample. Acceptable samples will be made available on-site as an example for welders to follow.

C. Certification: Certification that welding and inspection/testing personnel are qualified in accordance with AWS D1.3.

1.5 QUALITY ASSURANCE

A. Qualification of Welding Personnel: Employ welding and inspection/testing personnel whose qualification is certified in accordance with AWS D1.3.
D1.3. Such certification is to remain in force for the duration of the welding operations under this Contract. All inspection personnel shall be AWS CWI.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products in good condition.
B. Store products to preclude corrosion, deterioration, and damage.
C. Handle products to prevent damage.

1.7 JOB CONDITIONS

A. Do not apply construction loads, such as roofing materials and aggregate, in excess of the live loads for which the deck is designed.

PART 2 - PRODUCTS

2.1 STEEL DECKING

A. Galvanized: ASTM A653/A653M, Grade A, Coating G60, gauge as shown, or to be designed by manufacturer.
B. Ungalvanized: ASTM A1011/A1011M or ASTM A1008/A1008M, gauge as shown, or to be designed by manufacturer coated with the manufacturer’s standard rust-inhibiting primer. Do not use asphalt or bitumastic paint based products. Certify that paint is compatible with insulation and roofing systems.
C. Types shown or necessary to complete installation, such as 14-gauge recessed sump pans for roof drains, cover plates where panels abut or change direction, and closure plates.
D. Same gauge and finish as decking, unless otherwise shown or specified.

2.2 PAINTING AT OPEN CANOPIES

A. Roof deck panels shall be shop-finished with manufacturer’s standard prime paint finish system (both sides).
B. Prime finish shall be a light color (such as beige, off-white, or light gray).
C. Metal decking finish shall be touched up in field after installation.

2.3 GALVANIZING REPAIR COMPOUND

A. Galvanizing Repair Paint:
1. For Concealed or Top Coated Surfaces:
   a. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
      1) ASTM A780.
      2) SSPC Paint 20.
2. For Surfaces to be Left Exposed:
   a. In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
      1) MIL-P-21035.
      2) MIL-PRF-26915.
   b. Basis-of-Design: Brite Products “Brite Zinc”.

2.4 FASTENERS

A. As shown on approved shop drawings.

2.5 FABRICATION

A. General: Fabricate deck units in lengths to span three or more supports, with telescoped or nested 2 inch end laps and nested side laps, and end laps staggered by at least one deck span length, unless otherwise indicated. Provide deck configurations complying with SDI “Specification” and as specified herein; and of gages and section modulus per foot width shown on Contract Drawings.
B. Wide Rib Metal Deck Units: Provide 1-1/2 inches approximate depth; 6 inches approximate rib spacing; 2-1/2 inches maximum width of rib opening at roof surface; 1-3/4 inches minimum width of rib at bottom surface. Metal deck units to be 36 inches wide times width of roof, wherever possible.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Erect steel decking and accessories in accordance with approved shop drawings and manufacturer’s recommendations.
B. Place decking units on the supporting member, align and adjust to final position before permanent fastening. Do not use metal deck area as storage or working platform until fastened.
C. If supporting beams are not in proper alignment or at correct elevation to provide bearing and alignment of deck units, do not place decking units in deficient areas until necessary corrections have been made.

D. Continue decking over three or more spans.

E. Welding and inspection of welds shall be done in accordance with AWS D1.3.

F. Use electric-arc welding to weld deck panels to end supports as shown on approved shop drawings. Where panel ends meet, provide minimum 2 inches overlap and continuous weld to fuse ends of units together. Stagger end laps by at least one deck span length unless otherwise approved. At the canopy, welds shall not be visible from below.

G. Mechanically anchor side laps of adjacent panels at intervals not exceeding 3 feet with self drilling, No. 10 or larger, screws. Screws to be aligned (not random) and through metal supports below. Remove any screws that are non-functioning or misplaced at the canopy. Screws must be cut after installation is complete.

H. Remove burrs and sharp edges.

I. Where welding occurs through deck, plug weld to ensure proper attachment. Use proper welding rods and power to produce sound, full size welds without excessive burning, or damage to supporting steel members. Use welding washers for metal thickness less than 0.0239 inches.

J. Cut bevels and perform other special cutting and fitting at Worksite.

K. Provide necessary support framing and reinforcement and openings for items penetrating deck panels.

L. Coordinate cutting of openings for work of other trades with trades involved. Repair or replace deck where non-usable holes have been made.

M. Do not hang mechanical equipment or other loads from steel deck.

N. Over welded areas, apply galvanizing repair compound at rate of 2 ounces per square foot.

O. Deck with burned holes must be repaired or replaced.

3.3 ADJUSTING AND CLEAN-UP

A. Clean up rubbish and debris caused by this work and remove from site.

B. Leave decks and areas surrounding work in broom-clean condition.

C. Galvanized Surfaces:
   1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.
   2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Structural metal roof decking will not be measured under this section, but will be considered as subsidiary to Section 05130, “Structural Steel - Buildings”.

B. Structural metal roof decking, as described in this section, will be paid as subsidiary to Section 05130, “Structural Steel - Buildings”.

END OF SECTION 05300
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the requirements for determining, providing, and installing permanent metal deck forms and accessories when used for the forming of bridge or any other elevated slab concrete.

1.2 REFERENCE STANDARDS

A. American Welding Society (AWS):
   1. AWS D1.3 - Structural Welding Code - Sheet Steel

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

C. Military Specification (MIL):
   1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).
   2. MIL-PRF-26915 – Primer Coating, for Steel Surfaces.

D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

1.3 PERFORMANCE REQUIREMENTS

A. Permanent Metal Deck Forms (P.M.D. Forms) shall be designed for the dead load of form, reinforcement, and concrete, plus 50 pounds per square foot for construction loads.

B. The following allowable stresses shall be used in the design:

<table>
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<th>Grade</th>
<th>Yield (psi)</th>
<th>Allowable Stress (psi)</th>
</tr>
</thead>
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<tr>
<td>A</td>
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<td>23,900</td>
</tr>
<tr>
<td>B</td>
<td>37,000</td>
<td>26,800</td>
</tr>
<tr>
<td>C</td>
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</table>

C. The permissible form camber shall be limited to the actual dead load deflection of the form. Maximum deflection under the weight of forms, reinforcement, and concrete, or a minimum of 120 pounds per square foot shall not exceed 1/180 of the form span or 1/2 inch whichever is less.

D. Permanent metal deck forms shall not be used in panels where longitudinal deck construction joints are located between stringers.

E. Metal decks shall be grounded as shown on the drawings and in accordance with Section 16450, “Grounding and Bonding”.

1.4 SUBMITTALS

A. Shop Drawings:
   1. Include the layout, take and incorporate necessary field verified dimensions, details of fabrication and erection including materials, material thicknesses, dimensions, supports, form details, closures, methods of joining, fasteners, connectors, size and location of welds, accessories, openings through decking, special conditions, and protective coating data.

B. Design calculations covering all maximum stress conditions in forms and supports along with typical sketches of the system proposed and materials to be used will be required prior to fabrication or use of the forms. Calculations shall clearly indicate design spans, applied loads, loads on the support members, acceptable stresses or other evidence of the ability of the system to support the applied loads. Calculations shall be certified by a Professional Engineer licensed in the State of Texas.
Test results submitted as evidence of adequate strength shall be well documented and entirely conclusive that adequate strength is available. End closures, hangers, and connections differing from those shown on the plans will be considered if thoroughly detailed and documented.

C. Samples:
   1. Three of each type of the following products used in the work.
      a. Decking: 6 inches by width of material.
      b. Accessories.
      c. Fasteners.
   2. Welding Sample: Prepare and submit three samples of each type of deck welding specified and shown. Resubmit samples not approved as required to provide an acceptable sample. Acceptable samples will be made available on-site as an example for welders to follow.

D. Certification: Submit certification that welding personnel and inspection/testing personnel are qualified in accordance with AWS D1.3 and AWS CWI respectively.

1.5 QUALITY ASSURANCE

A. Qualification of Welding Personnel: Employ welding personnel whose qualification is certified in accordance with AWS D1.3. Such certification is to remain in force for the duration of the welding operations under this Contract. Inspection personnel shall be an AWS CWI.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products in good condition.
B. Store products to preclude corrosion, deterioration, and damage.
C. Handle products to prevent damage.

1.7 JOB CONDITIONS

A. Do not apply construction loads in excess of the live loads for which the deck is designed.

2.1 STEEL DECKING

A. Permanent metal deck forms shall be fabricated from steel conforming to ASTM A653/A653M (Grades A through E) with a galvanized coating class G165.

2.2 ACCESSORIES

A. Types shown or necessary to complete installation, such as form supports and closure plates.
B. Same finish as decking, unless otherwise shown or specified.

2.3 GALVANIZING REPAIR COMPOUND

A. Galvanizing Repair Paint:
   1. For Concealed or Top Coated Surfaces:
      a. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
         1) ASTM A780.
         2) SSPC Paint 20.
   2. For Surfaces to be Left Exposed:
      a. In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
         1) MIL-P-21035.
         2) MIL-PRF-26915.
      b. Basis-of-Design: Brite Products “Brite Zinc”.

2.4 FASTENERS

A. As shown on approved shop drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Erect permanent metal form decking and accessories in accordance with approved shop drawings and manufacturer’s recommendations.

B. Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of one inch at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. Place decking units on the form supports,
align, and adjust to final position before permanently fastening. Do not use metal deck area as storage or working platform until fastened. 

C. If supporting beams are not in proper alignment or at correct elevation to provide bearing and alignment of deck units, do not place decking units in deficient areas until necessary corrections have been made.

D. Welding and inspection of welds shall be done in accordance with AWS D1.3.

E. Attachments shall be made by permissible welds, screws, bolts, clips, or other approved means. Only welds or bolts shall be used to support vertical loads. Use electric-arc welding to weld deck panels to form supports. Where welding occurs through deck, plug weld to ensure proper attachment. Use proper welding rods and power to produce sound, full size welds without excessive burning or damage to form supports. Mechanical anchor side laps of adjacent panels at intervals not exceeding 3 feet with self drilling, No. 10 or larger, screws. Screws to be aligned (not random).

F. Permanently exposed form metal, where the galvanized coating has been damaged, shall be thoroughly cleaned, wire brushed, and coated with galvanizing repair compound at a rate of 2 ounces per square foot.

G. Flutes shall line up uniformly across the entire span where main reinforcing steel is located in the flute.

H. Construction joints will not be permitted unless shown on the plans. The location of and forming details for any construction joint used, shall be shown on the erection drawings. Forms below a construction joint must be removed after curing of the slab.

I. The direction of concrete placement will be such that the upper layer of the form overlay receives load first.

J. Utilize method to provide uniform vibration of concrete during placement. Attention must be given to prevent damage to the forms, yet provide proper vibration to prevent voids or honeycomb in the flutes and at headers and/or construction joints.

3.2 ADJUSTING AND CLEAN-UP

A. Clean up rubbish and debris caused by this work and remove from site.

B. Leave decks and areas surrounding work in broom-clean condition.

C. Galvanized Surfaces:

1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Permanent metal form deck used for slabs will not be measured directly under this section, but shall be considered subsidiary to Section 03300, “Cast-In-Place Concrete”.

B. Permanent metal form deck used for slabs will not be paid for directly under this section, but shall be considered subsidiary to Section 03300, “Cast-In-Place Concrete”.

END OF SECTION 053100
SECTION 05415
COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY
A. This section specifies cold-formed metal framing (screwable metal studs and joists, typically 16 or 18 gage) and supplementary items necessary to complete their installation.

B. For nonload-bearing metal-stud framing of 20, 22, and 25 gage metal studs and joists and ceiling-suspension assemblies refer to Section 09260, "Gypsum Board Assemblies".

1.2 DEFINITIONS
A. Minimum Uncoated Steel Thickness: Minimum uncoated thickness of cold-formed framing delivered to the Project site shall be not less than 95 percent of the thickness used in the cold-formed framing design. Lesser thicknesses shall be permitted at bends due to coldforming.

1.3 REFERENCE STANDARDS
A. American Iron and Steel Institute (AISI):
1. AISI SG03 - Cold-Formed Steel Design Manual
2. AISI SG-911/SG-912 - Load and Resistance Factor Design Specification and Commentary for Steel Structural Members

B. American Welding Society (AWS):
1. AWS D1.1/D1.1M - Structural Welding Code - Steel
2. AWS D1.3 - Structural Welding Code - Sheet Steel

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
4. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
5. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
7. ASTM C955 - Standard Specification for Load-Bearing (Transverse and Axial) Steel Studs, Runners (Tracks), and Bracing for Screw Application of Gypsum Panel Products and Metal Plaster Bases
8. ASTM C1007 - Standard Specification for Installation of Load Bearing (Transverse and Axial) Steel Studs and Related Accessories
11. ASTM E488 - Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements
12. ASTM E548 - Standard Guide for General Criteria Used for Evaluating Laboratory Competence
14. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

D. Gypsum Association (GA):
1. GA 600 - Fire Resistance Design Manual

E. Military Specification (MIL):
1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).
2. MIL-PRF-26915 - Primer Coating, for Steel Surfaces.
F. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

   1. SSPC Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic").

1.4 SYSTEM DESCRIPTION

A. This is a performance specification and the cold-formed metal framing fabricator shall be responsible for structural design and engineering required to meet specified performance requirements within physical and aesthetic requirements established.

B. Contract Documents are an outline of criteria and performance requirements for the System. Requirements specified or indicated by details are intended to establish aesthetic design requirements and performance of exterior and interior finish materials.

C. Drawings do not necessarily indicate or describe total work required for completion of Work. Furnish and install all items required for complete installation.

D. Dimension and profile adjustments may be made in proposed structural design in interest of fabrication or erection methods or techniques, weatherability factor, or ability of design to satisfy design and performance requirements, provided that aesthetic design intent and intent of Contract Documents are maintained. Include modifications or additions required to meet specified requirements and maintain the visual design concept.

1.5 SYSTEM PERFORMANCE REQUIREMENTS

A. Structural Performance: Engineer, fabricate, and erect cold-formed metal framing to withstand design loads within limits and under conditions required.

   1. Design Loads: Design framing system to withstand design loads required by local building code.

   2. Deflection Limits: Design framing systems to withstand design loads without deflections greater than following:

      a. Exterior Typical Wall Framing: Horizontal deflection of 1/360 of wall height.

      b. Exterior Masonry Wall Framing: Horizontal deflection of 1/720 of wall height.

   c. Interior Typical Wall Framing: Horizontal deflection of 1/240 of wall height.

   3. Design framing systems to provide for movement of framing members without damage to interior and exterior finishes, sheathing failure, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change (range) of 120 deg F.

   4. Design framing system to maintain clearances at openings, to allow for construction tolerances, and to accommodate live load deflection of primary building structure of 1/2 inch upward and downward movement.

   5. System design shall maintain visual design concept and incorporate an expansion and contraction joint located above ceiling line to isolate movement between interior and exterior finishes.

   6. Stud depth and maximum spacing indicated is critical for performance of other materials and shall not change without consideration of performance of materials dependent upon indicated depth and spacing. Spacing where indicated shall be construed to imply maximum spacing.

B. Design exterior wall framing to accommodate lateral deflection without regard to contribution of sheathing materials.

C. Engineering Responsibility: Engage fabricator who assumes undivided responsibility for engineering cold-formed metal framing by employing a qualified professional engineer to prepare and seal design calculations, shop drawings, and other structural data.

1.6 SUBMITTALS

A. Product Data: For each type of cold-formed metal framing, accessory, and product specified.

B. Shop Drawings: Show layout, spacings, sizes, thicknesses, and types of cold-formed metal framing, fabrication, fastening and anchorage details, including mechanical fasteners. Show reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachments to other units of Work.

   1. Include setting drawings, templates, and directions for the installation of anchor bolts.
and other anchorages installed as a unit of work under other sections.

2. If deviations are proposed indicate where and how the proposed system deviates from Contract Documents.

3. Shop drawings shall contain seal of a professional engineer currently registered in licensing jurisdiction of the project and a written statement that the wall system conforms to project requirements, applicable codes, and specified conditions.

4. Provide for information only, material properties and other information needed for structural analysis including computations, prepared, signed, and sealed by a professional engineer licensed to practice in the jurisdiction where the project is located.

C. Mill certificates signed by steel sheet producer or test reports from a qualified independent testing agency indicating steel sheet complies with requirements.

D. Certificates that welding and inspection/testing personnel are qualified in accordance with AWS D1.3.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

F. Product Test Reports: From a qualified testing agency indicating that each of the following complies with requirements, based on comprehensive testing of current products:

   1. Expansion anchors.
   3. Mechanical fasteners.
   4. Vertical deflection clips.
   5. Miscellaneous structural clips and accessories.

G. Research/Evaluation Reports: Evidence of cold-formed metal framing's compliance with building code in effect for Project, from a model code organization acceptable to authorities having jurisdiction.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed cold-formed metal framing similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Engineering Responsibility: Engage a qualified professional engineer to prepare design calculations, Shop Drawings, and other structural data.

C. Professional Engineer Qualifications: A professional engineer who is licensed in the State of Texas and experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of cold-formed metal framing that are similar to those indicated for this Project in material, design, and extent.

D. Mill certificates signed by steel sheet producer or test reports from a qualified independent testing agency indicating steel sheet complies with requirements, including uncoated steel thickness, yield strength, tensile strength, total elongation, chemical requirements, ductility, and galvanized-coating thickness.

E. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM E329 to conduct the testing indicated.


G. Fire-Test-Response Characteristics: Where metal framing is part of a fire-resistance-rated assembly, provide framing identical to that of assemblies tested for fire resistance per ASTM E119 by a testing and inspecting agency acceptable to authorities having jurisdiction.

AISI Specifications: Comply with AISI SG03 and AISI SG-911/SG-912 and the following for calculating structural characteristics of cold-formed metal framing:


**PART 2 - PRODUCTS**

**2.1 MATERIALS**

A. Steel Sheet: ASTM A653 structural steel, zinc coated, of grade and coating as follows:

1. Grade: 33 for minimum uncoated steel thickness of 0.0428 inch and less; 50 for minimum uncoated steel thickness of 0.0538 inch and greater.

2. Coating: G90.

**2.2 WALL FRAMING**

A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges, complying with ASTM C955, and as follows:

1. Uncoated-Steel Thickness: 0.0428 inch minimum.


B. Steel Track: Manufacturer's standard galvanized U-shaped steel track, of web depths indicated, with straight flanges, and complying with ASTM C955 and the following:

1. Design Uncoated-Steel Thickness: Matching steel studs.

2. Flange Width: Manufacturer's standard deep flange (minimum 2 inches) at head of exterior walls where studs occur between structural floors, standard flange elsewhere.

3. Web: Bottom track punched with 1 inch diameter holes at 24 inches on center, over openings to prevent track from holding water, unpunched elsewhere.

**2.3 FRAMING ACCESSORIES**

A. Fabricate steel-framing accessories of the same material and finish used for framing members, with a minimum yield strength of 33,000 psi.

B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:

1. Supplementary framing.

2. Bracing, bridging, and solid blocking.

3. Web stiffeners.

4. Gusset plates and clips.

5. Deflection track.


7. Reinforcing and backer plates.

**2.4 ANCHORS, CLIPS, AND FASTENERS**

A. Steel Shapes and Clips: ASTM A36/A36M, zinc coated by the hot-dip process according to ASTM A123/A123M.

B. Anchor Bolts: ASTM F1554, threaded carbon-steel hex-headed bolts and carbon-steel nuts; and flat, hardened-steel washers; zinc coated by hot-dip process according to ASTM A153.

C. Expansion Anchors: Fabricated from corrosion-resistant materials, with capability to sustain, without failure, load equal to 5 times the design load, as determined by testing per ASTM E488 conducted by qualified independent testing agency.

D. Powder-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with capability to sustain, without failure, a load equal to 10 times the design load, as determined by testing per ASTM E1190 conducted by a qualified independent testing agency.

E. Mechanical Fasteners: Corrosion-resistant coated, self-drilling, self-threading steel drill screws with low-profile type head beneath sheathing, manufacturer's standard elsewhere.

F. Welding Electrodes: Comply with AWS standards.
2.5 MISCELLANEOUS MATERIALS

A. Galvanizing Repair Paint:

1. For Concealed or Top Coated Surfaces:
   a. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
      1) ASTM A780.
      2) SSPC Paint 20.

2. For Surfaces to be Left Exposed:
   a. In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
      1) MIL-P-21035.
      2) MIL-PRF-26915.

b. Basis-of-Design: Brite Products “Brite Zinc”.

B. Structural Nonshrink Grout: As specified in Section 03305, “Portland Cement Concrete”.

C. Thermal Insulation: For boxed-in sections, ASTM C665, Type I, unfaced mineral-fiber blankets produced by combining glass or slag fibers with thermosetting resins.

3. INSTALLATION, GENERAL

A. Cold-formed metal framing may be shop or field fabricated for installation, or it may be field assembled.

B. Install cold-formed metal framing according to ASTM C 1007, unless more stringent requirements are indicated or required by conditions.

C. Install cold-formed metal framing and accessories plumb, square, true to line, and with connections securely fastened, according to manufacturer's recommendations and requirements of this Section.

1. Space studs at 16 inches on center maximum unless otherwise indicated.

2. Cut framing members by sawing or shearing; do not torch cut.

3. Fasten cold-formed metal framing members by screw fastening. Wire tying of framing members is not permitted.
   a. Locate mechanical fasteners and install according to cold-framed metal framing manufacturer's instructions with screw penetrating joined members by not less than three exposed screw threads.

D. Install framing members in one-piece lengths, unless splice connections are indicated for track or tension members.

E. Install temporary bracing and supports to secure framing and support loads comparable in intensity to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.

F. Do not bridge building expansion and control joints with cold-formed metal framing. Independently frame both sides of joints.

G. Install insulation in built-up exterior framing members, such as headers, sills, boxed joists, and multiple studs at openings that are inaccessible on completion of framing work.

H. Fasten reinforcement plate over web penetrations that exceed size of manufacturer's standard punched openings.

I. Erection Tolerances: Install cold-formed metal framing to a maximum allowable tolerance
variation from plumb, level, and true to line of 1/8 inch in 10 feet and as follows:

1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error shall not exceed minimum fastening requirements of sheathing or other finishing materials.

3.4 WALL FRAMING INSTALLATION

A. Install continuous top and bottom tracks sized to match studs. Align tracks accurately and securely anchor to supporting structure and at spacings recommended by manufacturer, but not greater than 24 inches on center.

B. Squarely seat studs against webs of top and bottom tracks. Fasten both flanges of studs to top and bottom track.

C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.

D. Isolate steel framing from building structure to prevent transfer of vertical loads while providing lateral support. Install deep-leg deflection tracks and anchor to building structure.

E. Install headers over wall openings wider than the stud spacing. Locate headers above openings as indicated. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.

1. Frame wall openings with not less than a double stud at each jamb of frame as indicated or required by manufacturer.

2. Install runner tracks and jack studs above and below wall openings. Anchor tracks to jamb studs with clip angles or by welding, and space jack studs same as full-height wall studs.

F. Install supplementary framing, blocking, and bracing in stud framing where required to support additional loads.

G. Install horizontal bridging in stud system, spaced in rows not more than 54 inches apart. Fasten at each stud intersection.

1. Bridging: Cold-rolled steel channel, welded or mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle.

2. Deflection Track: Install row of bridging within 18 inches of deflection track.

H. At shear walls install steel-sheet diagonal bracing strap to both stud flanges, terminate at and fasten to reinforced top and bottom track. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.

I. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.5 REPAIRS AND PROTECTION

A. Galvanized Surfaces:

1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

B. Provide final protection and maintain conditions in a manner acceptable to manufacturer and installer to ensure that cold-formed metal framing is without damage or deterioration at time of Substantial Completion.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section will not be measured separately, but payment made for on a lump sum basis for cold-formed metal framing per location indicated.

END OF SECTION 05415
SECTION 05430
SLOTTED CHANNEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies slotted channel framing and supplementary items necessary to complete their installation.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A575 - Standard Specification for Alloy Steel Bars, Carbon, Merchant Quality, M-Grades
2. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
3. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

B. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code - Steel

1.3 SYSTEM DESCRIPTION SUMMARY

A. General Description:

1. System shall consist of required elements such as struts, columns, braces, fittings, spanning members, longitudinal rails, track supports, nuts, bolts, washers, shim plates, etc. for a complete, adequate and properly functioning assembly.
2. System shall be a basic support assembly that permits transverse and longitudinal adjustment of bolt centers at the installation site.
3. System shall be adaptable to accommodate various circumstances and conditions at each installation.
4. When possible, the system shall be prefabricated for installation at the job site.
5. The system shall be rigid, securely braced and level in both directions at the finish ceiling line.

B. Aesthetic Requirements:

1. System shall be concealed above the ceiling to support items below the ceiling.
2. Bottom member shall be flush with the finished ceiling.

C. Structural Requirements:

1. System structural design shall be sufficient to support loads indicated on the drawings.
2. Top member shall be fastened to the building concrete or steel structure above.
3. Design shall include a minimum safety factor of three. Safety factor greater than three shall be used if required by applicable national, state or local codes.

D. Interface with Adjacent System(s):

1. System shall coordinate and properly interface with ceiling system.
2. System shall be installed prior to ceiling installation.
3. Coordinate with mechanical, electrical and plumbing (MEP) to avoid conflicts.

E. Tolerances (of total system):

1. Members shall be level in both directions to within 1/16 inch.
2. Members shall be parallel to within 1/16 inch.
3. System shall permit minimum 12 inch adjustment.

1.4 SUBMITTALS

A. Design Data:

1. Submit complete and specific design data for products specified.
2. Engineering design data shall be sufficient to permit the calculations of stresses and to verify the strength of individual members and/or components.

B. Product Data:

1. Submit manufacturer’s specifications to evidence compliance with these specifications.
C. Shop Drawings:
   1. Submit complete fabrication details and erection drawings.
   2. Drawings shall show plan layout, typical elevations, details and anchoring methods.

D. Samples: Submit two 12 inch long samples of each component of system, plus fasteners and anchors.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Products covered under this Section shall be produced by a single manufacturer unless otherwise specified.
   2. Manufacturer shall submit evidence of having not less than five years successful production of this product.

B. Subcontractor Qualifications:
   1. Subcontractor shall submit evidence of skill and not less than three years specialized experience with this product.
   2. Subcontractor shall be trained, approved and certified by the manufacturer.

C. Designer Qualification:
   1. Each component of the slotted channel framing systems shall be designed by a professional engineer who is licensed in the State of Texas and said engineer must be employed by the system manufacturer.
   2. Submit a statement certified by the licensed professional engineer that the design of components of the system, including connections to the structural frame, is in compliance with provisions of the Contract Documents, and is in keeping with generally accepted engineering practice.

D. Welder Qualification:
   1. AWI D1.1/D1.1M
   2. AWI Certified

E. Special Requirements of Regulatory Agencies:
   1. Material and design shall conform to specifications of the following organizations:
      a. American Iron and Steel Institute (AISI)
      b. American Institute of Steel Construction (AISC)
   c. American Welding Society (AWS)
   d. American Society For Testing and Materials (ASTM)

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in accordance with the manufacturer’s latest published requirements and specifications.

1.7 SEQUENCING AND SCHEDULING

A. Coordinate with structural concrete and steel trades for attachments.

B. Coordinate with mechanical (HVAC), electrical and plumbing trades to avoid conflicts.

C. Install system prior to ceiling installation. Coordinate with ceiling trade.

D. Report conflicts to the Contracting Officer.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are “acceptable” only if manufacturer can evidence product compliance with requirements of Contract Documents.
   1. B-Line Systems, Inc.
   2. Grinnell Supply Sales - “Power-Strut"
   3. Unistrut Corporation Building Systems
   4. Or approved equal

2.2 BASIS-OF-DESIGN PRODUCT

A. Manufacturer and Series/Model Number: Unistrut “P1000 1-5/8” Channel Width Series"

2.3 MATERIALS

A. Materials shall conform to one of the following ASTM Specifications:
   1. Hot Rolled Carbon Steel Sheet and Strip, Structural Quality: ASTM A1011/A1011M, Grade 33
   2. Zinc-Coated Steel Sheet, Structural Quality: ASTM A653/A653M, Grade A, G90
   3. Hot Rolled Steel Bar: ASTM A575
   4. Hot Rolled Steel Sheet and Strip: ASTM A1011/A1011M
B. Members and connections shall be coated with a corrosion resistant finish.

1. Electro-Galvanized (EG) Finish: Bolts, screws, nuts and washers shall be coated with zinc electrolytically to ASTM B633, Type 1, Class SC3.

2. Pre-Galvanized Channel (PG) Finish: Material (steel strip) shall be coated with zinc by hot-dipped process prior to roll forming or press operations. The zinc weight is G90, conforming to ASTM A1011/A1011M.

3. Finish For Exposed Members: Exposed members shall be carefully cleaned and phosphated. Immediately after phosphating, a uniform coat of rust inhibiting baked acrylic enamel paint shall be applied by electro-deposition. Paint color shall match ceiling grid color unless otherwise specified.

2.4 SYSTEM COMPONENTS

A. Horizontal Spanning Members (flush with ceiling): #P1001 channels

B. Vertical Columns: #P1001 channel

C. Diagonal Braces: #P1000 channel

D. Connectors, Fittings, and Hardware (nuts, bolts, washers, shims, etc.): As required

2.5 SYSTEM STRUCTURAL DESIGN

A. Support Structure:

1. The support members at the ceiling plane shall be located as indicated on the drawings.

2. It shall be possible to attach equipment support rails at any point along the support members without drilling into support system or welding to same.

B. Ceiling Anchorage: Wherever possible, attachment to ceiling shall be by means of embedded concrete inserts, through-bolts or by direct attachment to structural framing.

C. Loading:

1. The "concentrated load" is the maximum that will be encountered by positioning of equipment at the extremities of its travel (maximal load configuration).

D. Safety Factor:

1. The support structure shall be designed for a minimum safety factor of 3 based on the ultimate strength under static loading conditions.

2. In addition, structure shall not deflect more than 1/720 span in either plane (vertical or horizontal) when maximal loading conditions, due to equipment operation, is applied on either rail.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine and verify that receiving substrate surfaces of the structure have no defects or errors which would result in poor or potentially defective application or cause latent defects in workmanship.

B. Starting installation shall imply acceptance of surfaces.

3.2 PREPARATION

A. Structural Adequacy:

1. Prepare the structure to insure proper and adequate structural support for the framing support system specified.

2. Coordinate placement and location of embedded anchor receivers in structural concrete above.

3. Coordinate proper anchorage to structural steel above.

B. Prepare substrate surfaces to insure proper and adequate installation, in accordance with the Contract Documents and approved Shop Drawings, or framing support system manufacturer’s requirements.

C. Field Measurements/Verifications:

1. Field measure and verify dimensions as required.

2. Make field measurements to assure that the framing support system can be installed without interference with structural framing, mechanical systems, plumbing, or other obstructions.

D. Protect adjacent areas or surfaces from damage as a result of the Work of this Section.

3.3 INSTALLATION

A. Install in accordance with framing support system manufacturer’s latest published requirements, specifications, details and approved shop drawings.

B. Interface with Other Products/Trades:

1. Coordinate and cooperate with mechanical, electrical, plumbing and ceiling installation trades.

2. Coordinate and comply with requirements of medical equipment components.
C. Installation/Erection Tolerances:

1. Supporting framework shall be installed plumb and true.

2. The mounting surfaces of the support structure shall be horizontal within the tolerance of 1/32 inch in 24 inches and within 1/16 inch in 18 foot length.

3. The elevation of one rail mounting surface to the other shall be within 1/16 inch in any 24 inch length of the rails.

3.4 ADJUSTING

A. Adjust and leave the framing support system in perfect working order and in compliance with specified tolerances.

3.5 CLEANING

A. Immediately remove spots, smears, stains, residues, adhesives, etc., from the exposed portions of the work of this Section and/or upon adjacent areas or surfaces which result from the Work of this Section.

B. Upon the completion of the work of this Section, dispose of, away from the site, debris, trash, containers, residue, remnants and scraps which result from the Work of this Section.

3.6 PROTECTION

A. After installation and until Authority acceptance, protect the framing support system from damage.

B. Remove damaged items, elements, units or materials and replace with new, undamaged ones, at no cost to the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section will not be measured separately, but payment made for on a lump sum price for slotted channel framing per location indicated.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing miscellaneous metal, with the exception of ornamental (architectural) metal and metal work provided as a part of mechanical, electrical, and construction systems.

B. Seats for windscreens are specified in Section 02873, “Station Furnishings”.

C. Metal stairs are specified in Section 05510, “Metal Stairs”.

D. Cast abrasive nosings attached to metal stairs are specified in Section 05510, “Metal Stairs”.

E. Handrails and railings are specified in Section 05520, “Metal Railings”.

1.2 REFERENCE STANDARDS

A. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel
   2. AWS D1.3 - Structural Welding Code - Sheet Steel

B. Americans with Disabilities Act Accessibility Guidelines (ADAAG).

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   3. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   5. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   6. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   7. ASTM A229/A229M - Standard Specification for Steel Wire, Oil-Tempered for Mechanical Springs
   8. ASTM A242/A242M - Standard Specification for High-Strength Low-Alloy Structural Steel
   9. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes
   10. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
   11. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength
   13. ASTM A413/A413M - Standard Specification for Carbon Steel Chain
   14. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
   15. ASTM A536 - Standard Specification for Ductile Iron Castings
   16. ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
   17. ASTM A588/A588M - Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4-in. (100-mm) Thick
   18. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
   19. ASTM A786/A786M - Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
   20. ASTM D395 - Standard Test Methods for Rubber Property - Compression Set
23. ASTM D573 - Standard Test Method for Rubber - Deterioration in an Air Oven

24. ASTM D1149 - Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber

25. ASTM D2240 - Standard Test Method for Rubber Property - Durometer Hardness


27. ASTM E488 - Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements


D. Military Specification (MIL):
1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).
2. MIL-PRF-26915 - Primer Coating, for Steel Surfaces.

E. National Association of Architectural Metal Manufacturers (NAAMM):
1. NAAMM MBG 531 - "Metal Bar Grating Manual"

F. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
1. SSPC Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic").

G. Texas Accessibility Standards (TAS).

1.3 SUBMITTALS

A. Shop Drawings:
1. Include fabricated work showing details of construction and placement including hardware, fittings, and fastenings.
2. Submit manufacturer's standard drawings in lieu of prepared shop drawings if manufacturer's standard drawings show required details.

B. Certification:
1. Certificate from manufacturer of steel gratings verifying that gratings are capable of supporting loading as shown.
2. Certification that welding personnel and inspection/testing personnel are currently qualified in accordance with AWS D1.1/D1.1M and AWS CWI respectively.

1.4 QUALITY ASSURANCE

A. Qualifications of Welding Personnel:
1. Employ welders whose qualification is certified in accordance with AWS Standard D1.1/D1.1M.
2. Inspection personnel shall be an AWS CWI.
3. Certification shall remain in force for the duration of the welding operations under this Contract.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products undamaged.
B. Store products to prevent rust.
C. Handle products to prevent damage.
D. After completion of factory testing, package and ship hatches as directed.

PART 2 - PRODUCTS

2.1 METALS

A. Steel:
1. Structural steel: Plates, shapes, bars, and angles, ASTM A36/A36M.
2. Floor plate: ASTM A786 rolled from plate complying with ASTM A283, Grade C or D, ASTM A36/A36M or, diamond pattern unless otherwise specified, flat back, galvanized in accordance with ASTM A123/A123M.
3. High-strength low-alloy structural steel:
   a. ASTM A242.
   b. Resistance to atmospheric corrosion: Four times that of carbon steel, minimum.
6. Bolts:
   b. Stainless steel: ASTM F593, Group 1 for bolts and ASTM F594, Group 1 for nuts.
   c. High Strength: ASTM A325, Type 1. ASTM A563, Grade DH, for nuts. ASTM F436, Type 1 for washers.

7. Anchor Bolts, Nuts and Washers: ASTM F1554, Grade 55, unless noted otherwise on drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers. Galvanized per ASTM A153/A153M.

8. Screws: Stainless steel, ASTM F593, Group 1

B. Iron Castings:
   2. Ductile iron: ASTM A536.

C. Pipe, Pipe Sleeves, and Pipe Fittings:
   2. Steel: ASTM A53, galvanized unless otherwise shown or specified.

D. Grating: NAAMM MBG 531 Welded or pressure locked bar grating, depth and spacing as indicated, hot-dip galvanized.

2.2 FINISHES

A. Galvanizing Repair Paint:
   1. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
      a. ASTM A780.
      b. SSPC Paint 20.
   2. In addition to requirements for concealed and top coated surfaces, match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
      a. MIL-P-21035.
      b. MIL-PRF-26915.

B. Paint: As specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

C. Coal tar epoxy coating: Tnemec 4H-413 coal tar epoxy, Carbolene, Ameron, or approved equal.

D. Porcelain Enamel finish on steel: Provide porcelain enamel finished cladding on steel panels where shown and in accordance with PEI Specification SE-100 matching colors on the color schedule.

E. Baked Enamel on steel: Provide baked enamel finish on steel fabrications where shown by a thorough hot chemical cleaning process, a six step zinc phosphate process, two prime coats and one finish coat of sprayed acrylic enamel (1.25 mil thickness minimum), baked at 350 degrees F for a minimum of 30 minutes. Color as directed.

2.3 FASTENERS

A. Screws: Material, type and size to suit the purpose; steel, except stainless, cadmium-plated.

B. Machine bolts: Material, type, and size best suited to the purpose. Minimum tensile strength 60,000 psi.

C. Expansion anchors: Assembly of galvanized steel or stainless steel complying with ASTM F593 best suited to the purpose. Anchors shall be capable of resisting load equal to 6 times applied load at unit masonry and 4 times applied load at concrete per ASTM E488.

D. Screw anchors: Lead or plastic, for wood or metal screws.

E. Anchor bolt sleeve: Corrugated high-density polyethylene plastic.

2.4 NONSHRINK GROUT

A. Structural Nonshrink Grout: As specified in Section 03305, “Portland Cement Concrete”.

2.5 GENERAL REQUIREMENTS - FABRICATION

A. Insofar as practicable, furnish similar products of a single manufacturer.

B. Provide materials which have been selected for their surface flatness, smoothness, and freedom from blemishes, wherever exposed to view in the finished unit. Exposed to view surfaces which exhibit pitting seam marks, roller marks, “oil-canning”, stains, discolorations, or other imperfections on finished units will not be accepted.

C. Provide material that is free from mill scale, flake rust, and mill pitting.

D. Items formed and finished to shapes and sizes indicated or required with sharp angles and lines.
E. Metal work bent by shearing or punching may be straightened and used.

F. Plates shall be welded on for mounting hardware. Holes shall be drilled or punched for bolts and screws. Fastenings shall be concealed wherever practicable.

G. Exposed edges of work shall be ground smooth. Joints exposed to weather shall be constructed to exclude water.

H. Brackets, lugs, and similar accessories, required for installation, shall be included as a part of metal item.

I. Where miscellaneous access openings, with exception of gratings, occur in finished floor areas, include stainless steel edge rims of depth to accommodate floor finishing material.

J. Welding:
   1. Perform welding in accordance with AWS D1.1/D1.1M.
   2. Ensure all welds made in units exposed to view are completely filled, ground smooth, all pin holes removed. For unpainted surfaces, conform to AWS, NAAMM Standards, welding rod manufacturer and metal producer to produce absolute color and finish match of welds to the surrounding metal.

K. Fabricate exterior components to allow for expansion and contraction for an ambient temperature range from 0 degrees F to 120 degrees F, without causing buckling, excessive opening of joints or overstressing welds or fasteners.

L. Form to required shapes and sizes, with true curves, lines, and angles. Provide necessary rebates, lugs and brackets for assembly of units. Use concealed fasteners wherever possible.

M. Mill joints to a tight hairline fit. Cope or miter corner joints. Exposed edges to be ground smooth. Form joints exposed to weather to exclude water penetration.

N. Provide concealed corrosion resistant fasteners and flush type exposed fasteners located in vertical reveals.

O. Provide castings that are sound and free of warp or defects which impair strength and appearance. Mill joints to a close fit and finish exposed surfaces to smooth, sharp, well defined lines, and arises.

2.6 GUARD CHAINS
A. ASTM A413, Class Grade 28, galvanized steel, 9/32 inch thick, except where indicated as stainless steel, provide complete with stainless steel eyes, spring-loaded catches and mounting components.

2.7 PREFABRICATED EXPANSION JOINT
A. Extrusions or fabricated plates as shown in the plans.
B. Provide compression or strip seals as shown in the plans, to provide free movement of the joint as required.
C. Compression seals shall be extruded, multi-channel, elastomeric shapes conforming to ASTM D2628.
D. Strip seals shall have physical properties in accordance with the following table:

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTY</th>
<th>ASTM TEST</th>
<th>METHOD</th>
<th>REQTS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, min., psi</td>
<td>D412</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>Elongation @ Break, min., %</td>
<td>D412</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Hardness, Type A durometer Points, Modified</td>
<td>D2240</td>
<td>55(±)5</td>
<td></td>
</tr>
<tr>
<td>Oven aging, 70h@212 deg. F Tensile strength, max.% loss</td>
<td>D573</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elongation, max. % loss</td>
<td></td>
<td>20 max</td>
<td></td>
</tr>
<tr>
<td>Hardness, Type A durometer, points change</td>
<td></td>
<td>20 max</td>
<td></td>
</tr>
<tr>
<td>Oil Swell, ASTM Oil No. 3, 70 hours @ 212 deg. F Weight change, max. %</td>
<td>D471</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Ozone Resistance, 20% strain, 300 pphm in air 70 hours @ 104 deg</td>
<td>D1149</td>
<td>No cracks</td>
<td></td>
</tr>
<tr>
<td>Low temperature stiffening, 7 days @ 14 deg. F</td>
<td>D2240</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardness, Type A durometer, points change</td>
<td></td>
<td>0 to +15</td>
<td></td>
</tr>
<tr>
<td>Compression Set, 70 hours @ 212 deg. F</td>
<td>D395</td>
<td>Method B (modified) 40%</td>
<td></td>
</tr>
</tbody>
</table>

E. Joint seals shall be supplied and installed in one continuous length.

2.8 MANHOLE FRAME AND COVER; INLET FRAME AND GRATE; BALLAST SCREEN; AERIAL STRUCTURE DRAINS AND INLETS; AND OTHER CASTINGS FOR SERVICE WITH UTILITY SYSTEMS
A. Cast iron, ASTM A48, Class 40, or ductile iron, ASTM A536, fabricated as shown, with AASHTO HS-20-44 loading, where subject to vehicular traffic.
B. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes, and defects affecting strength.

C. Fillets at angles in casting with arrises sharp and true.

D. Sandblasted to effectively remove scale and sand, presenting smooth, clean, and uniform surfaces. Coat with 8 mil DFT of coal tar epoxy coating, where shown on Contract Drawings.

E. DART logo: For utility components which will remain Authority property and are not within boundaries of utility easements as shown, Cast DART logo as shown on drawings.

2.9 TRENCH FRAME AND COVER; PIT FRAME AND COVER

A. Fabrication: Floor plate, thickness as shown but in no case less than 1/4 inch in thickness, diamond pattern, flat back.

B. Surface: Abrasive, unless otherwise shown or specified.

C. Structural angle frames, anchored to supporting construction.

D. Plates in convenient lengths for handling and each section provided with finger holes for lifting.

E. Galvanize after fabrication.

F. Removable covers match-marked with their frames prior to shipping, fastened with stainless steel bolts.

2.10 STEEL GRATING

A. Angles or other structural shapes as supports for grating: Section 05120, “Structural Steel - Bridges”.

B. Removable steel gratings equipped with locking lugs and provision for bolting to supporting members with stainless steel bolts.

C. Grating manufactured by electro-pressure welding or pressure locking process, forming sound welded, or pressure locked joints at intersection of bars and having bars in the same plane.

1. For walkways, ventilation shafts, light wells, and other locations subject to possible vehicular traffic: gratings of plain, rectangular type, suitable for AASHTO HS-20-44 loading.

2. For track drainage pumping stations and other locations subject to foot traffic only: gratings of serrated, rectangular type, unless otherwise shown, fabricated of 1-1/4 inch x 1/8 inch bearing bars on 1-3/16 inch centers with cross bars on 4 inch centers and capable of supporting 250 psf uniform loading with a maximum deflection of 1/200 of span.

D. Galvanize after fabrication.

2.11 CORROSION-RESISTANT GRATING

A. Fabricated from high-strength low-alloy structural steel.

B. Gratings and related supports capable of supporting uniformly distributed live load shown.

C. Grating system fabricated to mechanically secure units in place and permit removal in sections of such size that one man can handle, weight not to exceed 50 pounds.

D. Unless otherwise shown, 2 inch x 3/16 inch bearing bars spaced at 5 inches on centers with cross bars at end of 6 feet long units, each unit electroforged or pressure-locked.


2.12 LADDERS

A. Designed to be bolted to floor, at top and at intermediate points on not more than 4 feet centers, with approved clips and anchors, conforming to OSHA requirements, including cages as applicable.

B. Fabricated of structural steel or high-strength low-alloy structural steel or stainless steel Type 304 or 306 as shown or specified.

C. Rails fabricated as detailed, or if not detailed, punched to receive rungs spaced at 12 inches on centers and fully welded to the rails.

D. Galvanize other than stainless steel after fabrication.

E. Provide non-slip surface on top of each rung, either by coating with aluminum oxide granules set in epoxy resin adhesive, or by using a type of manufactured rung which is filled with aluminum oxide grout.

F. Rungs shall withstand a 1000 lb. loading without failure.


2.13 CAST ABRASIVE NOSINGS

A. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions. Provide units of cast nickel bronze.
1. Provide cross hatched surface units, with abrasive, consisting of aluminum oxide, silicon carbide, or a combination of both, integrally cast into walking surface to minimum depth 1/32-inch.

2. Configuration: Units 3 inches wide, for casting into concrete steps.

B. Provide nosings full length of steps less 3-inch clearance at each end.

C. Provide concealed anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

D. Shot blasted finish.

E. Basis-of-Design Product: Wooster Products, Inc. Type 101

F. Acceptable Manufacturers:
   1. American Safety Tread Co., Inc.
   2. Safe-T-Metal Co.
   3. Wooster Products Inc.

2.14 STEEL LINTELS

A. Fabricated of structural steel.

B. Multiple members riveted or welded back-to-back or separated by spacers.

C. Shop primed and shop finish coated.

2.15 CORNER GUARDS, CURB ANGLES, AND BUMPERS

A. Fabricated of structural steel.

B. Shop primed and shop finish coated.

2.16 UNDERGROUND SAFETY WALKS

A. Grating: Bearing bars and end banding bar fabricated by electro-pressure welding process to form sound joints at intersections of bars with bars in same plane, size and design as shown.

   1. Designed to provide for hinged section of grating bolted to walls. Grating of such size to permit one-man operation and manual positioning vertically or horizontally.

   2. Structural steel plate hinges bolted to supporting construction with holes and slots as shown.

B. Locking pin: Stainless steel, diameter to fit receptacle in hinge assembly with tolerance not greater than plus or minus 1/64 inch.

C. Locking pin chain: Fabricated of 0.128 inch diameter spring steel wire.

D. Plug welded in accordance with AWS D1.1/D1.1M.


F. Bolts and washers: ASTM A325, nonrising, and vibrationproof.

G. Spring wire: ASTM A229, Class 1 or 4.

H. Ferrous metal components galvanized after fabrication.

2.17 AERIAL SAFETY WALKS

A. Fabricated of floor plate, diamond pattern, flat back.

B. Abrasive surface on plates, unless otherwise shown.

C. Structural steel angle frames anchored to supporting structure.

D. Plates in sections of convenient lengths for handling and with finger holes for lifting.

E. Galvanize after fabrication.

F. Bolts: Stainless steel.

2.18 LIFTING EYES

A. ASTM A572, Grade 50, 1 inch diameter steel rod, welded, galvanize after fabrication.

2.19 TREE GRATES, TREE GRATE FRAMES, AND TREE GUARDS

A. Tree grate:
   1. Round: Cast iron; as shown, radial pattern and expandable type.

   2. Square: Cast iron; expandable type, size as shown.

   3. Openings shall not exceed maximum width per TAS and ADAAG

B. Tree grate frame:
   1. Angles, plates, bars, and collars: Structural steel.

   2. Other elements: As shown and specified.

   3. Galvanize after fabrication.

C. Tree guard:
   1. Steel tubing; as shown.
2. Shop-coated.

2.20 PEDESTRIAN BARRIERS

A. Tubing: Hot-formed square steel. Fabricated as follows:
   1. Heated and bent smoothly without distortion.
   2. Joints fully welded as shown.
   3. Intersections coped, fully welded and ground smooth and flush.

B. Plate: Structural steel.

C. Floor cover flange: Cast steel, as shown.

D. Shop primed and shop finish coated.

2.21 BOLLARDS

A. Pipe: Black Steel, ASTM A53, Type E, Grade A, Schedule 80, sized as shown, with 1/4 inch steel plate cap welded all around and weld ground smooth.

B. Eyebolt: 1/4 inch diameter steel rod with 1/2 inch diameter eye.

C. Concrete fill: Section 03305, "Portland Cement Concrete", Mix M-1.

D. Shop primed and shop finish coated.

2.22 EQUIPMENT SUPPORTS

A. Fabricate from structural steel sections as detailed, with welded and bolted connections shown.

B. Shop primed and shop finish coated.

2.23 STEEL FINISHES

A. Galvanizing: Hot-dip galvanize items indicated to be galvanized and comply with applicable standard listed below:
   1. ASTM A123, for galvanizing steel and iron products.
   2. ASTM A153/A153M, for galvanizing steel and iron hardware.

B. Shop prime and shop finish coat steel surfaces, except the following:
   1. Items indicated to be galvanized.
   2. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.

C. Prepare steel surfaces; apply shop primer and shop finish coat as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A and as specified below:
   1. Use priming and painting methods that result in full coverage of joints, corners, edges, and exposed surfaces.
   2. Stripe paint corners, crevices, bolts, welds, and sharp edges.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove foreign substances from surfaces to receive metal items.

B. Coordinate setting drawings, diagrams, templates, instructions and directions for the installation of items having integral anchors which are to be embedded in concrete or masonry construction. Coordinate delivery of such items with concrete and masonry work.

C. Restore protective coverings that have been damaged in shipment or in the installation of the item. Remove protective covering from surfaces only when there is no possibility of damage from work yet to be performed after installation. Retain covering on all similarly finished items and remove only when all are in place, to preclude non-uniform oxidation and discoloration.

3.2 INSTALLATION

A. Perform cutting, drilling, and fitting required in the installation of the items. Where cutting, welding, and grinding are required for proper fitting and jointing of work, restore finish to eliminate evidence of such corrective work. Do not cut or abrade finishes that cannot be restored in the field. Return such items to the shop for required alterations and complete refinishing or replace with new units.

B. Provide anchors and inserts in sufficient numbers for proper fastening of metal items.

C. Provide bar anchors with turned ends extending 6 inches minimum into concrete and 12 inches minimum into masonry. Lay anchors flat in masonry joints.

D. Embed anchors accurately in concrete to permit aligning metalwork in proper position. Provide temporary bracing or anchors in formwork for items which are to be embedded.

E. Set metalwork accurately, level, plumb, and in true alignment with related work.
F. Drill holes in supports and in metal work for bolts and screws as necessary. Conceal fasteners where possible. Where fasteners are necessary, match fasteners to adjacent metal.

G. For fabricated items, use fastenings and anchors of size and type shown on approved shop drawings or manufacturer’s standard drawings.

H. Set products true to line and without sharp bends, twists, or kinks.

I. Provide lead caulkling as necessary to set, seal, and secure metal items.

J. Use bolts, screws, or locking lugs to secure safety walk gratings; do not weld.

3.3 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas to blend with the adjacent surfaces. Such touch up work shall be done in accordance with manufacturer’s instructions as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

1. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section, except for sealed expansion joints, will not be measured, but will be paid for at the lump sum price for “Metal Fabrications”, including nonshrink grout, anchoring devices and other accessories.

B. Sealed expansion joints including extrusions, fabricated plates, armor plates, and elastomeric materials will not be measured, but will be paid for at the lump sum price for the size and type specified, complete-in-place.

END OF SECTION 05500
SECTION 05510
METAL STAIRS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work required for this Section includes metal stairs and supplementary items necessary to complete their installation.

B. Handrails and railings attached to metal stairs are specified in Section 05520, "Metal Railings".

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME):

1. ASME B18.2.1 - Square and Hex Bolts and Screws (Inch Series)
2. ASME B18.6.3 - Machine Screws and Machine Screw Nuts
3. ASME B18.21.1 - Lock Washers (Inch Series)
4. ASME B18.22.1 - Plain Washers - Reaffirmation and Redesignation of ASA B27.2-1965

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
2. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamles
3. ASTM A185 - Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
4. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
5. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
6. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
7. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
8. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
10. ASTM E488 - Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

C. American Welding Society (AWS):

1. AWS D1.1/D1.1M - Structural Welding Code - Steel
2. AWS D1.3 - Structural Welding Code - Sheet Steel

D. National Association of Architectural Metal Manufacturers (NAAMM):

1. NAAMM AMP 510 - "Metal Stairs Manual"

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal stairs capable of withstanding the following structural loads without exceeding the allowable design working stress of the materials involved, including anchors and connections. Apply each load to produce the maximum stress in each component of metal stairs.

1. Treads and Platforms of Metal Stairs: Capable of withstanding a uniform load of 100 lb/sq. ft. or a concentrated load of 600 pounds per stair tread so as to produce maximum stress condition, whichever produces the greater stress.
2. Stair Framing: Capable of withstanding stresses resulting from loads specified above in addition to stresses resulting from railing system loads.
3. Limit deflection of treads, platforms, and framing members to L/360 or 1/4 inch, whichever is less.
4. Handrails and Railings: Refer to Section 05520, "Pipe and Tube Railings".
1.4 SUBMITTALS

A. Product Data: Manufactured products used in fabricating metal stairs including extruded nosings and paint products.

B. Shop Drawings: Show fabrication and installation details for metal stairs. Include plans, elevations, sections, and details of metal stairs and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.

1. For installed products indicated to comply with design loads, include shop drawings and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Certification: Submit certification that welding personnel and inspection/testing personnel are qualified in accordance with AWS D1.1/D1.1M, AWS D1.3 and AWS CWI respectively.

1.5 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of metal stairs (including handrails and railing systems) that are similar to those indicated for this Project in material, design, and extent.

B. Fabricator Qualifications: A firm experienced in producing metal stairs similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M and AWS D1.3. Inspection personnel shall be an AWS CWI.

1.6 COORDINATION

A. Coordinate installation of anchorages for metal stairs. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 FERROUS METALS

A. Metal Surfaces, General: Provide metal free from pitting, seam marks, roller marks, and other imperfections where exposed to view on finished units. Do not use steel sheet with variations in flatness exceeding those permitted by referenced standards for stretcher-leveled sheet.

B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.

C. Steel Tubing: Cold-formed steel tubing complying with ASTM A500.

D. Steel Pipe: ASTM A53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.

E. Uncoated, Hot-Rolled Steel Sheet: ASTM A1011/A1011M Commercial Steel (CS) Type B, unless another type is required by design loads.

F. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

2.2 FASTENERS

A. General: Provide zinc-plated fasteners with coating complying with ASTM B633, Class Fe/Zn 25 for exterior use, and Class Fe/Zn 5 where built into exterior walls. Select fasteners for type, grade, and class required.

B. Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563; and, where indicated, flat washers.

C. Machine Screws: ASME B18.6.3.

D. Lag Bolts: ASME B18.2.1.


G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488, conducted by a qualified independent testing agency.

1. Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

2.3 PAINT

A. As specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

2.4 CAST ABRASIVE NOSINGS

A. Fabricate units in sizes and configurations indicated and in lengths necessary to accurately fit openings or conditions. Provide units of cast nickel bronze.

1. Provide cross hatched surface units, with abrasive, consisting of aluminum oxide, silicon carbide, or a combination of both, integrally cast into walking surface to minimum depth 1/32-inch.

2. Configuration: Units 3 inches wide, for casting into concrete pan steps.

B. Provide nosings full length of steps less 1/8-inch clearance.

C. Provide concealed anchors for embedding units in concrete, either integral or applied to units, as standard with manufacturer.

D. Shot blasted finish.

E. Basis-of-Design Product: Wooster Products, Inc. Type 101SP

F. Acceptable Manufacturers:
1. American Safety Tread Co., Inc.
2. Safe-T-Metal Co.
3. Wooster Products Inc.
4. Or approved equal.

2.5 CONCRETE FILL AND REINFORCING MATERIALS

A. Concrete Fill: Concrete, weighing not less than 120 pounds per cubic foot, with a minimum compressive strength at 28 days of 4,000 psi. Maximum aggregate size shall be 3/8 inch. Concrete materials shall conform to the applicable requirements of Section 03305, “Portland Cement Concrete”,

B. Non-slip Finish: As specified in Section 03350, “Concrete Finishing”.

C. Welded Wire Fabric: ASTM A185, 6 by 6 inches-W1.4 by W1.4, unless otherwise indicated.

2.6 FABRICATION, GENERAL

A. Provide complete stair assemblies, including metal framing, hangers, struts, handrails, railings, clips, brackets, bearing plates, and other components necessary to support and anchor stairs and platforms on supporting structure.

1. Join components by welding, unless otherwise indicated.

2. Use connections that maintain structural value of joined pieces.

B. NAAMM Stair Standard: Comply with "Recommended Voluntary Minimum Standards for Fixed Metal Stairs" in NAAMM AMP 510, "Metal Stairs Manual", for class of stair designated, unless more stringent requirements are indicated.

1. Commercial class.

C. Shop Assembly: Preassemble stairs in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

D. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges. Shear and punch metals cleanly and accurately. Remove sharp or rough areas on exposed surfaces.

E. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

F. Weld connections to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. At exposed connections, finish exposed welds and surfaces smooth and blended so
no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

G. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

H. Fabricate joints of exterior stairs in a manner to exclude water, or provide weep holes where water may accumulate.

I. Fabricate treads and platforms of exterior stairs so finished walking surfaces slope to drain.

2.7 STEEL-FRAMED STAIRS

A. Stair Framing: Fabricate stringers of structural-steel channels, as indicated. Provide closures for exposed ends of stringers. Construct platforms of structural-steel channel headers and miscellaneous framing members as indicated. Bolt or weld headers to stringers; bolt or weld framing members to stringers and headers. If using bolts, fabricate and join so bolts are not exposed on finished surfaces.

B. Metal Risers, Subtread Pans, and Subplatforms: Form to configurations shown from steel sheet of thickness necessary to support indicated loads, but not less than 0.0677 inch.

1. Steel Sheet: Uncoated hot-rolled steel sheet.

2. Attach risers and subtreads to stringers with brackets made of steel angles or bars. Weld brackets to stringers and attach metal pans to brackets by welding.

3. Shape metal pans to include nosing integral with riser.

4. Provide subplatforms of configuration the same as subtreads. Weld subplatforms to platform framing.

C. Handrails and Railings: Fabricate handrails and railings to comply with requirements indicated in Section 05520, “Pipe and Tube Railings”.

D. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, end closures, flanges, miscellaneous fittings, and anchors for interconnecting railings and for attaching to other work. Furnish inserts and other anchorage devices for connecting to concrete or masonry work.

1. Connect railing posts to stair framing by direct welding, unless otherwise indicated.

2.8 FINISHES

A. Shop prime and shop finish coat steel surfaces, except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.

2. Surfaces to be field welded.

B. Prepare steel surfaces; apply shop primer and shop finish coat as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A and as specified below:

1. Use priming and painting methods that result in full coverage of joints, corners, edges, and exposed surfaces.

2. Stripe paint corners, crevices, bolts, welds, and sharp edges.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive metal stairs and associated work and conditions under which work will be installed. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

3.2 INSTALLATION

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal stairs to in-place construction. Include threaded fasteners for concrete and masonry inserts, through-bolts, lag bolts, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal stairs. Set units accurately in location, alignment, and elevation, measured from established lines and levels and free from rack.
C. Install metal stairs by welding stair framing to steel structure or to weld plates cast into concrete, unless otherwise indicated.

D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of units that are for bolted or screwed field connections.

F. Field Welding: Comply with the following requirements:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

G. Concrete Treads: Fill tread and landing metal pans with concrete, smooth and level with “float finish” in combination with a “nonslip finish”, per Section 03300, “Cast-In-Place Concrete” and Section 03350, “Concrete Finishing”.

H. Cast extruded abrasive nosings into concrete treads as concrete is poured. Make nosings full width of tread, with noses flush with riser faces and level with tread surfaces.

I. Weld handrails and railing systems to stair members as indicated in Section 05520, “Pipe and Tube Railings”.

3.3 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.
PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this Section includes metal handrails, railings and supplementary items necessary to complete their installation.

1.2 REFERENCE STANDARDS

A. American Institute of Steel Construction (AISC):

B. American Iron and Steel Institute (AISI):
   1. AISI SG03 - Cold-Formed Steel Design Manual.

C. American Society of Civil Engineers (ASCE):
   1. ASCE 8 - Specification for the Design of Cold-Formed Stainless Steel Structural Members.

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   11. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   14. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

E. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code Steel.
   2. AWS D1.3 - Structural Welding Code - Sheet Steel.

F. Military Specification (MIL):
   1. MIL-P-21035 - Paint High Zinc Dust Content, Galvanizing Repair (Metric).
2. MIL-PRF-26915 – Primer Coating, for Steel Surfaces.

G. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

2. SSPC-SP 6/NACE No. 3 - Commercial Blast Cleaning.

1.3 PERFORMANCE REQUIREMENTS

A. General: In engineering handrails and railings to withstand structural loads indicated, determine allowable design working stresses of handrail and railing materials based on the following:

1. Structural Steel: AISC S335
2. Stainless Steel: ASCE 8
3. Cold-Formed Structural Steel: AISI SG03

B. Structural Performance: Provide handrails and railings complying with requirements of ASTM E985 for structural performance, based on testing performed according to ASTM E894 and ASTM E935.

C. Thermal Movements: Provide handrails and railings that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

D. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.4 SUBMITTALS

A. Product Data: For brackets, grout and paint products.

B. Shop Drawings: Show fabrication and installation of handrails and railings. Include plans, elevations, sections, component details, and attachments to other Work.

1. For installed handrails and railings indicated to comply with design loads, include shop drawings and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Certification: Submit certification that welding personnel and inspection/testing personnel are qualified in accordance with AWS D1.1/D1.1M and AWS CWI respectively.

1.5 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of handrails and railings that are similar to those indicated for this Project in material, design, and extent.

B. Qualification of Welding Personnel: Employ welding personnel whose qualification is certified in accordance with AWS D1.1/D1.1M. Such certification is to remain in force for the duration of the welding operations under this Contract. Inspection personnel shall be an AWS CWI.

1.6 PROJECT CONDITIONS

A. Field Measurements: Verify handrail and railing dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating handrails and railings without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions.

1.7 COORDINATION

A. Coordinate installation of anchorages for handrails and railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products
that may be incorporated into the Work include, but are not limited to, the following:

1. **Stainless-Steel Wire Rope and Fittings:**
   a. Hayn Industries, Inc.
   b. Sava Industries, Inc.
   c. Seco South, Inc.
   d. Or approved equal.

2. **METALS**

A. **General:** Provide metals free from surface blemishes where exposed to view in finished unit. Exposed-to-view surfaces exhibiting pitting, seam marks, roller marks, stains, discolorations, or other imperfections on finished units are not acceptable.

B. **Steel and Iron:** Provide steel and iron in form indicated to comply with the following requirements:

   1. **Tubing:** Cold formed, ASTM A500.
   2. **Steel Pipe:** ASTM A53; finish, type, and weight class as follows:
      a. Galvanized finish, where not shown to be painted.
      b. Type S, Grade A, standard weight (schedule 40), unless otherwise indicated, or another weight required by structural loads.
   3. **Steel Plate, Shapes, and Bars:** ASTM A36/A36M.
   4. **Steel Sheet:** Commercial-quality, cold-rolled, stretcher-leveled, carbon-steel sheet complying with ASTM A1008/A1008M, Class I, matte finish.
   5. **Gray-Iron Castings:** ASTM A48/A48M, Class 30, Class 200).
   6. **Malleable-Iron Castings:** ASTM A47/A47M, grade as recommended by fabricator for type of use indicated.

C. **Stainless Steel:** Grade and type designated below for each form required:

   1. **Tubing:** ASTM A554, Grade MT 316.
      a. for Handrails: 1-1/2 inch outside diameter, not less than 13 gage.

2. **Pipe:** ASTM A312/A312M, Grade TP 316.
3. **Castings:** ASTM A743/A743M, Grade CF 8M.
4. **Sheet, Strip, Plate, and Flat Bar:** ASTM A666, Type 316.
5. **Bars and Shapes:** ASTM A276, Type 316.
6. **Wire Rope:** Specially fabricated 1-by-19 wire rope that is drawn through a die after laying to produce a smooth outer surface; made from wire complying with ASTM A492, Type 316.

D. **Brackets:**

1. Curved top for rail. 1-1/2 inch dim. inside face of rail to finished wall surface.
2. For concrete and CMU walls: Cast stainless steel with concealed stainless steel hanger bolt and with lead shields for concrete and CMU walls.
3. For railings: Galvanized malleable iron.

E. **Flanges, and Anchors:** Cast or formed metal of the same type material and finish as supported rails, unless otherwise indicated.

2.3 **WELDING MATERIALS, FASTENERS, AND ANCHORS**

A. **Welding Electrodes and Filler Metal:** Provide type and alloy of filler metal and electrodes as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items. Comply with AWS requirements.

B. **Fasteners for Anchoring Handrails and Railings to Other Construction:** Select fasteners of type, grade, and class required to produce connections suitable for anchoring handrails and railings to other types of construction indicated and capable of withstanding design loads.

   1. Use plated fasteners complying with ASTM B633, Class Fe/Zn 25 for electrodeposited zinc coating.

C. **Cast-in-Place and Post Installed Anchors:** Fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
2.4 **GROUT**

A. Structural Nonshrink Grout: As specified in Section 03305, “Portland Cement Concrete”.

2.5 **MISCELLANEOUS MATERIALS**

A. Wire-Rope Fittings: Connectors of types indicated, fabricated from stainless steel, and with capability to sustain, without failure, a load equal to minimum breaking strength of wire rope with which they are used.

B. Galvanizing Repair Paint:

1. Organic zinc-rich coating containing at least 65 percent metallic zinc, by weight in dry film and meeting performance requirements of:
   a. ASTM A780.
   b. SSPC Paint 20.

2. Match aesthetic appearance of hot-dip galvanizing and meet performance requirements of:
   a. MIL-P-21035.
   b. MIL-PRF-26915.


C. Paint: As specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

2.6 **FABRICATION**

A. General: Fabricate handrails and railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.

B. Assemble handrails and railings in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Form changes in direction of railing members as follows:

1. By flush radius bends.

D. Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

E. Welded Connections: Fabricate handrails and railings for connecting members by welding. Cope components at perpendicular and skew connections to provide close fit, or use fittings designed for this purpose. Weld connections continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove flux immediately.

4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

F. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect handrail and railing members to other work, unless otherwise indicated.

G. Provide inserts and other anchorage devices for connecting handrails and railings to concrete or masonry work. Fabricate anchorage devices capable of withstanding loads imposed by handrails and railings. Coordinate anchorage devices with supporting structure.

H. For railing posts set in concrete, provide preset sleeves of steel not less than 6 inches long with inside dimensions not less than 1/2 inch greater than outside dimensions of post, and steel plate forming bottom closure.

I. Shear and punch metals cleanly and accurately. Remove burns from exposed cut edges.

J. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.

K. Cut, reinforce, drill, and tap components, as indicated, to receive finish hardware, screws, and similar items.

L. Provide weep holes or another means to drain entrapped water in hollow sections of handrail and railing members that are exposed to exterior or to moisture from condensation or other sources.
M. Fabricate joints that will be exposed to weather in a watertight manner.

N. Close exposed ends of handrail and railing members with prefabricated end fittings.

O. Provide wall returns at ends of wall-mounted handrails, unless otherwise indicated. Close ends of returns, unless clearance between end of railing and wall is 1/4 inch or less.

P. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

Q. Fillers: Provide fillers made from steel plate, or other suitably crush-resistant material, where needed to transfer wall bracket loads through wall finishes to structural supports. Size fillers to suit wall finish thicknesses and to produce adequate bearing area to prevent bracket rotation and overstressing of substrate.

R. Make up wire-rope assemblies in the shop to field-measured dimensions with fittings machine swaged. Minimize amount of turnbuckle take-up used for dimensional adjustment so maximum amount is available for tensioning wire ropes. Tag wire-rope assemblies and fittings to identify installation locations and orientations for coordinated installation.

2.7 FINISHES

A. Galvanized Railings: Hot-dip galvanize exterior steel and iron handrails and railings to comply with ASTM A123. Hot-dip galvanize hardware for exterior steel and iron handrails and railings to comply with ASTM A153.

1. Fill vent and drain holes that will be exposed in finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.

2. Provide galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.

3. After galvanizing, thoroughly clean handrails and railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.

B. Iron and Steel Finishes:

1. Shop prime and shop finish coat steel surfaces, except the following:
   a. Items indicated to be galvanized.
   b. Surfaces embedded in concrete or mortar. Extend priming of partially embedded membersto a depth of 2 inches.
   c. Surfaces to be field welded.

2. Prepare steel surfaces; apply shop primer and shop finish coat as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A and as specified below:
   a. Use priming and painting methods that result in full coverage of joints, corners, edges, and exposed surfaces.
   b. Stripe paint corners, crevices, bolts, welds, and sharp edges.

3. Powder-Coated Finish: Prepare, treat, and coat nongalvanized ferrous metal to comply with resin manufacturer's written instructions and as follows:
   a. Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6.
   b. Treat prepared metal with iron-phosphate pretreatment, rinse, and seal surfaces.
   c. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils.

C. Stainless-Steel Finishes:

1. Remove or blend tool and die marks and stretch lines into finish.

2. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

3. Bright, Directional Polish: No. 4 finish.

4. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive railing system and associated work and conditions under which
railings will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator's acceptance of surface conditions.

3.2 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required to install handrails and railings. Set handrails and railings accurately in location, alignment, and elevation; measured from established lines and levels and free from rack.

1. Do not weld, cut, or abrade surfaces of handrail and railing components that have been coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.

2. Set posts plumb within a tolerance of 1/16 inch in 3 feet

3. Align rails so variations from level for horizontal members and from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet

C. Adjust handrails and railings before anchoring to ensure matching alignment at abutting joints. Space posts at interval indicated, but not less than that required by structural loads.

D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing handrails and railings and for properly transferring loads to in-place construction.

E. Ground handrail per Section 16450, "Grounding and Bonding".

3.3 RAILING CONNECTIONS

A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

B. Expansion Joints: Install expansion joints where joints occur in substrates and no farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.4 ANCHORING POSTS AND RAILING

A. Posts: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with grout anchoring material, mixed and placed to comply with anchoring material manufacturer's written instructions:

1. Leave anchorage joint exposed; wipe off surplus anchoring material; and leave 1/8 inch build-up, sloped away from post.

2. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions. Weld flanges to posts and bolt to metal supporting members.

3. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.

B. Railing Ends: Anchor railing ends to wall construction with round flanges connected to railing ends and anchored into wall construction with postinstalled anchors and bolts.

C. Handrails: Attach handrails to wall with wall brackets. Provide bracket with 1-1/2-inch clearance from inside face of handrail and finished wall surface. Locate brackets at spacing required to support structural loads, but not less than 5 feet on center. Secure wall brackets to building construction as follows:

1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.

2. For hollow masonry anchorage, use toggle bolts.

3. For steel-framed gypsum board assemblies, fasten brackets directly to steel framing or concealed reinforcements using self-tapping screws of size and type required to support structural loads.

3.5 ADJUSTING AND CLEANING

A. Galvanized Surfaces:

1. Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780.

2. For surfaces to be left exposed, apply galvanizing repair paint in at least two coats.
B. Clean stainless steel by washing thoroughly with clean water and soap and rinsing with clean water.

C. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

3.6 PROTECTION

A. Protect finishes of ornamental metal from damage during construction period with temporary protective coverings approved by ornamental metal fabricator. Remove protective covering at the time of Substantial Completion.

B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this Section will not be measured separately, but payment made for on a lump sum basis for metal railings per location indicated.
SECTION 05700
ORNAMENTAL METAL

PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this Section includes ornamental (architectural) metal and supplementary items necessary to complete their installation.

B. Non-ornamental metal fabrications are specified in Section 05500, “Metal Fabrications”.

C. Non-ornamental and ornamental handrails and railings are specified in Section 05520, “Metal Railings”.

1.2 REFERENCE STANDARDS

A. American Architectural Manufacturers Association (AAMA):
   1. AAMA 611 - Voluntary Standards for Anodized Architectural Aluminum.

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   6. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   8. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   10. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.

C. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel.
   2. AWS D1.2 - Structural Welding Code - Aluminum.
   3. AWS D1.3 - Structural Welding Code - Sheet Steel.

D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   2. SSPC-SP 6/NACE No. 3 - Commercial Blast Cleaning.

1.3 PERFORMANCE REQUIREMENTS

A. Thermal Movements: Provide ornamental metal items that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing...
buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.

B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1.4 SUBMITTALS

A. Product Data: For each product used in ornamental metal, including finishing materials and methods.

1. Include Product Data for grout and anchoring cement.

B. Shop Drawings: Show fabrication and installation of ornamental metal. Include plans, elevations, component details, and attachments to other Work. Indicate materials and profiles of each ornamental metal member, fittings, joinery, finishes, fasteners, anchorages, and accessory items.

1. Include setting drawings, templates, and directions for installing anchor bolts and other anchorages.

C. Welding Certificates: Copies of certificates that welding personnel and inspection/testing personnel are currently qualified in accordance with AWS D1.1/D1.1M and AWS CWI respectively.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Arrange for installation of ornamental metal specified in this Section by the same firm that fabricated it.

B. Fabricator Qualifications: A firm experienced in producing ornamental metal similar to that indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

C. Qualifications of Welding Personnel:

1. Employ welders whose qualification is certified in accordance with AWS Standard D1.1/D1.1M.

2. Inspection personnel shall be an AWS CWI.

3. Certification shall remain in force for the duration of the welding operations under this Contract.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store ornamental metal inside a well-ventilated area, away from uncured concrete and masonry, and protected from weather, moisture, soiling, abrasion, extreme temperatures, and humidity.

B. Deliver and store cast-metal products in wooden crates surrounded by sufficient excelsior to ensure that products will not be cracked or otherwise damaged.

1.7 PROJECT CONDITIONS

A. Field Measurements: Where ornamental metal is indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating ornamental metal without field measurements. Coordinate other construction to ensure that actual dimensions correspond to established dimensions.

1.8 COORDINATION

A. Coordinate installation of anchorages for ornamental metal items. Furnish Setting Drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

PART 2 - PRODUCTS

2.1 METALS

A. General: Provide metals free from surface blemishes where exposed to view in finished unit. Exposed-to-view surfaces exhibiting pitting, seam marks, roller marks, stains, discolorations, or other imperfections on finished units are not acceptable.

B. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required:

C. Stainless Steel: Grade and type designated below for each form required:
1. Tubing: ASTM A554, Grade MT 316.
2. Pipe: ASTM A312/A312M, Grade TP 316.
3. Castings: ASTM A743/A743M, Grade CF 8M.
4. Sheet, Strip, Plate, and Flat Bar: ASTM A666, Type 316.
5. Bars and Shapes: ASTM A276, Type 316.

D. Steel and Iron: Provide steel and iron in form indicated to comply with the following requirements:
1. Tubing: Cold formed, ASTM A500.
2. Steel Plate, Shapes, and Bars: ASTM A36/A36M.
5. Malleable-Iron Castings: ASTM A47/A47M, grade as recommended by fabricator for type of use indicated.

2.3 FABRICATION, GENERAL

A. Form ornamental metal to required shapes and sizes, with true curves, lines, and angles. Provide components in sizes and profiles indicated, but not less than that needed to comply with requirements indicated for structural performance.

B. Provide necessary rebates, lugs, and brackets to assemble units and to attach to other work. Drill and tap for required fasteners, unless otherwise indicated. Use concealed fasteners where possible.

C. Comply with AWS for recommended practices in shop welding and brazing. Provide welds and brazes behind finished surfaces without distorting or discoloring exposed side. Clean exposed welded and brazed joints of all flux, and dress all exposed and contact surfaces.

D. Mill joints to a tight, hairline fit. Cope or miter corner joints. Form joints exposed to weather to exclude water penetration.

E. Provide castings that are sound and free of warp, cracks, blowholes, or other defects that impair strength or appearance. Grind, wire brush, sandblast, and buff castings to remove seams, gate marks, casting flash, and other casting marks.

F. Finish exposed surfaces to smooth, sharp, well-defined lines and arrise.

2.2 MISCELLANEOUS MATERIALS

A. Welding Electrodes and Filler Metal: Type and alloy of filler metal and electrodes as recommended by producer of metal to be welded, complying with applicable AWS specifications, and as required for color match, strength, and compatibility in fabricated items.

B. Fasteners: Use fasteners of same basic metal as fastened metal, unless otherwise indicated. Do not use metals that are corrosive or incompatible with materials joined.

1. Provide concealed fasteners for interconnecting ornamental metal components and for attaching them to other work, unless otherwise indicated.

C. Cast-in-Place and Post Installed Anchors: Fabricated from corrosion-resistant materials with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488 conducted by a qualified independent testing agency.

D. Structural Nonshrink Grout: As specified in Section 03305, “Portland Cement Concrete”.

E. Paint: As specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

F. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12, except containing no asbestos fibers.
G. Assemble items in the shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

2.4 FINISHES, GENERAL

A. Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.5 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

B. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 607.1.

2.6 STAINLESS-STEEL FINISHES

A. Remove or blend tool and die marks and stretch lines into finish.

B. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

C. Bright, Directional Polish: No. 4 finish. Except where otherwise shown on Contract Drawings

D. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.7 IRON AND STEEL FINISHES

A. Shop prime and shop finish coat steel surfaces, except the following:

1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.

2. Surfaces to be field welded.

B. Prepare steel surfaces; apply shop primer and shop finish coat as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A and as specified below:

1. Use priming and painting methods that result in full coverage of joints, corners, edges, and exposed surfaces.

2. Stripe paint corners, crevices, bolts, welds, and sharp edges.

C. Powder-Coated Finish: Prepare, treat, and coat nongalvanized ferrous metal to comply with resin manufacturer’s written instructions and as follows:

1. Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6, “Commercial Blast Cleaning.”

2. Treat prepared metal with iron-phosphate pretreatment, rinse, and seal surfaces.

3. Apply thermosetting polyester or acrylic urethane powder coating with cured-film thickness not less than 1.5 mils.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Provide anchorage devices and fasteners where necessary for securing ornamental metal to in-place construction.

B. Perform cutting, drilling, and fitting required to install ornamental metal. Set products accurately in location, alignment, and elevation; measured from established lines and levels. Provide temporary bracing or anchors in formwork for items to be built into concrete, masonry, or similar construction.

C. Fit exposed connections accurately together to form tight, hairline joints or, where indicated, with uniform reveals and spaces for sealants and joint fillers. Where cutting, welding, and grinding are required for proper shop fitting and jointing of ornamental metal, restore finishes to eliminate any evidence of such corrective work.

D. Do not cut or abrade finishes that cannot be completely restored in the field. Return items with such finishes to the shop for required alterations, followed by complete refinishing, or provide new units as required.

E. Restore protective coverings that have been damaged during shipment or installation. Remove protective coverings only when there is no possibility of damage from other work yet to be performed at same location.

1. Retain protective coverings intact; remove coverings simultaneously from similarly finished items to preclude nonuniform oxidation and discoloration.
F. Field Welding: Comply with applicable AWS specification for procedures of manual shielded metal arc welding, for appearance and quality of welds, and for methods used in correcting welding work. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Grind exposed welded joints smooth and restore finish to match finish of adjacent surfaces.

G. Corrosion Protection: Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.2 CLEANING

A. Clean aluminum and stainless steel by washing thoroughly with clean water and soap and rinsing with clean water.

B. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas as specified in Section 09970, “Coatings for Steel” Paint and Coating System No. 2A.

3.3 PROTECTION

A. Protect finishes of ornamental metal from damage during construction period with temporary protective coverings approved by ornamental metal fabricator. Remove protective covering at the time of Substantial Completion.

B. Restore finishes damaged during installation and construction period so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for ornamental metal per location indicated wherein no measurement will be made.

END OF SECTION 05700
SECTION 06100
ROUGH CARPENTRY

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for providing miscellaneous rough carpentry, including wood nailers, backing, and blocking, as indicated or required.

B. Concrete formwork and falsework are specified in the applicable Sections under DIVISION 3 - CONCRETE.

C. Blocking and backing associated with cabinets and cabinetwork are specified in Section 06410, “Custom Cabinetwork”.

1.2 REFERENCE STANDARDS

A. ASME International (Formerly known as American Society for Mechanical Engineers) (ASME):
   1. ASME B18.2.1 - Square and Hex Bolts and Screws (Inch Series)
   2. ASME B18.6.1 - Wood Screws (Inch Series)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   2. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
   3. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
   4. ASTM A653 – Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   5. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus
   7. ASTM C954 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs From 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness
   11. ASTM E488 - Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

C. American Wood Preservers Association (AWPA):
   1. AWPA M4 – Standard for the Care of Preservative-Treated Wood Products
   2. AWPA U1 – User Specification for Treated Wood

D. Factory Mutual Global (FM Global)
   1. FM Global Property Loss Prevention Data Sheets 1-49 – Perimeter Flashing

E. U.S. Department of Commerce (DOC) Federal Construction Regulations (FED):
   1. DOC FED PS 1-83 - Construction and Industrial Plywood
   2. DOC FED PS 20-70 - American Softwood Lumber Standard

1.3 PERFORMANCE REQUIREMENTS

A. Flashings and Roof Coverings:
   1. Fabricate and install rough carpentry associated with flashings and roof coverings to withstand wind loads, structural movement, and thermally induced movement without contributing to failure of flashing or roof coverings.
2. Comply with recommendations of Factory Mutual (FM) Loss Prevention Data Sheet 1-49 for highest wind zone classification.

1.4 SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used, net amount of preservative retained, and chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material.

2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials, both before and after exposure to elevated temperatures when tested according to ASTM D5516 and ASTM D5664.

3. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

4. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.5 QUALITY ASSURANCE

A. Lumber grading agencies, and the abbreviations used to reference them, include the following:

1. NELMA - Northeastern Lumber Manufacturers Association.

2. NLGA - National Lumber Grades Authority.

3. SPIB - Southern Pine Inspection Bureau.

4. WCLIB - West Coast Lumber Inspection Bureau.

5. WWPA - Western Wood Products Association.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Keep wood products under cover and dry. Protect against exposure to moisture and contact with damp or wet surfaces. Stack material in a manner which promotes air circulation.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Lumber: DOC FED PS 20-70 and applicable rules of lumber grading agencies certified by the American Lumber Standards Committee Board of Review.

1. Factory mark each piece of lumber with grade stamp of grading agency.

2. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece, or omit grade stamp and provide certificates of grade compliance issued by grading agency if acceptable to authorities having jurisdiction.

3. Where nominal sizes are indicated, provide actual sizes required by DOC FED PS 20-70 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

4. Provide dressed lumber, S4S, unless otherwise indicated.

5. Provide dry lumber with 19 percent maximum moisture content at time of dressing for 2 inch nominal thickness or less, for concealed conditions.

6. Provide dry lumber with 15 percent maximum moisture content at time of dressing for 2 inch nominal thickness or less, for exposed conditions.

B. Wood Structural Panels:

1. Plywood: DOC FED PS 1-83.

2. Thickness: As needed to comply with requirements specified but not less than thickness indicated.


4. Factory mark panels according to indicated standard.

2.2 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure process complying with AWPA U1 (Use Category UC2) except that lumber that is not in contact with the ground and is continuously protected from liquid water may be treated according to AWPA U1 (Use Category UC1).

1. For exposed items indicated to receive painted, stained or natural finish, use chemical formulations that do not require
incising, contain colorants, bleed through, or otherwise adversely affect finishes.

B. Kiln-dry material after treatment to a maximum moisture content of 19 percent for lumber and 15 percent for plywood. Do not use material that is warped or does not comply with requirements for untreated material.

C. Mark each treated item with the treatment quality mark of an inspection agency approved by the American Lumber Standards Committee Board of Review.

1. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece, or omit marking and provide certificates of treatment compliance issued by inspection agency if acceptable to authorities having jurisdiction.

D. Application: Treat items indicated on Drawings, and the following:

1. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.

2. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.

3. Wood framing members less than 18 inches above grade.

2.4 DIMENSION LUMBER

A. General: Provide dimension lumber of Construction or No. 2 grade according to the American Lumber Standards Committee National Grading Rule provisions of the grading agency indicated and any of the following species:

1. Douglas fir-larch; WCLIB or WWPA.

2. Douglas fir-south; WWPA.

3. Douglas fir-larch (north); NLGA.

4. Hem-fir; WCLIB or WWPA.

5. Hem-fir (north); NLGA.

6. Mixed southern pine; SPIB.

7. Spruce-pine-fir (south); NELMA, WCLIB, or WWPA.

8. Spruce-pine-fir; NLGA.

2.5 MISCELLANEOUS LUMBER

A. General: Provide lumber for support or attachment of other construction including rooftop equipment bases and support curbs, blocking, cants, nailers, furring, and grounds.

B. For items of dimension lumber size, provide Construction, Stud, or No. 2 grade lumber with 19 percent maximum moisture content and any of the following species:

1. Mixed southern pine; SPIB.

2. Eastern softwoods; NELMA.

3. Northern species; NLGA.

4. Western woods; WCLIB or WWPA.

C. For exposed boards, provide lumber with 15 percent maximum moisture content and any of the following species and grades:

1. Eastern white pine, Idaho white, lodgepole, ponderosa, or sugar pine; D Select (Quality) grade; NELMA, NLGA, WCLIB, or WWPA.

2. Mixed southern pine, B & B Finish grade; SPIB.

3. Hem-fir or Hem-fir (north), Superior or C & Btr Finish grade; NLGA, WCLIB, or WWPA.
4. Spruce-pine-fir (south) or Spruce-pine-fir, D Select grade; NELMA, NLGA, WCLIB, or WWPA.

5. Western red cedar, A grade; NLGA or WWPA.

D. For concealed boards, provide lumber with 19 percent maximum moisture content and any of the following species and grades:

1. Mixed southern pine, No. 2 grade; SPIB.
2. Eastern softwoods, No. 3 Common grade; NELMA.
3. Northern species, No. 3 Common grade; NLGA.
4. Western woods, Standard or No. 3 Common grade; WCLIB or WWPA.

2.6 PANEL PRODUCTS

A. Miscellaneous Concealed Plywood: Exterior sheathing, span rating to suit framing in each location, and thickness as indicated but not less than 1/2 inch.

B. Miscellaneous Concealed Oriented Strand Board: Exposure 1 sheathing, span rating to suit framing in each location, and thickness as indicated but not less than 1/2 inch.

C. Exterior Cement Board: Composed of Portland cement, ground sand aggregate, cellulose fiber, selected additives and water. 1/2 inch thick, smooth surface, ASTM E84 flame spread 0, fuel contributed 0, smoke developed 5, recommended by manufacturer for exposed exterior application.

1. Fasteners: 1-5/8 inches No. 8 wafer-head steel drill screws complying with ASTM C954, with an organic-polymer coating or other corrosion-protective coating having a salt-spray resistance of more than 500 hours per ASTM B117.

D. Miscellaneous Exposed Plywood: FED PS1-83, A-D Interior, thickness as indicated but not less than 1/2 inch.

E. Telephone and Electrical Equipment Backing Panels: FED PS1-83, Exposure 1, C-D Plugged, fire-retardant treated, in thickness indicated or, if not indicated, not less than 1/2 inch thick.

2.7 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.

1. Where carpentry is exposed to weather, in ground contact, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153.


D. Screws for Fastening to Cold-Formed Metal Framing: ASTM C954, except with wafer heads and reamer wings, length as recommended by screw manufacturer for material being fastened.

E. Lag Bolts: ASME B18.2.1.

F. Bolts: Steel bolts complying with ASTM A307, Grade A with ASTM A563 hex nuts and, where indicated, flat washers.

G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.

1. Interior Anchors: Carbon-steel components, zinc plated to comply with ASTM B633, Class Fe/Zn 5.

2. Exterior Anchors: Stainless steel with bolts and nuts complying with ASTM F593 and ASTM F594, Alloy Group 1 or 2.

2.8 METAL FRAMING ANCHORS

A. General: Provide galvanized steel framing anchors of structural capacity, type, and size indicated and acceptable to authorities having jurisdiction.

B. Galvanized Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A653, G60 coating designation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive rough carpentry and associated work and conditions under which work will be installed. Do not proceed with installation until unsatisfactory conditions have been corrected. Starting work within a particular area will be construed as acceptance of surface conditions.

3.2 INSTALLATION, GENERAL

A. Discard units of material with defects that impair quality of carpentry and that are too small to use with minimum number of joints or optimum joint arrangement.
B. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry to other construction; scribe and cope as needed for accurate fit. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.

C. Apply field treatment complying with AWPA M4 to cut surfaces of preservative-treated lumber and plywood.

D. Securely attach carpentry work according to applicable codes and recognized standards.

E. Use preservative treated wood for roofing and exterior conditions, and use fire-retardant treated wood for building interior conditions.

F. Use fasteners of appropriate type and length. Predrill members when necessary to avoid splitting wood.

3.3 WOOD BLOCKING, AND NAILER INSTALLATION

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.

3.4 PANEL PRODUCT INSTALLATION


B. Exterior Cement Board: Install on metal framing to comply with cement board manufacturer's recommendations. Install with steel drill screws spaced no more than 8 inches o.c. along framing with perimeter fasteners at least 3/8 inch but less than 5/8 inch from edges of boards.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Rough carpentry and related rough hardware therefor will not be measured separately for payment.

B. Rough carpentry and related rough hardware will be paid for as part of the Contract unit price or Contract lump-sum price for the associated work requiring rough carpentry work as indicated in the Bid Schedule of the Bid Form.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for furnishing and installing cabinets, countertops, and cabinet hardware as indicated.

1.2 REFERENCE STANDARDS

A. American Hardboard Association (AHA):
   1. AHA A135.4 - Basic Hardboard

B. Composite Panel Association (CPA):
   1. CPA A208.1 - Wood Particleboard
   2. CPA A208.2 - Medium Density Fiberboard (MDF) for Interior Applications

C. Architectural Woodwork Institute (AWI):
   1. AWI Architectural Woodwork Quality Standards

D. Hardwood Plywood and Veneer Association (HPVA):
   1. HPVA HP-1 - American Hardboard Association

E. National Electrical Manufacturer's Association (NEMA):
   1. NEMA LD 3 - High-Pressure Decorative Laminates
   2. NEMA LD 3.1 - Performance, Application, Fabrication, and Installation of High-Pressure Decorative Laminates

F. U.S. Department of Commerce (DOC) Federal Construction Regulations (FED):
   1. DOC FED PS1-83 - Construction and Industrial Plywood

1.3 DEFINITIONS

A. "Exposed Surfaces", "Semi-Exposed Surfaces", "Concealed Surfaces" and "Types of Cabinet Construction" and other terms are defined in referenced quality standards.

1.4 SUBMITTALS

A. Shop Drawings: Submit fully detailed Shop Drawings of the cabinetwork, including plastic-laminate work and countertop edging.

B. Product Data: Submit manufacturers' product data for plastic laminates, cabinet hardware, and any other manufactured or fabricated items indicated or specified.

C. Samples: Submit samples of plastic laminates and cabinet finish hardware.

1.5 QUALITY ASSURANCE

A. Cabinetwork, as indicated, shall be manufactured or fabricated in accordance with the standard details and specifications of AWI Architectural Woodwork Quality Standards, as hereinafter specified.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Comply with referenced standard and obtain fabricator's and installer's coordinated advice for optimum temperature and humidity conditions during cabinet storage and installation. Do not install woodwork until conditions have been attained and stabilized.

B. Field Measurements: Where woodwork is indicated to be fitted to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on final shop drawings.
   1. Locate concealed framing, blocking, and reinforcements, that support cabinet work by field measurements before being enclosed and indicate measurements on final shop drawings.
   2. Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating cabinets without field measurements. Provide allowance for trimming at site and coordinate construction to ensure that actual dimensions correspond to established dimensions.

1.7 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery, storage, and handling of cabinets and related items shall be in accordance with applicable requirements AWI Section 1700.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Provide materials that comply with requirements of the referenced cabinet quality
standard for each type of cabinet and quality grade indicated unless otherwise indicated.

B. Wood Panel Products: Comply with the following:

1. Hardboard: AHA A135.4, tempered, smooth two sides (vertical dividers only).
2. Medium-Density Fiberboard: CPA A208.2, Grade MD.
3. Particleboard: CPA A208.1, Grade M-3, 47 lb. density, engineered board.

C. Thermoset Decorative Overlay: Particleboard complying with CPA A208.1, Grade M-2, or medium-density fiberboard complying with CPA A208.2, Grade MD, with surface of thermally fused, melamine-impregnated decorative paper.

D. High-Pressure Decorative Laminate: NEMA LD3 and referenced standard.

1. Face Sheet:
   a. Doors and Vertical Surfaces: General Purpose VGS, 0.028 inch thick.
   b. Shelves and Horizontal Surfaces: General Purpose HGL, 0.039 inch thick.
   c. Countertops: General Purpose HGS, 0.048 inch thick.
   d. Colors: As scheduled on Contract Drawings.

2. Cabinet Liner: Cabinet Liner CLS, 0.020 inch thick, or Thermoset Decorative Overlay (Melamine).
   a. Color: As selected from manufacturer's standard colors.
   b. Backing Sheet: Backer BKL, 0.020 inch thick.

3. Acceptable Manufacturers:
   a. Formica Corporation.
   b. International Paper
   c. Laminart.

D. Scheme for each type of cabinet and quality grade indicated unless otherwise indicated.

E. Cabinet Hardware: Comply with BHMA A156.9 for items indicated by referencing BHMA numbers or items referenced to this standard.

1. Frameless Concealed Hinges (European Type): BHMA A156.9, B01602, 100 degrees of opening, self-closing.
2. Wire Pulls: Back mounted, 4 inches long, 5/16 inches in diameter.
3. Catches: Magnetic catches, BHMA A156.9, B03141.
4. Shelf Rests: BHMA A156.9, B04013.
5. Drawer Slides: Side-mounted, full-extension, zinc-plated steel drawer slides with steel ball bearings, BHMA A156.9, B05091, and rated for 75 lbf. load.
7. Drawer Locks: BHMA A156.11, E07041.
8. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with BHMA A156.18 for satin stainless steel BHMA 630.

2.2 PLASTIC LAMINATE FACED WOOD CABINETS

A. Comply with following quality standard requirements except where more restrictive requirements are specified.

1. AWI Section 400 Premium Grade.

B. Finishes:

1. Exposed Surfaces: Face Sheet
2. Semi-exposed Surfaces: Cabinet Liner
3. Concealed Surfaces: Backing Sheet
4. Edges: 3 mil PVC
5. Interior Drawer Box: Clear Polyurethane Wood Sealer
2.3 CABINET COMPONENTS

A. Body Members (Ends, Divisions, Bottoms and Tops): 3/4 inch veneer core plywood or 47 lb. particleboard.

B. Rails: 3/4 inch lumber or veneer core plywood (do not use if hinge screws enter only edge of rail).

C. Shelves: Veneer core plywood or 47 lb. particleboard in minimum thickness of:
   1. 3/4 inch for spans up to 32 inches
   2. 1 inch for spans up to 42 inches

D. Drawer Box Construction:
   1. Comply with Premium Grade requirements.
   2. Joints (one of following):
      a. Glued multiple dovetail
      b. Glued French dovetail
      c. Glued and doweled
   3. Drawer Sides, Backs and Semi-Exposed Fronts (Sub-Fronts): 1/2 inch hardwood lumber or 7-ply hardwood veneer core plywood with no voids.
   4. Drawer Bottoms: 1/4 inch hardwood faced plywood (veneer core).

E. Drawer Fronts: 3/4 inch thick 47 lb. particleboard.

F. Doors:
   1. Hinged Flush Type: 47 lb. particleboard in minimum thickness:
      a. 3/4 inch for width up to 30 inches and height up to 60 inches.
      b. 1 inch to 1-1/4 inch for width up to 36 inches and height up to 72 inches.
      c. Doors in excess of sizes listed above shall be 1-3/8 inch or 1-3/4 inch doors. See Division 8 Section “Flush Wood Doors”.
      d. If hinge screws enter only edge of door, provide 3/4 inch lumber edges glued to core prior to laminating.

2.4 COUNTERTOPS

A. Comply with referenced standard Premium Grade requirements except where more restrictive requirements are specified.

B. Plastic Laminate:
   1. Substrate: 3/4 inch thick veneer core exterior grade plywood top and 1/2 inch thick backsplash.
   2. Exposed Finish: Face sheet on exposed surfaces; Backing sheet on concealed surfaces.

2.5 CABINET HARDWARE

A. Fit hardware for drawers and doors so that it will permit items to close without forcing or rattling. Carefully fit and adjust doors as required to insure smooth and noiseless operation.

2.6 FABRICATION AND ASSEMBLY

A. Fabricate cabinets with flush overlay construction unless otherwise indicated on drawings.

B. Fabricate and assemble finished work at shop in largest possible sections and deliver to building ready for installation.

C. Construct large pieces requiring sectional construction so their several parts are accurately fitted and aligned with each other. Joints between sections shall not be obvious and distance between edges of door/drawer fronts shall be consistent.

D. Allow sufficient additional material to permit accurate scribing to walls, floors and related work, and make ample allowances for cutting and fitting, and for shrinkage as may develop after installation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive cabinets and associated work and conditions under which cabinets will be installed. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to Installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.
3.2 INSTALLATION

A. Do not install cabinets with chips, cracks, stains, or other defects which might be visible in the finished work.

B. Comply with requirements of referenced standard for quality grade specified in Part 2 of this section for type cabinet work involved.

1. AWI Section 1700.

C. Install cabinets to comply with drawings and final shop drawings in strict compliance with manufacturer's instructions.

D. Install plumb, level, and true; shim as required, using concealed shims. Where cabinetwork abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

E. Base Cabinets: Set cabinets straight, level, and plumb. Adjust subtops within 1/16 inch of a single plane. Fasten cabinets to partition framing, or reinforcements in partitions with fasteners spaced 24 inches o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform. Align similar adjoining doors and drawers to a tolerance of 1/16 inch.

1. Where base cabinets are not installed adjacent to walls, fasten to floor at toe space with fasteners spaced 24 inches o.c. Secure sides of cabinets to floor, where they do not adjoin other cabinets, with not less than two fasteners.

F. Wall Cabinets: Hang cabinets straight, level, and plumb. Adjust fronts and bottoms within 1/16 inch of a single plane. Fasten to hanging strips, partition framing or reinforcements in partitions. Align similar adjoining doors to a tolerance of 1/16 inch.

1. Fasten through back, near top and bottom, at ends, and not more than 16 inches o.c. with No. 10 wafer-head sheet metal screws through metal reinforcement or metal framing behind wall finish.

G. Install hardware uniformly and precisely. Set hinges snug and flat in mortises, unless otherwise indicated. Adjust and align hardware so moving parts operate freely and contact points meet accurately. Allow for final adjustment after installation.

H. Adjust casework and hardware so doors and drawers operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.

I. Countertops: Where possible make field jointing in the same manner as shop jointing, using dowels, splines, adhesives, and fasteners recommended by manufacturer. Prepare edges to be joined in shop so Project-site processing of top and edge surfaces is not required. Locate field joints where shown on Shop Drawings.

1. Secure field joints in plastic-laminate countertops with concealed clamping devices located within 6 inches of front and back edges and at intervals not exceeding 24 inches. Tighten according to manufacturer's written instructions to exert a constant, heavy-clamping pressure at joints.

2. Secure tops to cabinets with Z-type fasteners or equivalent, using two or more fasteners at each front, end, and back.

3. Abut top and edge surfaces in one true plane, with internal supports placed to prevent deflection.

4. Secure backsplashes to tops with concealed metal brackets at 16 inches o.c. and to walls with adhesive.

5. Seal junctures of top, splash, and walls with mildew-resistant silicone sealant or another permanently elastic sealing compound recommended by countertop material manufacturer.

3.3 ADJUSTING AND CLEANING

A. Repair damaged and defective woodwork, where possible, to eliminate functional and visual defects; where not possible to repair, replace woodwork. Adjust joinery for uniform appearance.

B. Clean, lubricate, and adjust hardware.

C. Clean woodwork on exposed and semiexposed surfaces. Touch up shop-applied finishes to restore damaged or soiled areas.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for custom cabinetwork per location indicated wherein no measurement will be made.

END OF SECTION 06410
SECTION 07120
SHEET WATERPROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Work of this Section includes sheet waterproofing system and supplementary items necessary to complete the installation.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
2. ASTM C836 - Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
3. ASTM D412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
5. ASTM D1621 - Standard Test Method for Compressive Properties of Rigid Cellular Plastics
9. ASTM E154 - Standard Test Methods for Water Vapor Retarders Used in Contact with Earth under Concrete Slabs, on Walls, or as Ground Cover

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide waterproofing that prevents the passage of liquid water under hydrostatic pressure and complies with requirements as demonstrated by testing performed by an independent testing agency of manufacturer's current sheet membrane.

1.4 SUBMITTALS

A. Samples: 6 by 6 inch square of following products:
   1. Sheet Membrane.
   2. Protection Board.

B. Product Data: Manufacturer's technical product information for membrane and accessories including instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties.

C. Shop Drawings: Show locations and extent of waterproofing, including details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining construction, and other termination conditions.

D. Certification: By manufacturer that products supplied comply with local VOC regulations.

E. Manufacturer's Project Acceptance Document: Certification that manufacturer and installer will warrant waterproofing system for the specific site, design, details and application indicated for this Project.

F. Product Test Reports: From a qualified independent testing agency indicating and interpreting test results of waterproofing for compliance with requirements, based on comprehensive testing of current waterproofing formulations.

G. Sample Warranty: Copy of waterproofing manufacturer's and Installer's special extended warranty stating obligations, remedies, limitations, and exclusions before starting waterproofing.

H. Manufacturer's Field Report: Summary report specified in Field Quality Control paragraph 3.4/A/2.

1.5 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Obtain primary waterproofing materials of each type required from single manufacturer to the greatest extent possible. Provide secondary materials only as recommended by manufacturer of primary materials.

1. Manufacturer's qualified technical representative will be required to visit Project site to advise applicator of procedures and precautions for installation of waterproofing materials.
B. Installer Qualifications: Engage an experienced installer to perform waterproofing work who has a minimum of 5 years specialized experience in installing waterproofing systems similar to that required for this Project and who is acceptable to the waterproofing manufacturer to install manufacturer's products.

1. Installer Certification: Submit written certification from manufacturer of waterproofing system certifying that installer is approved by manufacturer to install specified system.

2. Installer’s Field Supervision: Require installer to maintain a full-time supervisor/foreman who is on job site during times that waterproofing work is in progress and who is experienced in installing systems similar to type and scope required for this Project.

1.6 WARRANTY

A. Warranty: Submit a written warranty signed by the membrane manufacturer and installer, agreeing to repair or replace sheet membrane waterproofing that fails in materials or workmanship or that does not remain watertight within five years from date of Final Acceptance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Specific product, material or manufacturer listed under each item below is "acceptable" only if manufacturer can evidence product compliance with requirements of Contract Documents.

2.2 MEMBRANE

A. Rubberized-Asphalt Sheet: 60-mil-thick, self-adhering sheet consisting of 56 mils of rubberized asphalt laminated to a 4-mil-thick, polyethylene film with release liner on adhesive side and formulated for application with primer or surface conditioner that complies with VOC limits of authorities having jurisdiction.

1. Physical Properties: As follows, measured per standard test methods referenced:
   a. Tensile Strength: 250 psi minimum; ASTM D 412, Die C, modified.
   b. Ultimate Elongation: 300 percent minimum; ASTM D 412, Die C, modified.
   d. Crack Cycling: Unaffected after 100 cycles of 1/8-inch movement; ASTM C 836.
   e. Puncture Resistance: 40 lbf minimum; ASTM E 154.
   f. Hydrostatic-Head Resistance: 150 feet minimum; ASTM D 5385.
   g. Water Absorption: 0.15 percent weight-gain maximum after 48-hour immersion at 70 deg F; ASTM D 570.
   h. Vapor Permeance: 0.05 perms; ASTM E 96, Water Method.

2. Low Temperature Membrane: Provide manufacturers rubberized asphalt sheets produced for low-temperature if ambient and substrate temperatures are below manufacturers recommendations.

3. Acceptable Manufacturers:
   e. Pecora Corporation; Duramem 700-SM.
   f. Polyguard Products, Inc.; Polyguard 650.
   g. Progress Unlimited, Inc.; Plastiwrap 60.
   h. Tamko Roofing Products, Inc.; TW-60.
   i. Or approved equal.

2.3 AUXILIARY MATERIALS

A. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with waterproofing sheet membrane.

1. Furnish liquid-type auxiliary materials that meet VOC limits of authorities having jurisdiction.

B. Substrate Patching Membrane: Low-viscosity, two component, asphalt modified coating.
C. Adhesives and Mastic: Liquid mastic and adhesive compounds recommended by sheet waterproofing manufacturer.

D. Primers and Surface Conditioners: Liquid type of concrete primer or surface conditioner recommended by manufacturer of sheet waterproofing material for applications required.

E. Liquid Membrane: Elastomeric type recommended by waterproofing sheet manufacturer.

F. Sheet Flashing: Self-adhering, rubberized-asphalt composite sheet strips of same material, construction, and thickness as waterproofing sheet membrane.

G. Metal Termination Bars: Aluminum bars, approximately 1 by 1/8 inch thick, predrilled at 9-inch centers.

H. Protection Board: Provide type of protection board recommended by waterproofing sheet manufacturer. Include adhesives recommended by manufacturer.

1. Vertical Surfaces: Any of the following:
   a. Molded polystyrene, ASTM C 578, Type I, 0.90 lb. per cu. ft., 1 inch thick.
   b. Extruded polystyrene, ASTM C 578, Type X, 1/2 inch thick.
   c. Fan folded, extruded-polystyrene core sandwiched between 2 sheets of plastic film, 1/4 inch thick, with compressive strength of 15 psi per ASTM D 1621.

2. Horizontal Surfaces:
   a. Semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners
   b. Provide 1/8 inch thick board except where covered with steel reinforced concrete slab, apply two layers of 1/8 inch thick board or one layer of 1/4 inch thick board.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates surfaces to receive waterproofing system and associated work and conditions under which work will be installed. Do not proceed with waterproofing until unsatisfactory conditions have been corrected in a manner acceptable to Installer. Starting work within a particular area will be construed as applicator's acceptance of surface conditions.

   1. Verify that concrete has cured and aged for minimum time period recommended by waterproofing manufacturer.
   2. Verify that concrete is visibly dry and free of moisture.
   3. Test for capillary moisture by plastic sheet method according to ASTM D 4263.

3.2 PREPARATION

A. Comply with manufacturer's latest published requirements, instructions and specifications for surface preparations.

B. Clean, prepare, and treat substrates to provide dust-free, and dry substrates for waterproofing application.

C. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.

D. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

E. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids, flush with adjacent surfaces.

F. Prepare, fill, prime, and treat joints and cracks in substrates. Remove dust and dirt from joints and cracks according to ASTM D 4528.

   1. Install sheet strips and center over treated construction and contraction joints and cracks exceeding a width of 1/16 inch.
   2. Install sheet strips to accommodate movement at expansion joints in accordance with manufacturer's recommendations.

G. Verify and submit certification that materials and methods to be used for repair work are compatible with the membrane material to be used and are approved by the membrane manufacturer.
3.3 INSTALLATION

A. Install in accordance with manufacturer’s latest published requirements, instructions, specifications, details and approved shop drawings.

B. Apply primer or surface conditioner to substrates at required rate and allow to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours. Provide manufacturers special primer for damp surfaces if necessary due to construction schedule.

C. Apply and firmly adhere sheets over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch minimum side and end laps. Overlap and seal seams and stagger end laps to ensure watertight installation.

1. Apply membrane firmly into place without wrinkles, buckles or kinks.

2. Apply sheets so that direction of flow of water is over and not against laps.

3. Apply double layer of membrane under clamping ring at drains, at wall angles, corners, penetrations or where waterproofing membrane may be subject to unusual strain.

4. Apply liquid membrane fillet at interior corners under sheet strips.

5. Terminate membrane into a reglet or under counter flashing.

6. Apply mastic or liquid membrane to other vertical and horizontal terminations.

7. Patch misaligned or inadequately lapped seams with membrane.

8. Slit fishmouths, overlap the flaps, and repair with a patch and press or roll in place.

9. Seal edges of patch with a troweling of mastic.

D. Protection Course Installation:

1. Apply protection course in compliance with waterproofing and protection course manufacturer’s latest published recommendations, requirements and specifications.


3. Butt edges without overlap.

E. Backfilling:

1. Place and compact backfill to specified density; prevent damage to the sheet waterproofing and to protection board.

2. Replace damaged work as recommended by the manufacturer.

3.4 FIELD QUALITY CONTROL

A. Manufacturer’s Field Services:

1. Notify manufacturer prior to start of Work and make arrangements for manufacturer’s technical representative to be present during first day’s work to verify work is being conducted in accordance with their requirements.

2. Submit summary report; include Project site observations, instructions and monitoring activities.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for sheet waterproofing per location indicated wherein no measurement will be made.
PART 1 - GENERAL

1.1 SUMMARY
A. Work required for this section includes cold fluid-applied polyurethane membrane waterproofing system and supplementary items necessary to complete their installation.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM C836 - Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
6. ASTM D4258 - Standard Practice for Surface Cleaning Concrete for Coating
7. ASTM D4259 - Standard Practice for Abrading Concrete
8. ASTM D4263 - Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
9. ASTM D4716 - Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

1.3 PERFORMANCE REQUIREMENTS
A. General: Provide waterproofing that prevents the passage of liquid water under hydrostatic pressure and complies with physical requirements of ASTM C836 as demonstrated by testing performed by an independent testing agency of manufacturer’s current waterproofing formulations.

1.4 SUBMITTALS
A. Product Data: Include manufacturer’s written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties of waterproofing.
B. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins to adjoining waterproofing, and other termination conditions.
C. Samples: 6 inch by 6 inch square of the following products:
2. Flashing sheet.
D. Product Test Reports: From a qualified independent testing agency indicating and interpreting test results of waterproofing for compliance with requirements, based on comprehensive testing of current waterproofing formulations.
E. Certification: By manufacturer that products supplied comply with local VOC regulations.
F. Manufacturer's Project Acceptance Document: Certification that manufacturer and installer will warrant waterproofing system for the specific site, design, details and application indicated for this Project.
G. Manufacturer’s Field Report: Summary report specified in Field Quality Control article.
H. Sample Warranty: Copy of waterproofing manufacturer's special extended warranty stating obligations, remedies, limitations, and exclusions before starting waterproofing.

1.5 QUALITY ASSURANCE
A. Manufacturer Qualifications: Obtain primary waterproofing materials of each type required from single manufacturer to the greatest extent possible. Provide secondary materials only as recommended by manufacturer of primary materials.
1. Manufacturer’s qualified technical representative will be required to visit Project site to advise applicator of procedures and precautions for installation of waterproofing materials.
B. Installer Qualifications: Engage an experienced Installer to perform waterproofing work who has a minimum of 10 years specialized experience in installing waterproofing systems similar to that required for this Project and who is acceptable to waterproofing manufacturer to install manufacturer’s products.

1. Installer Certification: Submit written certification from manufacturer of waterproofing system certifying that Installer is approved by manufacturer to install specified system.

2. Installer’s Field Supervision: Require installer to maintain a full-time supervisor/foreman who is on job site during times that waterproofing work is in progress and who is experienced in installing systems similar to type and scope required for this Project.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate, when relative humidity exceeds 85 percent, or when temperatures are less than 5 degrees F. above dew point.

1. Do not apply waterproofing in snow, rain, fog or mist, or when such weather conditions are imminent during application and curing period.

B. Maintain adequate ventilation during application and curing of waterproofing materials.

1.7 WARRANTY

A. Manufacturer’s Warranty: Submit written warranty, signed by waterproofing manufacturer and installer agreeing to repair or replace cold fluid applied waterproofing that fails in material or workmanship or that do not remain watertight within specified warranty period.

1. Warranty does not include failure of waterproofing due to failure of substrate prepared and treated according to requirements or formation of new joints and cracks in substrate that exceed 1/16 inch in width.

2. Warranty Period: Five years after date of Final Completion.

PART 2 - PRODUCTS

2.1 MEMBRANE

A. Cold Fluid-Applied Waterproofing: Single-component, bitumen-modified, polyurethane-based cold liquid membrane material, self-bonding to substrates, and compounded specifically for application and slope of substrate indicated. Provide VOC compliant membrane with not less than 90 percent solids, minimum 6 month shelf life in uncured state, and tested by manufacturer to comply with requirements of ASTM C836.

1. Acceptable Manufacturers and Products:
   a. The Neogard Corporation; “Neogard 7401 Perma-Gard III”.
   c. Pecora Corporation; “Duramem H-500/V-500”.
   d. Sonneborn Building Products; “HLM 5000”.
   e. Tremco, Inc.; “Tremproof 60”, “Vulkem 201”.
   f. Or approved equal.

2.2 AUXILIARY MATERIALS

A. Primer: Manufacturer’s standard, factory-formulated polyurethane or epoxy primer.

B. Sheet Flashing: 50-mil- minimum, nonstaining uncured sheet neoprene.

1. Adhesive: Manufacturer’s recommended contact adhesive.

C. Reinforcing Strip: Manufacturer’s recommended fiberglass mesh or polyester fabric.

D. Joint Sealant: Multicomponent polyurethane sealant, compatible with waterproofing, complying with ASTM C920 Type M, Class 25; Grade NS for sloping and vertical applications or Grade P for deck applications; Use NT exposure; and as recommended by manufacturer for substrate and joint conditions.

1. Backer Rod: Closed-cell polyethylene foam.

E. Protection Course: Semi-rigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners and as follows:
1. Thickness: 1/8 inch, nominal, for vertical applications; 1/4 inch, nominal, for horizontal applications.

2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for type of protection course.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive waterproofing system and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

1. Verify that concrete has cured and aged for minimum time period recommended by waterproofing manufacturer.

2. Verify that substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D4263.

3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

A. Clean and prepare substrate according to manufacturer’s written instructions. Provide clean, dust-free, and dry substrate for waterproofing application.

B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.

C. Close off deck drains and other deck penetrations to prevent spillage and migration of waterproofing fluids.

D. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

E. Abrasive blast clean concrete surfaces uniformly to expose top surface of fine aggregate according to ASTM D4259 with a self-contained, recirculating, blast-cleaning apparatus. Remove material to provide a sound surface free of laitance, glaze, efflorescence, curing compounds, concrete hardeners, or form-release agents. Remove remaining loose material and clean surfaces according to ASTM D4258.

3.3 PREPARATION AT TERMINATIONS AND PENETRATIONS

A. Prepare vertical and horizontal surfaces at terminations and penetrations through waterproofing and at expansion joints, drains, and sleeves according to ASTM C898 and manufacturer’s written instructions.

B. Prime substrate, unless otherwise instructed by waterproofing manufacturer.

C. Apply a double thickness of waterproofing and embed a joint reinforcing strip in preparation coat when recommended by waterproofing manufacturer.

1. Provide sealant cants around penetrations and at inside corners of deck-to-wall butt joints when recommended by waterproofing manufacturer.

3.4 JOINT AND CRACK TREATMENT

A. Prepare, treat, rout, and fill joints and cracks in substrate according to ASTM C898 and waterproofing manufacturer’s written instructions. Remove dust and dirt from joints and cracks complying with ASTM D4258 before coating surfaces.


2. Apply bond breaker between sealant and preparation strip.

3. Prime substrate and apply a single thickness of preparation strip extending a minimum of 3 inches along each side of joint. Apply a double thickness of waterproofing and embed a joint reinforcing strip in preparation coat.

B. Install sheet flashing and bond to deck and wall substrates where indicated or required according to waterproofing manufacturer’s written instructions.

1. Extend sheet flashings onto perpendicular surfaces and other work penetrating substrate according to ASTM C898.

3.5 WATERPROOFING APPLICATION

A. Apply waterproofing according to ASTM C898 and manufacturer's written instructions.

B. Start installing waterproofing in presence of manufacturer's technical representative.

F. Remove fins, ridges, and other projections and fill honeycomb, aggregate pockets, and other voids.
C. Apply primer over prepared substrate.

D. Mix materials and apply waterproofing by spray, roller, notched squeegee, trowel, or other application method suitable to slope of substrate.

1. Apply one or more coats of waterproofing to obtain a seamless membrane free of entrapped gases, with an average dry film thickness of 60 mils and a minimum dry film thickness of 50 mils at any point.

2. Apply waterproofing to prepared wall terminations and vertical surfaces.

3. Verify wet film thickness of waterproofing every 100 sq. ft.

E. Install protection course with butted joints over nominally cured membrane before starting subsequent construction operations.

1. Molded-sheet drainage panels may be used in place of a separate protection course when approved by waterproofing manufacturer.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. Notify manufacturer prior to start of Work and make arrangements for manufacturer's technical representative to be present during first day's work to verify work is being conducted in accordance with their requirements.

2. Submit summary report; include Project site observations, instructions and monitoring activities.

B. Flood Testing: Flood test each horizontal area for leaks, according to recommendations in ASTM D5957, after completing waterproofing but before overlying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.

1. Flood to an average depth of 2-1/2 inches with a minimum depth of 1 inch and not exceeding a depth of 4 inches. Maintain 2 inches of clearance from top of sheet flashings.

2. Flood each area for 24 hours.

3. After flood testing, repair leaks, repeat flood tests, and make further repairs until waterproofing installation is watertight.

4. Keep record of test performed and repairs made.

3.7 CURING, PROTECTING, AND CLEANING

A. Cure waterproofing according to manufacturer's written recommendations, taking care to prevent contamination and damage during application stages and curing. Do not permit foot or vehicular traffic on unprotected membrane.

B. Protect waterproofing from damage and wear during remainder of construction period.

C. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for cold fluid-applied polyurethane membrane waterproofing system per location indicated wherein no measurement will be made.
PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes dampproofing and supplementary items necessary to complete work required for its installation.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):


3. ASTM D1227 - Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing

4. ASTM D1668 - Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing


7. ASTM E1677 - Standard Specification for an Air Retarder (AR) Material or System for Low-Rise Framed Building Walls

B. Federal Specifications (FS):

1. FS UU-B-790 - Building Paper, Vegetable Fiber: (Kraft, Waterproofed, Water Repellent and Fire Resistant)

1.3 SUBMITTALS

A. Product Data: For each type of product specified, including data substantiating that materials comply with requirements for each dampproofing material specified. Include recommended method of application.

1. Certification by dampproofing manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs).

1.4 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Obtain primary waterproofing materials of each type required from single manufacturer to the greatest extent possible. Provide secondary materials only as recommended by manufacturer of primary materials.

B. Installer Qualifications: Engage experienced installer who has completed dampproofing work similar in material, design, and extent to that indicated for Project and with record of successful in-service performance.

PART 2 - PRODUCTS

2.1 DAMPPROOFING MASTIC

A. Asphalt Mastic: Dampproofing emulsion with refined asphalt, emulsifiers, non-asbestos fibers and selected clay fillers.

1. Trowel, brush or spray grade.

2. ASTM D 1227, Type II, Class 1, VOC compliant.

3. Acceptable Manufacturers and Products:

   a. Kamak Chemical Corporation

      1) "Karnak 920 Fibrated Emulsion" (trowel mastic)

      2) "Karnak 220 Fibrated Emulsion" (brush or spray)

   b. W. R. Meadows, Inc.

      1) "Sealmastic - Emulsion Type 3" (trowel mastic)

      2) "Sealmastic - Emulsion Type 2" (brush or spray)

   c. Sonneborn Building Products, Division of ChemRex Inc

      1) "Hydrocide 700 Mastic" (trowel mastic)

      2) "Hydrocide 700B Semimastic" (brush or spray)

   d. Or approved equal.
B. Primer: Emulsified asphalt primer complying with ASTM D 1227, Type III, Class 1, for asphalt-based dampproofing, water based, VOC Compliant. Dilute with water as recommended by manufacturer.

C. Glass Fabric: Woven glass fabric, treated with asphalt, complying with ASTM D 1668, Type I.

### 2.2 DAMPROOFING PAPER

A. Building Paper Dampproofing: Asphalt-saturated heavy duty building paper meeting FS UU-B-790, Type 1, Style 2, Grade D.


4. Tensile Strength: ASTM D 828, MD 68 lb.f./in., CD 31 lb.f./in.

B. Mastic Sealer: ASTM D 1227, Type IV Fibrated (Non-asbestos) asphalt mastic, VOC Compliant.

### 2.3 DAMPROOFING AIR-BARRIER

A. Air-Infiltration Barrier: ASTM E 1677, Type 1. Proprietary building wrap with flame-spread and smoke-developed ratings of less than 25 and 450, respectively, when tested according to ASTM E 84; and with a minimum water-vapor transmission rate equaling 125 g through 1 sq. m of surface in 24 hours according to ASTM E 96, Desiccant Method (Method A). Provide one of the following products:

1. Polyethylene sheet; 9.6 mils thick; formed by spinning continuous strands of fine, high-density-polyethylene inter-connected fibers and bonding them together by heat and pressure; incorporating an additive to provide ultraviolet light resistance for up to 120 days; “Tyvek CommercialWrap” by DuPont Company or approved equal.

2. Polypropylene sheet; 11.5 mils thick; consisting of spun-bonded polypropylene substrate with a polypropylene coating attached directly to one side; “Typar HouseWrap” by Reemay, Inc. or approved equal.

3. Laminated polyethylene sheet; 3 mils thick; consisting of 2 plies of microperforated, cross-laminated, high-density polyethylene; “Rufco-Wrap” by Raven Industries, Inc. or approved equal.

B. Air-Infiltration Barrier Tape: Adhesive coated, weather resistant type recommended by the air-infiltration barrier manufacturer.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

A. Examine substrate surfaces to receive dampproofing and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

#### 3.2 DAMPROOFING MASTIC INSTALLATION

A. Substrate Surface:

1. Prepare substrate surfaces to insure proper and adequate installation, in accordance with manufacturer’s requirements.

2. Clean surfaces smooth and free from projections or holes.

3. Dry surfaces before applying mastic.

4. Prime substrate as recommended by asphalt mastic manufacturer.

B. Mastic Application:

1. Apply in accordance with manufacturer’s latest published requirements.

2. Apply direct from container without heating or thinning.

3. Keep mastic material at temperature above 40 deg. F. for ease of application.

4. Apply trowel mastic heavily in one coat with trowel.

5. Apply sprayable mastic in two coats with spray or heavy brush.

6. Allow 24 hours drying between coats.
C. Coverage: Apply at manufacturer's recommended rate to produce average wet film thickness of not less than 1/8 inch.

D. Glass Fabric Application:
   1. Apply reinforcement ply of fabric and mastic at wall angles, corners, penetrations or place where dampproofing course may be subject to unusual strain.
   2. Embed glass fabric reinforcing into mastic, lapping ends not less than 4 inches and sides not less than 2 inches. Roll or press fabric firmly into place without wrinkles, buckles or kinks.
   3. Apply second coat of mastic over glass fabric as specified above.

E. Cooperate and coordinate with trades of related specified adjacent materials to ensure compatibility.

3.3 DAMPPROOFING PAPER INSTALLATION

A. Building Paper Dampproofing: Cover gypsum board sheathing with dampproofing barrier as follows:
   1. Apply sheets horizontally, starting at base of wall, and lapping each successive upper sheet over previous lower sheet.
   2. Overlap horizontal joints one half sheet to form double sheet thickness. Overlap vertical end joints 6-inches. Cover upstanding flashing with 6-inches overlap.
   3. Cut and seal with mastic sealer around penetrations, openings or projections.
   4. Install with corrosion-resistant screws and metal or plastic disk anchored into steel studs at top of each sheet. Hold bottom of sheet in place with spots of mastic.
   5. Anchor entire sheet to studs with screws and disk if metal lath is not installed immediately.

3.4 DAMPPROOFING AIR-BARRIER INSTALLATION

A. Air-Infiltration Barrier Application: Covers sheathing with air-infiltration barrier as follows:
   1. Apply proprietary building wrap to comply with manufacturer's written installation instructions.
   2. Apply air-infiltration barrier to cover vertical flashing with a 4 inch minimum overlap.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies building insulation for walls and ceilings. Insulation for roofs is provided under each specific roofing type.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C516 - Standard Specification for Vermiculite Loose Fill Thermal Insulation
2. ASTM C549 - Standard Specification for Perlite Loose Fill Insulation
5. ASTM E136 - Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C

1.3 SUBMITTALS

A. Product Data: Submit product data including manufacturer's material, handling, adhesive mixing, installation, and application instructions.

B. Samples: Submit three of each type of the following materials used in the work:

1. Insulation: 12 inches square.
2. Adhesive: 1/2 pint containers.
3. Vapor retarder: 12 inches square.
4. Fasteners: Six each type.

C. Certification:

1. Submit certification that materials furnished meet specified requirements and are compatible with each other.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store products in approved dry area and protect from contact with soil, exposure to the elements and temperatures lower than 150 deg. F. Keep products dry; store rolled goods standing on end.

1.5 JOB CONDITIONS

A. Environmental Requirements: Maintain temperature of 55 deg. F minimum in structure for 48 hours prior to, during and 48 hours after application of wall insulation.

PART 2 - PRODUCTS

2.1 MASONRY WALL INSULATION

A. Loose Granular Insulation:


B. Pre-formed Foam Inserts: Expanded Polystyrene Foam: ASTM C578, Standard Type 1, pre-formed inserts for insertion in concrete masonry cores, 1.0 pounds per cubic foot density, "Korofil" as manufactured by Concrete Block Insulating Systems or approved equal.

2.2 BAT INSULATION

A. Unfaced Mineral Fiber Batts: ASTM C665, Type I, and ASTM E136; fibers from glass, slag wool or rock wool, width to match support spacing, thickness as indicated.

B. Vapor Barrier: Polyethylene sheet, 6 mil thick

C. Joint Seam Tape: As recommended by vapor barrier manufacturer

PART 3 - EXECUTION

3.1 PREPARATION

A. Prepare surfaces smooth, dry, clean, and free of projections, oil, grease, wax, rough mortar, debris, and other substances that might prevent proper application of insulation. Protect other surfaces from drippings.

B. Allow decks and wall surfaces to dry thoroughly before application of insulation.

C. Cut mortar joints flush with masonry walls. Remove fins and projections left after removal of concrete forms.

D. Back plaster walls, if necessary to obtain smooth surfaces.
E. Tape joints in precast/prestressed roof decking with hot-asphalt resistant tape so that liquid asphalt shall not pass through joints.

3.2 APPLICATION OF LOOSE GRANULAR WALL INSULATION

A. Loose Granular Insulation: Pour insulation into cells of concrete masonry units as masonry work progresses in not more than 24-inch lifts. Use manufacturer’s recommended installation procedures to ensure complete filling of masonry cells.

B. Pre-Formed Foam Inserts: Install in accordance with insulation manufacturer’s instructions.

3.3 APPLICATION OF GLASS FIBER INSULATION BOARD

A. General Application:
   1. Comply with insulation manufacturer’s instructions applicable to products and application indicated. If printed instructions are not available or do not apply to project conditions, consult manufacturer’s technical representative for specific recommendations before proceeding with installation of insulation.
   2. Extend insulation full thickness as indicated to envelop entire area to be insulated. Cut and fit tightly around obstructions, and fill voids with insulation. Remove projections that interfere with placement.
   3. Apply a single layer of insulation of required thickness, unless otherwise shown or required to make up total thickness.

B. Protection: Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation will be subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

3.4 APPLICATION OF BATT INSULATION

A. General Application:
   1. Do not install batt insulation until all penetrations through walls, floors, and decks have been sealed and bottom track cleaned.
   2. Friction fit batts between supports for full fill of cavity.
   3. Fit tightly to electrical boxes, pipe penetrations, openings, and other items within wall cavity. Where feasible, place insulation on exterior side of boxes and piping to maintain thermal envelope.
   4. Unless available otherwise, provide insulation thicknesses over 6 inches as a combination of faced and unfaced batts. Faced batts shall have a minimum thickness of 3-1/2 inches.
   5. Provide wire or chicken wire retainer at batt insulation installed at roofs or ceilings where gypsum board or other finish material is not installed directly under insulation.

B. Vapor Barrier Application:
   1. Install vapor barrier perpendicular to supports and fasten with adhesive or staples.
   2. Seal seams and staples with seam tape. Seal penetrations with tape or sealant as appropriate. Seal edges with sealant.

3.5 INSPECTION

A. After completion of insulating work, but prior to covering with other materials, notify the Contracting Officer so that insulated areas may be inspected for completeness of cover and thickness. Correct any deficiencies reported by the Contracting Officer to the satisfaction of the Contracting Officer.

3.6 CLEAN-UP

A. Clean up all rubbish and debris caused by this work and remove from site.

B. Remove drippings of asphalt and adhesives in exposed places on brick, concrete, steel, metal, or other surfaces.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described under this section will not be measured or paid for separately, but shall be considered as incidental to other items of work.

END OF SECTION 07210
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies prefinished metal roofing and associated gutters, fascias, and trim.

B. Coordinate metal roofing with roof drainage work, flashing, trim and the construction of decks, parapets, walls, and other adjoining work, to provide a permanently weather tight, secure and non-corrosive installation. Roofing details shown on the Contract Drawings are minimum requirements; and shall be modified to conform with the requirements of the manufacturer for a warranted roof at no additional cost to the Authority.

1.2 REFERENCED STANDARDS

A. American Architectural Manufacturers Association (AAMA):
   1. AAMA 2605 - Voluntary Specifications, Performance Requirements and Test Procedures for Superior Performing Organic Coatings and Aluminum Extrusions and Panels

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   4. ASTM A792/A792M - Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
   6. ASTM D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
   8. ASTM E1514 - Standard Specification for Structural Standing Seam Steel Roof Panel Systems

C. National Association of Architectural Metal Manufacturers (NAAMM):
   1. NAAMM AMP 500 - 505 - Metal Finishes Manual

D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC Paint 12 - Cold-Applied Asphalt Mastic (Extra Thick Film)

E. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):
   1. SMACNA - Architectural Sheet Metal Manual

F. Underwriters Laboratories, Inc. (UL):

1.3 SUBMITTALS

A. Manufacturer's Data:
   1. Submit metal manufacturer's specifications, installation instructions, and general recommendations for roofing applications.

B. Samples: Submit three 12 inch square samples of specified metal to be used as roofing. Samples will be reviewed by Contracting Officer for color and texture only.

C. Shop Drawings: Submit shop drawings showing the manner of forming, joining and securing the metal roofing, and the pattern of seams, gutters, collection boxes, fascia, and trim. Show expansion joint details and waterproof connections to adjoining work and at obstructions and penetrations. Obtain manufacturer's approval of shop drawings as satisfactory for a warranted roof prior to submittal.
D. Pre-Roofing Conference: Submit copies of pre-roofing conference records.

E. Installer Qualifications: Submit resume of experience with projects listed with contact names and telephone numbers.

1.4 QUALITY ASSURANCE

A. Manufacturer: Obtain primary metal roofing from a single manufacturer. Provide secondary materials as recommended by manufacturer of primary materials.

B. Installer: A firm with not less than 3 years of successful experience in installation of roofing systems similar to those required for this project and which is pre-certified or licensed by manufacturer of primary roofing materials as a premium (top level) contractor. In the immediate past 3 years of experience on similar roof systems, installer shall have worked without interruption or work stoppage due to unacceptable materials or workmanship.

C. Assign work closely associated with metal roofing, including (but not limited to) flashing and counterflashing, underlayments, expansion joints, and joint sealers, to installer of roofing. Pre-Roofing Conference: A pre-roofing conference is to be held to include representatives from the general contractor, subcontractor, manufacturer and the COR. Issues of quality control to be reviewed are handling, lifting, installation and setting the standard for minimum acceptable appearance of the mock-up.

D. Manufacturer’s inspection: Require that a manufacturer’s representative be present at job startup to ensure that installer’s workmen are properly trained and that manufacturer’s instructions are being followed.

1. Require that manufacturer’s representative make at least two interim inspections to ensure good quality control.

2. Upon completion of installation, require manufacturer’s representative to make a final inspection and issue the specified roofing warranty. Submit written certification that installation has been completed in accordance with manufacturer’s recommendations and that punch list items have been completed.

3. The roofing manufacturer is responsible for the proper calibration of the rolling machine to the specific characteristics of the project.

E. Sample Panel: Before proceeding with final purchase of materials and fabrication of metal roofing components, prepare a sample panel of the work. Incorporate materials and methods of fabrication and installation which are identical with the project requirements. Provide sample panel of sufficient scope, as directed, to show typical pattern of seams, edge construction, and finish texture and color. Provide a full-size mock-up section for approval in the middle of a typical roof consisting of four panels to establish the standard of quality that will be accepted. The panels are to lie flat on the substrate free of buckles, excessive waves, wrinkles, creases, ridges, oil-canning and avoidable tool marks. Complete the sample panel work at the time and location directed by the Contracting Officer. Retain accepted sample panel as quality standard for acceptance of completed metal roofing.

F. Metal roofing system shall be designed by the manufacturer to resist wind uplift as indicated in Underwriter’s Laboratories Class 90. If actual UL test has not been performed, submit in-house testing methods and certified engineering calculations, signed by a Professional Engineer registered in the State of Texas, indicating that I-90 classification could be achieved.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, sheets, metal roof panels, and other manufactured items so as not to be damaged or deformed. Package metal roof panels for protection during transportation and handling.

B. Unload, store, and erect metal roof panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal roof panels on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal roof panels to ensure dryness. Do not store metal roof panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Protect strippable protective covering on metal roof panels from exposure to sunlight and high humidity, except to extent necessary for period of metal roof panel installation.

E. Protect foam-plastic insulation as follows:

1. Do not expose to sunlight, except to extent necessary for period of installation and concealment.

2. Protect against ignition at all times. Do not deliver foam-plastic insulation materials to Project site before installation time.
3. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.6 PROJECT CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal roof panels to be performed according to manufacturers' written instructions and warranty requirements.

1.7 COORDINATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal roof panel assemblies that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures, including rupturing, cracking, or puncturing.
   b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Final Acceptance.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal roof panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Fluoropolymer Finish: Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Final Acceptance.

C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace metal roof panel assemblies that fail to remain weathertight, including leaks, within specified warranty period.

1. Weathertight Warranty Period: 20 years from date of Final Acceptance.

PART 2 - PRODUCTS

2.1 PANEL MATERIALS

A. Metallic-Coated Steel Sheet Prepainted with Coil Coating: Steel sheet metallic coated by the hot-dip process and prepainted by the coil-coating process to comply with ASTM A755/A755M.

1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A653/A653M, G90 coating designation; structural quality.

2. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A792/A792M, Class AZ50 coating designation, Grade 40; structural quality.


4. Exposed Finishes: Apply the following coil coating, as specified or indicated on Drawings.
   a. High-Performance Organic Finish: Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

   1) Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with physical properties and coating performance requirements of AAMA 2605, except as modified below:
      a) Humidity Resistance: 2000 hours.
5. Concealed Finish: Apply pretreatment and manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with a minimum total dry film thickness of 0.5 mil.

2.2 UNDERLAYMENT MATERIALS

A. Self-Adhering, Polyethylene-Faced Sheet: ASTM D 1970, 40 mils thick minimum, consisting of slip-resistant polyethylene-film reinforcing and top surface laminated to SBS-modified asphalt adhesive, with release-paper backing; cold applied.

1. Products:
   a. Carlisle Coatings & Waterproofing, Div. of Carlisle Companies Inc.; Dri-Start "A."
   c. Henry Company; Perma-Seal PE.
   e. NEI Advanced Composite Technology; AC Poly Ice and StormSeal.
   f. Owens Corning; WeatherLock.
   g. Polyguard Products, Inc.; Polyguard Deck Guard.
   h. Protecto Wrap Company; Rainproof TM.
   i. Or approved equal.

B. Slip Sheet: Building paper, minimum 5 lb/100 sq. ft., rosin sized.

2.3 MISCELLANEOUS MATERIALS

A. Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets and bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. Provide exposed fasteners with heads matching color of metal roof panels by means of plastic caps or factory-applied coating.

1. Fasteners for Roof Panels: Self-drilling or self-tapping, zinc-plated, hex-head carbon-steel screws, with a stainless-steel cap or zinc-aluminum-alloy head and EPDM or neoprene sealing washer.

2. Fasteners for Flashing and Trim: Blind fasteners or self-drilling screws with hex washer head.


B. Bituminous Coating: Cold-applied asphalt mastic, SSPC Paint 12, compounded for 15 mil dry film thickness per coat. Provide inert-type noncorrosive compound free of asbestos fibers, sulfur components, and other deleterious impurities.

2.4 BATTEN-SEAM METAL ROOF PANELS

A. General: Provide factory-formed metal roof panel assembly designed to be field assembled by covering vertical side edges of adjacent panels with battens and mechanically attaching panels to supports using concealed clips. Include battens and accessories required for weathertight installation.

B. Narrow-Profile, Snap-on-Batten-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and flat pan between ribs; designed for independent installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels, and installation of 3/8 to-1/2 inch wide, snap-on battens over panel joints.

1. Manufacturers:
   a. AEP-Span - “Curved Cap Seam”
   b. ATAS International, Inc. - “PC Snap-On Seam”
   c. Berridge Manufacturing Company - “Curved Tee-Panel”
   d. Or approved equal.

2. Panel Material: Zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet, 0.0159 inch thick.
   b. Color: As selected from manufacturer's full range.

3. Batten Material: Same material, finish, and color as roof panels.
4. **Clips:** One piece.
   a. **Material:** 0.0209-inch thick, zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet.

5. **Panel Coverage:** 12 inches nominal.

6. **Batten Height:** 1.0 inch or 1.25 inch

7. **Uplift Rating:** UL Class 90.

### 2.5 ACCESSORIES

A. **Roof Panel Accessories:** Provide components required for a complete metal roof panel assembly including trim, copings, fascia, corner units, ridge closures, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels, unless otherwise indicated.

1. **Closures:** Provide closures at eaves and ridges, fabricated of same metal as metal roof panels.

2. **Clips:** Minimum 0.0625 inch thick, stainless-steel panel clips designed to withstand negative-load requirements.

3. **Cleats:** Mechanically seamed cleats formed from minimum 0.0250 inch thick, stainless-steel or nylon-coated aluminum sheet.

4. **Backing Plates:** Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

5. **Closure Strips:** Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1 inch thick, flexible closure strips; cut or premolded to match metal roof panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

B. **Flashing and Trim:** Formed from 0.0179-inch thick, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Provide flashing and trim as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, comers, bases, framed openings, ridges, fascia, and fillers. Finish flashing and trim with same finish system as adjacent metal roof panels.

   1. **Formed from other than aluminum:** Formed with straight joints; secure with screws, bolts, or similar means.

C. **Gutters:** Formed from 0.0179 inch thick, zinc-coated (galvanized) steel sheet or aluminum-zinc alloy-coated steel sheet prepainted with coil coating. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96 inch long sections, sized according to SMACNA's "Architectural Sheet Metal Manual." Furnish gutter supports spaced 36 inches o.c., fabricated from same metal as gutters. Provide bronze, copper, or aluminum wire ball strainers at outlets. Finish gutters to match metal roof panels.

### 2.6 FABRICATION

A. **General:** Fabricate and finish metal roof panels and accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. **Provide panel profile**, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

C. **Where indicated**, fabricate metal roof panel joints with factory-installed captive gaskets or separator strips that provide a tight seal and prevent metal-to-metal contact, in a manner that will minimize noise from movements within panel assembly.

D. **Sheet Metal Accessories:** Fabricate flashing and trim to comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to the design, dimensions, metal, and other characteristics of item indicated.

   1. **Formed from other than aluminum:** Formed with straight joints; secure with screws, bolts, or similar means.

2. **Seams for Aluminum:** Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

3. **Seams for Other Than Aluminum:** Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

4. **Sealed Joints:** Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA standards.

5. **Conceal fasteners and expansion provisions where possible. Exposed fasteners are not...**
allowed on faces of accessories exposed to view.

6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended by metal roof panel manufacturer.
   a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal roof panel manufacturer for application but not less than thickness of metal being secured.

2.7 FINISHES, GENERAL

A. Comply with NAAMM AMP 500 - 505 for recommendations for applying and designating finishes.

B. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 CONDITION OF SUBSTRATE

A. Examine the substrate and the conditions under which metal roofing work is to be performed. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 UNDERLAYMENT INSTALLATION

A. Self-Adhering Sheet Underlayment: Install self-adhering sheet underlayment, wrinkle free, on roof sheathing under metal roof panels. Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation; use primer rather than nails for installing underlayment at low temperatures. Apply over entire roof, in shingle fashion to shed water, with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Extend underlayment into gutter trough. Roll laps with roller. Cover underlayment within 14 days.

B. Fasteners: Use stainless-steel fasteners for surfaces exposed to the exterior and galvanized steel fasteners for surfaces exposed to the interior.

C. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.

D. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal roof panel assemblies. Provide types of gaskets, fillers, and
3.4 FIELD-ASSEMBLED METAL ROOF PANEL INSTALLATION

A. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended by manufacturer.

1. Install clips to supports with self-tapping fasteners.

2. Install pressure plates at locations indicated in manufacturer’s written installation instructions.

3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.

3.5 ACCESSORY INSTALLATION

A. General: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal roof panel assembly including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.

B. Flashing and Trim: Comply with performance requirements, manufacturer’s written installation instructions, and SMACNA’s "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without excessive oil canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.

2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

C. Gutters: Join sections with riveted and soldered or lapped and sealed joints. Attach gutters to eave with gutter hangers spaced not more than 4 feet o.c. using manufacturer’s standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.

3.6 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align metal roof panel units within installed tolerance of 1/4 inch in 20 feet on slope and location lines as indicated and within 1/8 inch offset of adjoining faces and of alignment of matching profiles.

3.7 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal roof panels are installed, unless otherwise indicated in manufacturer’s written installation instructions. On completion of metal roof panel installation, clean finished surfaces as recommended by metal roof panel manufacturer. Maintain in a clean condition during construction.

B. Replace metal roof panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Light rail station roofs: Metal roof work for the construction of light rail stations will not be measured but will be paid for as “metal roofing work” as described in this section together with metal decking and removal of temporary cross bracing as per Section 05300, “Metal Decking”, on a lump sum basis for each location wherein no other measurement will be made.
B. The metal roofing described in this section for all work except light rail stations will be paid for as “metal roofing” for each location on a lump sum basis wherein no measurement will be made.

END OF SECTION 07410
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies single-ply ethylene propylene
diene monomer membrane roofing (SPMR),
non-traffic-bearing partially attached sheet
membrane system intended for weather exposure
as primary roofing.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American
Society for Testing and Materials) (ASTM):

1. ASTM C578 - Standard Specification for
Rigid, Cellular Polystyrene Thermal
Insulation

2. ASTM C1289 - Standard Specification for
Faced Rigid Cellular Polyisocyanurate
Thermal Insulation Board

3. ASTM E84 - Standard Test Method for
Surface Burning Characteristics of Building
Materials

4. ASTM E119 - Standard Test Methods for
Fire Tests of Building Construction and
Materials

5. ASTM E136 - Standard Test Method for
Behavior of Materials in a Vertical Tube
Furnace at 750 Degrees C

B. Factory Mutual Global (FM):

1. Factory Mutual Approval Guide

2. FM Global Property Loss Prevention Data
Sheets 1-28: Wind Design

C. Underwriter’s Laboratories, Inc. (UL)

1.3 SUBMITTALS

A. Product Data: Submit specifications, installation
instructions, and general recommendations from
manufacturers of single-ply membrane roofing
system materials, for types of roofing required.
Include data substantiating that materials comply
with requirements.

B. Samples: Submit manufacturer’s standard samples
of required insulation and membrane.

C. Shop Drawings: Submit complete shop drawings
showing roof configuration, sheet layout, seam
locations, details at perimeter, and special
conditions.

1.4 QUALITY ASSURANCE

A. Manufacturer: Obtain primary single-ply membrane
roofing and roof insulation from a single
manufacturer. Provide secondary materials as
recommended by manufacturer of primary
materials.

B. Installer: A firm with not less than 5 years of
successful experience in installation of roofing
systems similar to those required for this project
and which is acceptable to or licensed by
manufacturer of primary roofing materials.

1. Assign work closely associated with single-
ply membrane roofing, including (but not
limited to) insulation, flashing and
counterflashing, expansion joints, and joint
sealers, to Installer of flexible sheet roofing.

C. Pre-Roofing Conference: Prior to installation of
roofing and associated work, meet at project site, or
other mutually agreed location, with Installer,
roofing manufacturer, installers of related work, and
other entities concerned with roofing performance,
including (where applicable) Owner’s insurer, test
agencies, governing authorities, and Contracting
Officer. Record discussions and agreements and
furnish copy to each participant. Provide at least 72
hours advance notice to participants prior to
convening pre-roofing conference.

D. Manufacturer’s Inspection: Require that a
manufacturer’s representative be present at job
start-up to ensure that installer’s workmen are
properly trained and that manufacturer’s instructions
are being followed.

E. Insurance Certification: Assist Owner in preparation
and submittal of roof installation acceptance
certification necessary in connection with fire and
extended coverage insurance on roofing and
associated work.

1.5 JOB CONDITIONS

A. Weather: Proceed with roofing work when existing
and forecasted weather conditions permit work to
be performed in accordance with manufacturer’s
recommendations and warranty requirements.
1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form, without monetary limitation (No-Dollar Limit), in which manufacturer agrees to repair or replace components of membrane roofing system that fail in materials or workmanship within specified warranty period. Failure includes roof leaks.

1. Total system warranty includes roofing membrane, base flashings, roofing accessories, roof insulation fasteners and other components of membrane roofing system.
   a. Warranty Period: 15 years from date of Final Acceptance.

2. Membrane material warranty includes membrane deterioration to point of failure due to weathering.
   a. Warranty Period: 20 years from date of Final Acceptance.

PART 2 - PRODUCTS

2.1 ROOFING SYSTEM REQUIREMENTS

A. UL Listing: Provide labeled materials which have been tested and listed by UL in "Building Materials Directory" for application indicated, with "Class A" rated materials/system for roof slopes shown.

B. FM Listing: Provide flexible sheet roofing system and component materials which have been evaluated by Factory Mutual System for fire spread, wind up-lift, and hail damage and are listed in "Factory Mutual Approval Guide" for Class I construction.

2.2 ETHYLENE PROPYLENE DIENE MONOMER (EPDM)


B. Thickness: 45 mils, nominal.

C. Reinforcing Scrim: Polyester or nylon.

D. Exposed Face Color: Manufacturer's standard gray.

2.3 MISCELLANEOUS MATERIALS FOR SPMR

A. Sheet Seaming System: Manufacturer's standard materials for sealing lapped joints, including edge sealer to cover exposed spliced edges as recommended by manufacturer of SPMR system.

B. Cant Strips, Tapered Edge Strips, and Flashing Accessories: Types recommended by manufacturer of SPMR material, provided at locations indicated and at locations recommended by manufacturer, including adhesive tapes, flashing cements, and sealants.

C. Slip Sheet: Type recommended by manufacturer of SPMR material for protection of membrane from incompatible substrates.

D. Mechanical Fasteners: Metal plates, caps, battens, accessory components, fastening devices, and adhesives to suit substrates and as recommended by SPMR membrane manufacturer.

E. Membrane Adhesive: As recommended by SPMR membrane manufacturer for particular substrate and project conditions, formulated to withstand minimum 60 psf uplift force.

2.4 INSULATING MATERIALS

A. General: Provide insulating materials to comply with requirements indicated for materials and compliance with referenced standards; in sizes to fit applications indicated, selected from manufacturer's standard thickness, widths, and lengths.

B. Polyisocyanurate Board Roof Insulation: Rigid, cellular thermal insulation with polyisocyanurate closed-cell foam core and manufacturer's standard facing laminated to both sides; complying with ASTM C1289; 23 R-value minimum as designated at mean temperatures indicated, after conditioning per RIC/TIMA Bulletin #281-1; and as follows:

1. Surface Burning Characteristics: Maximum flame spread of 25 measured in accordance with ASTM E84.

2. Thermal Resistivity: 12.1 at 75 degrees F for 2 inch thick insulation board.

3. Application: Use a primary insulation over metal decking.

C. Extruded Polystyrene Board Insulation: Rigid, cellular thermal insulation with closed cells and integral high density skin, formed by the expansion of polystyrene base resin in an extrusion process to comply with ASTM C578 for Type indicated; with minimum R-values of 23; and as follows:

1. Compressive Strength: 25 pounds per inch minimum.

2. Provide tapered boards where indicated for sloping to drain; fabricate with taper of 1/4 inch per foot in the 24 inch dimension.

2.5 MISCELLANEOUS INSULATION MATERIALS

A. Adhesive for Bonding Insulation: Type recommended by insulation manufacturer and complying with fire resistance requirements.
B. Mastic Sealer: Type recommended by insulation manufacturer for bonding edge joints and filling voids.

C. Mechanical Anchors: As recommended by insulation manufacturer for deck type, and complying with fire and insurance rating requirements.

2.6 MISCELLANEOUS ROOFING ACCESSORIES

A. Flashing Material: Manufacturer's standard system compatible with single-ply membrane.

PART 3 - EXECUTION

3.1 PREPARATION OF SUBSTRATE

A. General: Comply with manufacturer's instructions for preparation of substrate to receive SPMR system.

B. Clean substrate of dust, debris, and other substances detrimental to SPMR system work. Remove sharp projections.

C. Install cant strips, flashings, and accessory items as shown, and as recommended by manufacturer even though not shown.

3.2 INSTALLATION GENERAL

A. General: Comply with manufacturer's instructions, except where more stringent requirements are indicated.

B. Insurance/Code Compliance: Install SPMR system for compliance with governing regulations and with the following insurance requirements:

1. Factory Mutual requirements for "Class I" construction with Windstorm Resistance Classification I-90.

2. Underwriters Laboratory requirements for Class A.

3.3 INSULATION INSTALLATION

A. General: Extend insulation fill thickness as a single layer, in two layers, or in multiple layers over entire surface to be insulated, cutting and fitting tightly around obstructions. Form cant strips and tapered areas with additional material as shown, as required, for proper drainage of membrane.

1. Stagger all joints in one direction for each course. For multiple layers, stagger joints both directions between courses.

B. Do not install more insulation each day than can be covered with membrane before end of day and before start of inclement weather.

C. Secure roof insulation to substrate with mechanical anchors of type and spacing indicated; but in no case provide less than one anchor per 4 square feet of surface area, or less anchorage than required by FM "Loss Prevention Data Sheet 1-28".

3.4 SPMR MEMBRANE INSTALLATION

A. General: Start installation only in presence of manufacturer's technical representative.

B. Partially Attached SPMR: Install membrane by unrolling over prepared substrate, lapping adjoining sheets as recommended by manufacturer, and bonding and sealing seams. Install mechanical fasteners at spacing recommended by manufacturer, covering with adhesive-applied membrane so that no fasteners are exposed. Install flashings and counterflashings as shown or recommended by manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will not be measured but will be paid for at the lump sum price for “Single-Ply Membrane Roofing” per location. No separate measurement will be made for wastage, insulation, trim, closures, roof curbs, flashing and any other equipment or accessories specified for the work, as they are considered incidental to and integral part of the finished Work.

END OF SECTION 07531
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies metal flashing, coping, miscellaneous waterproofing sheet metal, scuppers, and downspouts where shown.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM A653/A653M - Standard Specification for Steel Sheet, Znc-Coated (Galvanized) or Znc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   3. ASTM B32 - Standard Specification for Solder Metal
   4. ASTM B101 - Standard Specification for Lead-Coated Copper Sheet and Strip for Building Construction
   5. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
   6. ASTM B370 - Standard Specification for Copper Sheet and Strip for Building Construction

B. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):

C. Federal Specifications (FS):
   1. FS QQ-T-201F - Temeplate, for Roofing and Roofing Products
   2. FS UU-B-790A - Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellent and Fire Resistant)

1.3 SUBMITTALS

A. Shop Drawings: Submit shop drawings for shop-fabricated work including complete details of joints, supports, and fasteners, in accordance with SMACNA 1013 where applicable.

   1. Show dimensions and locations of wood nailing strips and details of installation.

B. Product Details: Describe complete composition and types of elements being submitted, including finishes and thicknesses.

C. Samples: Submit three of each type of the following materials used in the work:

   1. Stainless steel: 12 inches square.
   2. Sheet metal coping: 12 inches square.
   3. Aluminum coping: 12 inch by 12 inch corner section.
   5. Expansion joint flashing: 12 inch strips, Prefabricated "T", Prefabricated "X".
   6. Downspout: 12 inch length with anchor strap.
   7. Lead coated copper: 12 inches square.

1.4 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual." Conform to dimensions and profiles shown unless more stringent requirements are indicated.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store products in approved dry area and protect from contact with soil and exposure to the elements. Keep products dry.

PART 2 - PRODUCTS

2.1 STAINLESS STEEL FLASHING BUILT INTO MASONRY

A. ASTM A167, Type 304, 2D finish minimum thickness 26-gauge (0.0187 inch); material for flashing mechanically keyed elements of walls, or parapets. Use for flashing built onto masonry, unless otherwise shown.
2.2 SHEET METAL

A. Zinc coated steel, ASTM A653 for lock-forming. G90 hot-dipped galvanized, mill phosphotized for painting, and 20-gauge unless noted otherwise.

2.3 REGLETS

A. Closed slot, friction type, stainless steel, or lead-coated copper, matching flashing material.

2.4 EXPANSION JOINT FLASHING

A. Combination of neoprene and 16 ounce lead-coated copper, with the following additional requirements:

1. Flashing with neoprene bonded to metal edgings by means of neoprene-based adhesive comprising primer and vulcanizing cement to produce high-strength bond.

2. For neoprene part of flashing, cured neoprene sheet, tensile strength 1,500 psi minimum, elongation 250 percent minimum, bonded to lead-coated copper with peel-pull value of 25 pounds per inch minimum at right angles; thickness and width as shown.

3. Edgings of 16 ounce lead-coated copper, 4 inches wide, perforated with holes 4 inches on centers minimum.

2.5 ALUMINUM COPING AND GRAVEL STOPS

A. Type: Extruded, ASTM B221, Alloy 6063-T5; minimum thickness, 0.125 inch.

B. Size: 10 feet long sections, with factory formed corners and intersections, formed with no visible fasteners before color anodizing, or painting.

C. Finish: Factory applied, as shown on the plans.

D. Fasteners and clips: Hardened aluminum or stainless steel as standard with the manufacturer, color, and finish to match base metal.

2.6 STAINLESS STEEL

A. AISI Type 302/304, complying with ASTM A167, 2D annealed finish.

B. 26 gauge, unless noted otherwise.

2.7 COPPER SHEET AND STRIPS

A. ASTM B370: 16 ounce, unless otherwise shown.

2.8 LEAD-COATED COPPER

A. ASTM B101, 16 ounce roofing temper.

2.9 TERNE-COATED STAINLESS STEEL

A. FS QQ-T-201F, Type 304, 40 pound coating weight.

B. 26-gauge, unless noted otherwise.

C. Coating: Both sides with teule alloy, 80 percent lead and 20 percent tin.

D. Gross weight: 0.82 pounds per square foot.

E. Size: Flashing and downspouts; longest practical lengths.

2.10 STRAINER

A. Stainless steel, 12 gauge wires spaced not greater than 1/2 inch apart, as shown.

2.11 DOWNSPOUT

A. Plain, rectangular, in accordance with SMACNA 1013.

B. 20 gauge hot-dipped galvanized steel, unless otherwise noted.

2.12 METAL SCUPPERS

A. In accordance with SMACNA 1013 and as shown on the Contract Drawings.

2.13 ACCESSORIES

A. Vinyl Tape: As recommended by the metal product manufacturer.

B. Nailing Strips: Pressure treated wood nailing strips and miscellaneous wood supports: Section 06100, "Rough Carpentry".

C. Coal-Tar Epoxy Paint: Themec 4H-413 coal tar epoxy, Carboline, Ameron, or approved equal. Applied to a minimum dry thickness of 8 mils.

D. Solder: ASTM B32.

E. Sealant: Section 07900, "Seals and Sealants".

2.14 FABRICATION

A. Fabricate sheet metal work in accordance with details in referenced SMACNA 1013.
PART 3 - EXECUTION

3.1 PREPARATION

A. Clean dirt, debris, grease, oil, and other foreign substances from surfaces that are to receive metal work.

3.2 INSTALLATION

A. Coordinate flashing and sheet metal work with the work of other trades. Shop fabricate the work whenever possible. Provide for expansion and contraction of sheet metal work, in accordance with SMACNA 1013.

B. Perform cutting, drilling, and other operations in connection with sheet metal work to accommodate work of other trades. Provide accessories as recommended by SMACNA 1013.

C. Where sheet metal abuts or interfaces with adjacent materials, join as shown on approved shop drawings. Isolate dissimilar metals by use of coal-tar epoxy coating. Apply backing for sheet metal applied to any surface to permit movement caused by expansion or to prevent galvanic action.

D. Soldering:
   1. Brush liberal amount of flux on seams, solder immediately, neutralize acid, and clean.
   2. Solder slowly, thoroughly heating seam and completely sweating solder through full width of seam. Use ample solder for full width along seams.

E. Seams:
   1. Flat lock: 3/4 inch wide, minimum.
   2. Solder lap: 1 inch wide, minimum.
   3. Unsoldered plain lap: 3 inches wide, minimum.
   4. Seams: Corresponding to direction of flow.

F. Form flashings from material shown or specified made up from sheets 8 to 10 feet long with locked and soldered seams into units of not more than 16 feet. Join units together with 3 inch wide loose-locked seams filled with sealant before units are joined. Runs of flashing shorter than 16 feet will not require loose seam joints. Miter corners and join by locked and soldered joints.

G. Install expansion joint flashing at locations shown and in accordance with manufacturer's recommendations. Splice ends of adjoining lengths of flashing with neoprene tabs applied to both faces with approved adhesive. Provide prefabricated corners, intersections and crossovers.

H. Form cap flashing at parapet walls and other vertical surfaces to extend into metal reglets built into structure and prefilled with sealant. Lap built-up roof flashings and form metal to provide spring action against roof flashings. Prior to installation, coat flashing portions to be concealed with coal-tar epoxy paint.

I. Where cants do not occur at intersections of roof decks and vertical surfaces of walls and other construction, provide lead-coated copper flashings. Extend base flashings up vertical surfaces eight inches unless otherwise shown, behind metal cap flashing and out onto roof or horizontal surface not less than 8 inches. Coat back sides of base flashing with bituminous paint and set into angle formed by roof and vertical surfaces after three plies of underlayment have been laid. Nail flange with copper nails spaced 3 inches on centers and 3/4 inch from edge into wooden nailer provided in roof slab.

J. Reglets: Form reglets to reproduce detail and design shown. Form sharp, even and true profiles, bends and intersections. Lock or lap joints and solder or reinforce joints as shown or specified.

K. Aluminum Coping: Install coping in accordance with manufacturer's recommendations and as follows: Fasteners and clips:
   1. At joints and at 5 feet maximum intervals.
   2. Center butt joints over anchor clips.
   3. Secure in place allowing for thermal expansion and establishing watertight joint with vinyl seal.

L. Terne-Coated Stainless Steel: Install flat-locked seam roofing, flashing and downspouts in accordance with manufacturer's recommendations and as follows:
   1. Install clips, 2 inches wide, spaced 12 inches on center.
   2. Solder:
      a. Tin content: 50 percent minimum.
      b. Use only rosin flux for soldering.
      c. Remove excess flux after soldering.
3. Installation of strips:
   b. Form flat overlapping surface by malleting seams down. Flood seam with solder.
   c. Form base flashing and downspouts with flatlocked seams and solder as for roofing.
   d. Where shown, form compression seal between the teene-coated stainless steel flashing and other metals with closed-cell vinyl tape.

4. Install strainer at top of downspout.

3.3 CLEAN-UP

A. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain in a clean condition during construction.

B. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will not be measured but will be paid for on a lump sum basis as "Flashing and Sheet Metal" per location.

END OF SECTION 07600
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes through penetration firestopping systems for openings and penetrations through smoke and fire-resistance-rated assemblies, and supplementary items necessary to complete their installation.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

2. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide firestopping systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of assembly penetrated.

B. F-Rated Systems: Provide through-penetration firestopping systems with F-ratings determined per ASTM E814, equaling or exceeding fire-resistance rating of constructions penetrated.

C. T-Rated Systems: For the following conditions, provide through-penetration firestopping systems with T-ratings, as well as F-ratings, determined per ASTM E814, where systems protect penetrating items exposed to potential contact with adjacent materials in occupiable floor areas:

1. Penetrations located outside wall cavities.
2. Penetrations located outside fire-resistant shaft enclosures.
3. Penetrations located in construction containing fire-protection-rated openings.
4. Penetrating items larger than 4 inch diameter nominal pipe or 16 sq. in. in overall cross-sectional area.

D. For through-penetration firestopping systems exposed to view, provide products with flame-spread ratings of less than 25 and smoke-developed ratings of less than 450, as determined per ASTM E84.

1.4 SUBMITTALS

A. Product Data: For each type of firestopping system product indicated.

B. Shop Drawings: For each firestopping system, show each kind of construction condition penetrated, relationships to adjoining construction, and kind of penetrating item. Include firestopping design designation of testing and inspecting agency acceptable to authorities having jurisdiction that evidences compliance with requirements for each condition indicated.

1.  Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each firestopping system configuration for construction and penetrating items.

2. Where Project conditions require modification of qualified testing and inspecting agency's illustration to suit a particular firestopping condition, submit illustration, with modifications marked, approved by firestopping system manufacturer's fire-protection engineer.

C. Product Certificates: Signed by manufacturers of firestopping system products certifying that products furnished comply with requirements.

D. Product Test Reports: From a qualified testing agency indicating firestopping system complies with requirements, based on comprehensive testing of current products.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed firestopping systems similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Source Limitations: Obtain through-penetration firestopping systems, for each kind of penetration and construction condition required, from a single manufacturer.

C. Fire-Test-Response Characteristics: Provide firestopping systems that comply with the following requirements and those specified in 'Performance Requirements' Article:

1. Firestopping tests are performed by a qualified testing and inspecting agency performing testing and follow-up inspection
services for firestopping systems acceptable to authorities having jurisdiction.

2. Through-penetration firestopping systems: Provide materials that are identical to those tested per ASTM E 814. Provide rated firestopping system products that bear classification marking of qualified testing and inspecting agency.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not install firestopping systems when ambient or substrate temperatures are outside limits permitted by firestopping system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate firestopping systems per manufacturer's written instructions by natural means or, where this is inadequate, forced-air circulation.

1.7 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that firestopping systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate firestopping systems.

C. Do not cover up firestopping system installations that will become concealed behind other construction until building inspector, if required by authorities having jurisdiction, has examined each installation.

PART 2 - PRODUCTS

2.1 FIRESTOPPING, GENERAL

A. Acceptable Manufacturers: Manufacturer is "acceptable" if firestopping system has been tested and listed by UL or other testing and inspection agency acceptable to authorities having jurisdiction and manufacturer can evidence product compliance with requirements of the Contract Documents.

B. Compatibility: Provide firestopping systems that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating firestopping systems, under conditions of service and application, as demonstrated by firestopping system manufacturer based on testing and field experience.

C. Accessories: Provide components for each firestopping system that are needed to install fill materials and to comply with “Performance Requirements” Article. Use only components specified by firestopping system manufacturer and approved by the qualified testing and inspecting agency for firestopping systems indicated.

2.2 THROUGH-PENETRATION FIRESTOP SYSTEMS

A. Description: Classified in Underwriters Laboratories (UL) Fire Resistance Directory, "Section XHEZ - Through Penetration Firestop Systems", and/or "Section XHHW - Fill Void or Cavity Materials" for specific project conditions.

B. Application Considerations:

1. Firestops exposed to view and/or are scheduled to receive finishes shall be paintable or capable of receiving finish materials.

2. Firestops exposed to traffic, moisture, and physical damage shall be products that do not deteriorate when exposed to these conditions.

3. Firestops for water piping penetrations of any type, shall be moisture-resistant products.

4. Firestops for floor penetrations with annular spaces exceeding 4 inches or more in width and exposed to possible loading and traffic shall be products capable of supporting the floor loads involved either by installing floor plates or by other means.

5. Firestops for penetrations involving insulated piping shall be products that do not require removal of insulation.

6. Firestops for cable trays and future penetrations shall be reusable pillows or bags.

C. Provide firestops within fire resistive walls and partitions containing flush mounted devices such as outlet boxes, electrical cabinets and mechanical cabinets mounted back to back and spaced less than 24 inches on center in accordance with UL Fire Resistance Directory "Wall Opening Protective Materials", Category CLIV.

D. For those products requiring mixing before application, comply with through-penetration firestopping system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing
time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrate surfaces to receive firestopping systems and associated work and conditions under which work will be installed. Do not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Installer. Starting of work within a particular area will be construed as installer’s acceptance of surface conditions.

3.2 PREPARATION
A. Surface Cleaning: Clean out openings and joints immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer and the following requirements:
   1. Remove foreign materials from surfaces of openings, joints and penetrating items that could interfere with adhesion of firestopping.
   2. Clean opening and joint substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form release agents from concrete.

B. Priming: Prime substrates where recommended by firestopping manufacturer using that manufacturer’s recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Masking Tape: Use masking tape to prevent firestopping from contacting adjoining surfaces that will remain exposed upon completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestopping materials. Remove tape as soon as it is possible to do so without disturbing firestopping’s seal with substrates.

3.3 INSTALLATION OF THROUGH-PENETRATION FIRESTOPS
A. General: Comply with the “System Performance Requirements” article and the through-penetration firestop manufacturer’s installation instructions and drawings pertaining to products and applications indicated.

B. Install forming/damming materials and other accessories of types required to support fill materials during their application and in the position needed to produce the cross-sectional shapes and depths required to achieve fire ratings of designated through-penetration firestop systems. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Install fill materials for through-penetration firestop systems by proven techniques to produce the following results:
   1. Completely fill voids and cavities formed by openings, forming materials, accessories, and penetrating items.
   2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
   3. For fill materials that will remain exposed after completing Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 CLEANING
A. Clean off excess fill materials and sealants adjacent to openings and joints as work progresses by methods and with cleaning materials approved by manufacturers of firestopping system products and of products in which opening and joint occur.

B. Protect firestopping system components during and after curing period from contact with contaminating substances or from damage resulting from construction operations or other causes so that they are without deterioration or damage at time of Final Acceptance. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The work described in this section will be paid for on a lump sum basis for firestopping per location indicated wherein no measurement will be made.

END OF SECTION 07840
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies compression seals, joint fillers, and sealants.

B. The applications of seals and sealants required include the following:

1. Pavement, curb, and walk joints.
2. Control and expansion joints.
3. Flashing reglets and retainers.
5. Joint fillers and sealants, other than firestopping, around penetrations of equipment, and services through walls and floors.

C. Firestopping seals and sealants are specified under Section 07840, “Firestopping”.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C719 - Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants under Cyclic Movement (Hockman Cycle)
2. ASTM C834 - Standard Specification for Latex Sealants
7. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications
8. ASTM D2628 - Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

1.3 SUBMITTALS

A. Product Data: Submit manufacturer’s specifications, recommendations, and installation instructions for each type of sealant and associated miscellaneous material required. Include manufacturer’s published data, or letter of certification, or certified test laboratory report indicating that each material complies with the requirements and is intended specifically for the applications shown.

B. Samples: Submit three of each type of the following materials used in the work. The Contracting Officer will review for color, shape, and texture only.

1. Compression seals: 12 inches long.
2. Sealants: 12 inch long samples of each color required (except black) for each type of sealant exposed to view. Install sample between two strips of material similar to or representative of typical surfaces where sealant or compound is to be used, and spaced apart to represent typical joint widths.
3. Sealant colors: Fully cured beads of each color used, each 6 inches long.
4. Color chips: Do not submit color chips. Submit actual samples of the materials.

1.4 QUALITY ASSURANCE

A. Performance Criteria: Install seals and sealants to perform as durable air-tight and watertight joints for the applications and exposures indicated, and to be free of adhesion and cohesion failures; to be resistant to abrasion, weather, extrusion, migration, and staining; and not to deteriorate in any other manner not clearly indicated by submitted manufacturer’s data as an inherent quality of the material.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Store products in approved dry area and protect from contact with soil and from exposure to the elements. Keep products dry.
1.6 JOB CONDITIONS

A. Weather Conditions: Do not proceed with installation of sealants under adverse weather conditions, or when temperatures are below or above manufacturer's recommended limitations for installation. Proceed with the work only when forecast weather conditions are favorable for proper cure and development of high early bond strength. Wherever joint width is affected by ambient temperature variations, install elastomeric sealants only when temperatures are in the lower third of manufacturer's recommended installation temperature range, so that sealant is not subjected to excessive elongation and bond stress at subsequent low temperatures.

B. Application of seals or sealants when ambient temperature is lower than 40 degrees F or when there is ice, frost, or dampness visible on surfaces to be sealed is prohibited.

1.7 WARRANTY

A. Furnish four year warranty in addition to one year warranty requirements of the General Provisions for a total of five years issued jointly by the manufacturer and the installer. Replace joints failing to meet this warranty. Replacement shall cover materials and labor.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT SELECTION REQUIREMENTS

A. Colors:
   1. Provide custom-made, factory premixed color to match material adjacent to joint or area to be sealed. Where an approved manufacturer cannot provide color-match, use custom colors by another approved manufacturer.
   2. Where sealant is not exposed to view, provide manufacturer's standard color which has the best overall performance characteristics for the application shown.

B. Compatibility: Before purchase of each specified sealant, investigate its compatibility with the joint surfaces, joint fillers and other materials in the joint system. Provide only materials (manufacturer's recommended variation of the specified materials) which are known to be fully compatible with the actual installation conditions, as shown by manufacturer's published data or written certification.

C. Non-Staining Requirement: Provide all products, adhesives, and primers non-staining to the adjacent surfaces when tested in accordance with ASTM C1248.

D. Shelf-Life: Do not use materials if shelf-life of products exceeds manufacturers published shelf-life for these materials.

2.2 COMPRESSION SEAL MATERIALS

A. Paving Compression Seals: Pre-compressed, hollow or compartmentalized neoprene extrusion, designed to withstand compression to 40 percent of normal width without extrusion from joint, and with full recovery; with heavy, durable top member, suitable for long-term exposure to severe traffic abrasion and contamination; complying with ASTM D2628.

B. Neoprene Gaskets: Extruded neoprene gaskets, complying with ASTM D2000, designation 2BC 415 to 3BC 620, black; of the profile shown or, if not shown, as required by the joint shape, size and movement characteristics to maintain a watertight and airtight seal.

C. Lubricant Adhesive and Splicing Adhesive: Non-staining, one-part, of the type recommended by the manufacturer of the compression seals, as appropriate for the use and substrates being adhered.

2.3 SEALANTS

A. Horizontal Joints Subject to Traffic: Polyurethane-based, either one-part elastomeric sealant, complying with ASTM C920, Class 25, Grade P, Type 5 or two-part elastomeric sealant, complying with ASTM C920, Class 25, Grade P, Type M as shown, or as recommended by manufacturer for application indicated.

B. Overhead, Vertical, and Horizontal Non-Traffic-Bearing Joints: Polyurethane based, low modulus, one-part elastomeric sealant, complying with or two-part elastomeric sealant, complying with ASTM C920, Class 25, Grade NS, Type M and as shown, or recommended by manufacturer for application indicated. Sealant shall have a minimum of 50 percent movement capability.

C. Overhead, vertical and horizontal non-traffic-bearing joints: silicone based, low modulus, one part elastomeric sealant, complying with ASTM C920 Class 25, Grade NS, Type S or two-part elastomeric sealant, complying with ASTM C920, Class 25, Grade NS, Type M and as shown or recommend by manufacturer for application intended. Sealant shall have a minimum of 50 percent movement capability.
D. Sanitary Sealant: Acrylic-latex based, one component sealant complying with ASTM C834 with anti-fungal additive for use in restrooms in joints without significant movement.

E. Latex sealant: Acrylic-latex or silicone-latex based, one component sealant complying with ASTM C834 for use in interior joints without significant movement. Use for perimeters of door frames and windows.

F. Primers: As recommended by sealant manufacturer tested for nonstaining and durability characteristics on samples of actual surfaces to be sealed.

G. Solvents, cleaning agents, and similar materials: As recommended by sealant manufacturer.

2.4 SEALANT BACKER ROD AND BOND-BREAKER TAPE

A. Backer Rod:

1. Compressible rod stock polyethylene foam or polyethylene-jacketed polyurethane foam, or other flexible, permanent, durable non-absorptive material which will maintain a uniform round or oval cross-sectional shape when compressed into joint, and which is recommended for compatibility with sealant by the sealant manufacturer.

2. Provide size and shape of rod which will control the joint depth for sealant placement, break bond of sealant at bottom of joint, form optimum shape of sealant bead on back side, and provide a highly compressible backer to minimize the possibility of sealant extrusion when joint is compressed.

B. Bond Breaker Tape: Polyethylene tape or other plastic tape as recommended by the sealant manufacturer, to be applied to sealant-contact surfaces where bond to the substrate or joint filler must be avoided for proper performance of sealant. Provide self-adhesive tape wherever practicable.

2.5 JOINT FILLERS

A. General:

1. Color: Provide each concealed material in manufacturer's standard color which has the best overall performance characteristics for the application shown. For exposed materials provide color selected from manufacturer's standard products, unless a special color requirement is indicated.

2. Compatibility: Before purchase of each filler material, confirm that it is compatible with the substrate, sealants, and other materials in the joint system.

3. Adhesives: Pressure sensitive adhesives, compatible with each material in the joint system, may be applied to one face of joint fillers to facilitate installation and permanent anchorage. Do not allow adhesives to contaminate sealant bond surfaces in the joint system.

4. Bituminous fillers, lubricants, and adhesives are prohibited.

5. Provide fillers as specified in this section, except as required in specific work sections.

B. Closed-Cell Neoprene Joint Filler (Paving joints below sealants, compression seals, and below expansion joint covers).

1. Provide expanded neoprene complying with ASTM D1056, Class SC (oil-resistant and medium swell), of 2 to 5 psi compression deflection (Grade SCE 41); except provide 13 to 17 psi compression deflection (Grade SCE 44) wherever filler is applied under sealant exposed to traffic.

2. Products offered by manufacturers to comply with the requirements include the following:

   b. Closed Cell Neoprene: Rubatex Corp.
   c. Neoprene NN; Williams Products, Inc.
   d. Or approved equal.

C. Sponge Rubber Joint Filler (Exposed joints in concrete surfaces):

1. Provide resilient, non-extruding, open-cell type premolded rubber, color to match concrete, complying with ASTM D1752, Type I.

2. Products offered by manufacturers to comply with the requirements include the following:

b. Gray Sponge Rubber; W.R. Meadows, Inc.

c. Concrete Grey; Williams Products, Inc.

d. Rubberfoam; Sonnebom/Contech, Inc.

e. Or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joint surfaces and backing for insecure surfaces and other conditions that will adversely affect the quality of the installation. Do not proceed with the installation until adverse conditions have been corrected.

B. For joints where filler is exposed to view, such as not covered with sealant or finish materials, provide sponge rubber joint filler.

C. For joints where filler is hidden, such as below sealant and backer rod, provide closed cell neoprene joint filler.

3.2 PREPARATION

A. Clean joint surfaces of dirt, coatings, moisture, and other substances which could interfere with bond of sealant or seals by means of spatula, compressed air and approved cleaners. Remove trash and dirt from the full depth of each joint immediately before proceeding with priming and sealing.

B. Etch concrete and masonry joint surfaces and roughen vitreous and glazed joint surfaces where recommended by the sealant or seal manufacturer.

1. Etch with 5 percent solution of muriatic acid, neutralize with dilute ammonia solution, rinse thoroughly with water, and allow to dry before sealant installation.

2. Roughen joint surfaces on vitreous coated and similar non-porous materials with fine abrasive cloth or wool to produce a dull sheen.

3.3 INSTALLATION

A. General:

1. Comply with manufacturer's printed instructions except where more stringent requirements are shown or specified.

2. Prime or seal the joint surfaces wherever shown or recommended by the manufacturer. Do not allow primer/sealer to spill or migrate onto adjoining surfaces.

B. Compression Seals:

1. If adjacent surfaces are to receive waterproofing, install compression seals prior to application of waterproofing.

2. Lubricate joints by coating both sides of joint with lubricant/adhesive.

3. While lubricant/adhesive is still wet, install compression seals to depth shown.

4. Recess exposed edges slightly behind adjoining surfaces, unless otherwise shown, so that compressed units will not protrude from joints.

5. Bond ends together with adhesive or adhere by other means as recommended by manufacturer to ensure continuous watertight and airtight performance. Miter-cut and bond ends at corners unless molded corner units are provided.

C. Joint Fillers:

1. Set joint filler units at depth or position, fully filling joint as shown, to coordinate with other work, including installation of bond breakers, backer rods, and sealants. Do not leave voids or gaps between ends of joint filler units.

2. Recess exposed joint fillers, slightly behind adjoining surfaces, unless otherwise shown, so that compressed units will not protrude from the joint.

Do not proceed with installation of sealants over joint surfaces which have been painted, lacquered, waterproofed, or treated with water repellent or other coating or treatment unless a test for durability (bond and cohesion) in compliance with ASTM C719 has successfully demonstrated that sealant bond is not impaired by coating or treatment. Remove bond-impairing coatings or treatments from joint surfaces before installing sealant.
D. Backer-Rod:

1. Install sealant backer rod at all liquid-applied elastomeric sealant locations, except where specifically noted to be omitted or recommended to be omitted by sealant manufacturer for the particular applications shown.

2. Install bond breaker tape in lieu of backer rod at joints having insufficient depth for proper sealant coverage over a backer rod.

3. Depth of backer rod: Install backer rod at a depth which allows sealant to be installed within the thickness limits specified below.

4. Install joint fillers and backer rods without gaps or voids between ends of units and without ends of units protruding from joints.

E. Bond Breaker Tape: Install bond breaker tape where shown and where recommended by manufacturer to ensure that sealants will perform properly.

F. Sealants:

1. Thickness (Depth): Install sealants to depths as shown or, if not shown, as recommended by the sealant manufacturer but within the following general limitations, measured at the center (thin) section of the bead.

   a. For walkways, pavements and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, fill joints to a depth equal to 75 percent of joint width, but not more than 5/8 inch deep or less than 3/8 inch deep.

   b. For normal moving joints bonded with elastomeric sealants, but not subject to traffic, fill joints to a depth equal to 50 percent of joint width, but not more than 1/2 inch deep or less than 1/4 inch deep.

2. Employ installation techniques which will ensure that sealants are deposited in uniform, continuous ribbons without gaps or air pockets, with complete wetting of joint bond surfaces equally on opposite sides. Except as otherwise shown, fill sealant rabbet to slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between horizontal surface and vertical surface, fill joint to form slight cove, so that joint will not trap moisture and dirt.

3. Spillage: Do not allow sealants or compounds to overflow from confines of joints, to spill onto adjoining work or to migrate into voids of exposed finishes. Eliminate evidence of spillage.

4. Granite joints: Seal joints in granite work with sealant, except granite paving joints that are shown to be grouted.

3.4 CURING AND PROTECTING

A. Cure sealants in compliance with manufacturer's recommendations, to obtain high early bond strength, internal cohesive strength and surface durability.

B. Cure and protect joint sealants during construction period, so that they will be without deterioration or damage, other than normal wear and weathering, at time of final acceptance.

C. Replace or restore sealants damaged or deteriorated during construction.

3.5 CLEANING

A. Immediately clean adjacent surfaces which have been soiled, and leave the work in a neat, clean condition. Use cleaning fluid, solvent, of type recommended by sealant manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described under this section will not be measured, but shall be considered as incidental to other items of work.

END OF SECTION 07900
SECTION 08115
HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes custom-fabricated, commercial-quality steel doors, frames and supplementary items necessary to complete their installation.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):
   1. ANSI/SDI A250.4 - Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcements
   2. ANSI/SDI A250.10 - Test Procedure and Acceptance Criteria for Prime Painted Steel Surfaces for Steel Doors and Frames

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   2. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   3. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
   4. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   5. ASTM A1011 - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

C. Door & Hardware Institute (DHI):
   1. DHI A115 - Series for Steel Door Preparation Standards

D. National Fire Protection Association (NFPA):
   1. NFPA 80 - Standard for Fire Doors and Windows

E. National Association of Architectural Metal Manufacturers (NAAMM):
   1. NAAMM AMP 500-505 - "Metal Finishes Manual"

F. National Association of Architectural Metal Manufacturers (NAAMM / Hollow Metal Manufacturers Association (HMMA)):
   1. NAAMM HMMA 831 - Recommended Hardware Locations for Custom Hollow Metal Doors and Frames
   2. NAAMM HMMA 861 - Guide Specifications for Commercial Hollow Metal Doors and Frames

G. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC SP 1 - Solvent Cleaning
   2. SSPC SP 3 - Power Tool Cleaning
   3. SSPC SP 6 - Commercial Blast Cleaning - NACE No. 3
   4. SSPC Paint 20 - Zinc-Rich Primers (Type I - Inorganic & Type II - Organic)

1.3 SUBMITTALS

A. Product Data: Include construction details, material descriptions, core descriptions, label compliance, fire-resistance ratings, and finishes for each type of door and frame specified.

B. Shop Drawings: Show fabrication and installation of doors and frames. Include details of each frame type, elevations of door design types, conditions at openings including surrounding materials, details of construction, dimensions of profiles and hardware preparation, location and installation requirements of door and frame hardware and reinforcements, and details of joints and connections. Show anchorage and accessories.

C. Door Schedule: Submit schedule of doors and frames using same reference numbers for details and openings as those on Drawings.

D. Product Certificates: Signed by manufacturers of doors certifying that products furnished comply with or exceed the acceptance criteria of ANSI/SDI A250.4 for Level A doors.
1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: A firm experienced in manufacturing custom steel doors and frames similar to those indicated for this project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

B. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to UBC 7-2 (1997) and UL 10C.

1. Test Pressure: After 5 minutes into the test, the neutral pressure level in furnace shall be established at 40 inches or less above the sill.

2. Smoke-Labeled Doors: For 20-minute-rated doors and doors scheduled as smoke- and draft-controlled assemblies, provide doors that a smoke-control rating of 20 minutes. Fire-rating label shall have the letter "S" following the hourly fire rating.

3. Notify Contracting Officer, prior to fabrication, if fire doors indicated cannot qualify for labeling because of design, size, hardware or other reason.

4. If door specified as fire rated and labeled can be obtained from one manufacturer, no consideration will be given to those manufacturers who are not authorized to fabricate and label items.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors and frames palleted, wrapped, or crated to provide protection during transit and storage. Do not use nonvented plastic.

B. Inspect doors and frames, on delivery, for damage. Minor damage may be repaired provided refinished items match new work otherwise, remove and replace damaged items.

C. Store doors and frames under cover at building site. Provide wood blocking between stacked doors to permit air circulation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Hot-Rolled Steel Sheets: ASTM A1011, CS (commercial steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.

B. Cold-Rolled Steel Sheets: ASTM A1008, CS (commercial steel), Type B.

C. Metallic-Coated Steel Sheets: ASTM A653, CS (commercial steel), Type B; with G60 zinc (galvanized) or A60 zinc-iron-alloy (galvannealed) coating.

D. Inserts, Bolts, and Fasteners: Manufacturer's standard units. Where items are to be built into exterior walls, zinc coat according to ASTM A153, Class C or D as applicable.

2.2 DOORS

A. General: Provide flush-design doors, 1-3/4 inches thick, of seamless hollow construction, meeting NAAMM HMMA 861. Construct doors with smooth, flush surfaces without visible joints or seams on exposed faces or stile edges.

1. Visible joints or seams around glazed inserts are permitted.

2. For single-acting swing doors, bevel both vertical edges 1/8 inch in 2 inches.

B. Core Construction: Provide the following core construction welded to both door faces:

1. Steel-Stiffened Core: 0.026-inch (22 gauge) steel vertical stiffeners extending full-door height, spaced not more than 6 inches apart and spot welded to face sheets a maximum of 6 inches o.c. Fill spaces between stiffeners with insulation of minimum 0.6-lb/cu. ft. density or sound deadener applied to inside surfaces of face sheets.

2. Fire Door Cores: As required to provide fire-protection and temperature-rise ratings indicated.

C. Seals: Obtain fire rating without use of intumescent seals.

D. Astragals: As required by NFPA 80 to provide fire ratings indicated.

E. Top and Bottom Channels: Spot weld metal channel not less than thickness of face sheet to face sheets not more than 6 inches o.c.

1. Reinforce tops and bottoms of doors with inverted horizontal channels of same material as face sheet so flanges of channels are even with bottom and top edges of face sheets.
F. Hardware Reinforcement: Fabricate reinforcing plates from the same material as door to comply with the following:

1. Hinges and Pivots: 0.167 inch (7 gauge) thick by 1-1/2 inches wide by 6 inches longer than hinge, secured by not less than 6 spot welds.
2. Lock Face, Flush Bolts, Closers, and Concealed Holders: 0.093 inch (12 gauge) thick.
3. Other Surface-Mounted Hardware: 0.053 inch (16 gauge) thick.

G. Glass Molding and Stops: Provide frame for glazed openings between face sheets continuously around perimeter of glass opening and weld to face sheets.

1. Form frame with integrally formed stop on security side.
2. Miter corners, weld and grind smooth.
3. Do not overlap molding on face of door.
4. Use 20 gauge loose stop for flush glazing.
5. Apply stop to frame with countersunk screws 6 inches on centers.

H. Interior Doors: Fabricate face sheets of doors from two 0.042 inch (18 gauge) thick, cold-rolled, stretcher-leveled steel sheets and other metal components from hot- or cold-rolled steel sheets unless noted to be galvanized.

I. Galvanized Steel Doors: Fabricate face sheets of doors from two 0.053 inch (16 gauge) thick, stretcher-leveled, metallic-coated steel sheets.

1. Close bottom edge with metallic-coated steel closing channel and top edge with filler channel of same material, so webs of channels are flush with bottom and top door edges.
2. Provide weep-hole openings in bottom of doors to permit entrapped moisture to escape.
3. Seal joints in top edges of doors against water penetration.
4. Provide galvanized doors at following locations:
   a. Exterior doors.
   b. Elevator equipment room doors.
   c. Other locations indicated.

2.3 FRAMES

A. Fabricate frames meeting NAAMM HMMA 861, of full-welded unit construction, with comers mitered, reinforced, and continuously welded full depth and width of frame. Knockdown frames are not acceptable.

1. For exterior use, form frames from 0.067 inch (14 gauge) thick, metallic-coated steel sheets.
2. For interior use, form frames from cold- or hot-rolled steel sheet of the following thicknesses:
   a. Openings up to and Including 48 Inches Wide: 0.053 inch (16 gauge).
   b. Openings More Than 48 Inches Wide: 0.067 inch (14 gauge).

B. Hardware Reinforcement: Fabricate from same material as frame. Minimum thickness of steel reinforcing plates for the following hardware:

1. Hinges and Pivots: 0.167 inch (7 gauge) thick by 1-1/2 inches wide by 6 inches longer than hinge, secured by not less than 6 spot welds.
2. Strikes, Flush Bolts, and Closers: 0.093 inch (12 gauge).
3. Surface-Mounted Hold-Open Arms and Panic Devices: 0.093 inch (12 gauge).

C. Mullions and Transom Bars: Provide closed or tubular mullions and transom bars where indicated. Fasten mullions and transom bars at crossings and to jambs by butt welding. Reinforce joints between frame members with concealed clip angles or sleeves of same metal and thickness as frame.

D. Supports and Anchors: After fabricating, galvanize units to be built into exterior walls according to ASTM A153, Class B.

E. Jamb Anchors: Weld jamb anchors to frames near hinges and directly opposite on strike jamb as required to secure frames to adjacent construction. Unless otherwise required for fire rating, provide anchors as follows.

1. Masonry Construction: Adjustable, flat, comugated, or perforated T-shaped anchors to suit frame size; formed of same material
as frame; not less than 0.053 inch thick; with leg not less than 2 inches wide by 10 inches long. Furnish at least the number of anchors per jamb according to the following frame heights:

a. Two anchors per jamb up to 60 inches in height.
b. Three anchors per jamb from 60 to 90 inches in height.
c. Four anchors per jamb from 90 to 96 inches in height.
d. One additional anchor per jamb for each 24 inches or fraction thereof more than 96 inches in height.

2. Metal-Stud Partitions: Insert type with notched clip to engage metal stud, welded to back of frames, formed of same material as frame, not less than 0.042 inch (18 gauge) thick. Provide at least the number of anchors for each jamb according to the following heights:

a. Three anchors per jamb up to 60 inches in height.
b. Four anchors per jamb from 60 to 90 inches in height.
c. Five anchors per jamb from 90 to 96 inches in height.
d. One additional anchor per jamb for each 24 inches or fraction thereof more than 96 inches in height.

3. In-Place Concrete or Masonry: Anchor frame jambs with minimum 3/8 inch diameter concealed bolts into expansion shields or inserts 6 inches from top and bottom and 26 inches o.c., unless otherwise indicated. Reinforce frames at anchor locations. Except for fire-rated openings, apply removable stop to cover anchor bolts, unless otherwise indicated.

F. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor, formed of same material as frame, 0.067 inch (14 gauge) thick, as follows:

1. Monolithic Concrete Slabs: Clip-type anchors, with two holes to receive fasteners, welded to bottom of jambs and mullions.
2. Separate Topping Concrete Slabs: Adjustable type with extension clips, allowing not less than 2 inch height adjustment. Terminate bottom of frames at finish floor surface.

G. Head Anchors: Provide 2 head anchors for frames more than 42 inches wide and mounted in steel-stud walls.

H. Structural Reinforcing Members: Provide as part of frame assembly, at mullions, transoms, or other locations to be built into frame where required for additional support.

I. Head Reinforcement: For frames more than 48 inches wide in masonry wall openings, provide continuous steel channel or angle stiffener, 0.093 inch (12 gauge) thick for full width of opening, welded to back of frame at head.

J. Spread Bar: Provide removable spreader bar across bottom of frames, tack welded to jambs and mullions.

K. Rubber Door Silencers: Except on weather-stripped doors, drill stop in strike jamb to receive three silencers on single-door frames and drill head jamb stop to receive two silencers on double-door frames. Install plastic plugs to keep holes clear during construction.

L. Plaster Guards: Provide 0.016 inch (26 gauge) thick plaster guards or dust-cover boxes of same material as frame, welded to frame at back of hardware cutouts to close off interior of openings and prevent mortar or other materials from obstructing hardware operation.

2.4  STOPS

A. Provide stops on door frames and around glazed panels.

B. Form fixed stops integral with frame, unless otherwise indicated.

C. Provide removable stops around glazed panels, formed of 0.032 inch (20 gauge) thick steel sheets matching steel frames. Secure with countersunk flat or oval-head machine screws spaced uniformly not more than 12 inches o.c. Form corners with butted hairline joints.

D. Coordinate rabbet width between fixed and removable stops with type of glass or panel and type of installation indicated.

2.5  FABRICATION

A. Fabricate doors and frames rigid, neat in appearance, and free of defects, warp, or buckle. Accurately form metal to required sizes and
profiles. Weld exposed joints continuously; grind, fill, dress, and make smooth, flush, and invisible. Where practical, fit and assemble units in manufacturer's plant. Clearly identify work that cannot be permanently factory assembled before shipment, to assure proper assembly at Project site.

B. Hardware Preparation: Prepare doors and frames to receive hardware, including cutouts, reinforcement, mortising, drilling, and tapping, according to final hardware schedule and templates provided by hardware supplier. Comply with applicable requirements of DHI A115 Series specifications for door and frame preparation for hardware.

1. Reinforce doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied hardware may be done at Project site.

2. Locate hardware according to NAAMM HMMA 831, "Recommended Hardware Locations for Custom Hollow Metal Doors and Frames."

2.6 FINISHES

A. Comply with NAAMM AMP 500-505 - "Metal Finishes Manual " for recommendations for cleaning, treating, priming, and when specified, finishing.

B. Finish products specified in this Section after fabrication.

C. Metallic-Coated Steel Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a conversion coating suited to primer to be applied over it. Clean welds, mechanical connections, and abraded areas, and apply galvanizing repair paint specified below to comply with ASTM A 780.


D. Non-Coated Steel Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning"; remove dirt, oil, grease, or other contaminants that could impair paint bond. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC SP 3, "Power Tool Cleaning", or SSPC SP 6, "Commercial Blast Cleaning- NACE No. 3"

E. Factory Priming for Field-Painted Finish for Non-Coated Steel: Apply shop primers specified below immediately after surface preparation and pretreatment. Apply a smooth coat of even consistency to provide a uniform dry film thickness of not less than 0.7 mils.

1. Shop Primer: Manufacturer's or fabricator's standard, fast-curing, corrosion-inhibiting, lead- and chromate-free, universal primer complying with ANSI/SDI A250.10 acceptance criteria; compatible with substrate and field-applied finish paint system indicated; and providing a sound foundation for field-applied topcoats despite prolonged exposure.

F. Do not prime metallic-coated steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install doors and frames according to DHI A115.IG and manufacturer's written instructions.

B. Frames: Install steel frames for doors, transoms, sidelights, borrowed lights, and other openings, of size and profile indicated.

1. Floor anchors may be set with powder-actuated fasteners instead of masonry anchorage devices and machine screws, if so indicated on Shop Drawings.

2. Placing Frames: Set frames accurately in position; plumb; align, and brace securely until permanent anchors are set. After wall construction is complete, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.

a. At existing concrete or masonry construction, set frames and secure in place with machine screws and masonry anchorage devices.

b. At fire-rated openings, install frames according to NFPA 80.

c. Field splice only at approved locations. Weld, grind, and finish as required to conceal evidence of splicing on exposed faces.

C. Doors: Fit non-fire-rated doors accurately in their respective frames, with the following clearances:


3. Bottom: 3/8 inch, if no threshold or carpet.

4. Bottom: 1/8 inch, at threshold or carpet.

D. Fire-Rated Doors: Install with clearances as specified in NFPA 80.

3.2 ADJUSTING AND CLEANING

A. Final Adjustments: Check and readjust operating hardware items just before final inspection. Leave work in complete and proper operating condition. Remove and replace defective work, including doors or frames that are warped, bowed, or otherwise unacceptable.

B. Factory-Finish Touchup: Immediately after erection, sand to feather-edge minor scratched, chipped, or damaged areas and apply touchup of compatible air-drying paint. Minor finish imperfections may be repaired provided finish matches new work finish and is approved by Contracting Officer; otherwise, remove and replace.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for hollow metal doors and frames per location indicated wherein no measurement will be made.

END OF SECTION 08115
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work required for this section includes access doors and frames in walls, floors, and ceilings, and supplementary items necessary to complete their installation:

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
4. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes
5. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
7. ASTM A591/A591M - Standard Specification for Steel Sheet, Electrolytic Zinc-Coated, for Light Coating Weight (Mass) Applications
8. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
9. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
10. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
11. ASTM A924/A924M - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
12. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

B. Military Specifications (ML):

1. MIL-PRF-26915 - Primer Coating, for Steel Surfaces

C. National Fire Protection Association (NFPA):

1. NFPA 80 - Standard for Fire Doors and Fire Windows

D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

1. SSPC-Paint 20 - Zinc-Rich Primers (Type I, "Inorganic," and Type II, "Organic")
2. SSPC-PA 1 - Shop, Field, and Maintenance Painting of Steel
3. SSPC-SP 3 - Power Tool Cleaning
4. SSPC-SP 6 - Commercial Blast Cleaning-NACE No. 3

1.3 SUBMITTALS

A. Product Data: For each type of door and frame indicated. Include construction details relative to materials, individual components and profiles, finishes, and fire ratings (if required).

B. Door Schedule: Provide complete door and frame schedule, including types, general locations, sizes, construction details, latching or locking provisions, and other data pertinent to installation.

C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items with concealed framing, suspension systems, piping, ductwork, and other construction. Show the following:

1. Method of attaching door frames to surrounding construction.
2. Ceiling-mounted items including access doors and frames, lighting fixtures, diffusers, grilles, speakers, sprinklers, and special trim.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain doors and frames through one source from a single manufacturer.

DART - September 2004 08313 - 1
B. Fire-Rated Access Doors and Frames: Units complying with NFPA 80 that are identical to access door and frame assemblies tested for fire-test-response characteristics that are labeled and listed by UL, ITS, or another testing and inspecting agency acceptable to authorities having jurisdiction.

C. Size Variations: Obtain Contracting Officer’s acceptance of manufacturer’s standard-size units, which may vary slightly from sizes indicated.

1.5 COORDINATION

A. Verification: Determine specific locations and sizes for access doors needed to gain access to concealed equipment, and indicate on door schedule specified in “Submittals” Article.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are “acceptable” only if manufacturers can evidence product compliance with requirements of Contract Documents.

1. Acudor Products, Inc.
2. Cierra Products.
3. J. L. Industries, Inc.
5. Larsen’s Manufacturing Company.
7. Nystrom Building Products Co.
8. Williams Bros. Corporation of America (The).
9. Or approved equal.

2.2 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A36/A36M.

B. Cold-Rolled Steel Sheets: ASTM A1008/A1008M, Commercial Steel (CS), stretcher-leveled standard of flatness; with minimum thickness indicated representing specified nominal thickness according to ASTM A568. Electrolytic zinc-coated steel sheet, complying with ASTM A591/A591M, Class C coating, may be substituted at fabricator’s option.

C. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B, with A60 zinc-iron-alloy (galvannealed) coating or G60 mill-phosphatized zinc coating; stretcher-leveled standard of flatness; with minimum thickness indicated representing specified thickness according to ASTM A924.

D. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304; with minimum sheet thickness indicated representing specified thickness according to ASTM A480 with No. 4 satin finish.

E. Stainless-Steel Bars and Shapes: ASTM A276, Type 304.

F. Drywall Beads: Edge trim formed from 0.0299-inch zinc-coated steel sheet formed to receive joint compound and in size to suit thickness of gypsum board.

G. Plaster Bead: Casing bead formed from 0.0299-inch zinc-coated steel sheet with flange formed out of expanded metal lath and in size to suit thickness of plaster.

2.3 PAINT

A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chrome-free, universal modified-alkyd primer complying with performance requirements in MIL-PRF-26915; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.


2.4 ACCESS DOORS AND FRAMES

A. Flush, Insulated, Fire-Rated Doors with Exposed Frame:

1. Metal: Steel, metallic-coated steel or stainless-steel sheet as scheduled.
2. Locations: Masonry and Ceramic-tile wall surfaces.
3. Fire-Resistance Rating: One and one-half hours.
4. Temperature Rise Rating: 250 deg F at the end of 30 minutes.
5. Door: Flush panel with a core of mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.036 inch.
6. Frame: Minimum 0.060 inch thick sheet metal with 1 inch to 1-1/2 inch wide, surface-mounted trim.
10. Size: 12 inch by 12 inch unless otherwise indicated.

11. Basic-of-Design Product: Nystrom Building Products, model IT.

B. Flush, Insulated, Fire-Rated Doors with Trimless Frames:

1. Metal: Steel, metallic-coated steel or stainless-steel sheet as scheduled.
2. Locations: Gypsum board wall surfaces.
3. Fire-Resistance Rating: One and one-half hours.
4. Temperature Rise Rating: 250 deg F at the end of 30 minutes.
5. Door: Flush panel with a core of mineral-fiber insulation enclosed in sheet metal with a minimum thickness of 0.036 inch.
6. Frame: Minimum 0.060 inch thick sheet metal with drywall bead.
10. Size: 12 inch by 12 inch unless otherwise indicated.
11. Basic-of-Design Product: Nystrom Building Products, model IT.

C. Flush Doors with Exposed Frames:

1. Metal: Steel, metallic-coated steel or stainless-steel sheet as scheduled.
2. Locations: Masonry and Ceramic-tile wall surfaces.
3. Door: Minimum 0.075 inch thick sheet metal, set flush with exposed face flange of frame.
4. Frame: Minimum 0.060 inch thick sheet metal with 1 inch to 1-1/4 inch wide, surface-mounted trim.
5. Hinges: Continuous piano hinge.
7. Size: 12 inch by 12 inch unless otherwise indicated.
8. Basic-of-Design Product: Nystrom Building Products, model IW or IP as applicable.

D. Flush Doors with Trimless Frames:

1. Metal: Steel, Metallic-coated steel or stainless-steel sheet as scheduled.
2. Locations: Gypsum board wall and ceiling surfaces.
3. Door: Minimum 0.075 inch thick sheet metal, set flush with surrounding finish surfaces.
4. Frame: Minimum 0.060 inch thick sheet metal with drywall bead.
5. Hinges: Continuous piano hinge.
7. Size: 12 inch by 12 inch unless otherwise indicated.
8. Basic-of-Design Product: Nystrom Building Products, model NT.

2.5 FABRICATION

A. General: Provide access door assemblies manufactured as integral units ready for installation.

B. Metal Surfaces: For metal surfaces exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

C. Steel Doors and Frames: Grind exposed welds smooth and flush with adjacent surfaces. Furnish attachment devices and fasteners of type required to secure access panels to types of supports indicated.

1. For trimless frames with drywall bead for installation in gypsum board assembly provide edge trim for gypsum board base securely attached to perimeter of frames.
2. For trimless frames with plaster bead for full-bed plaster applications, provide zinc-coated expanded metal lath and exposed casing bead welded to perimeter of frames.
3. Provide mounting holes in frames to attach frames to metal framing in metal stud construction and to attach masonry anchors in masonry construction.

D. Latching Mechanisms: Furnish number required to hold doors in flush, smooth plane when closed.

1. For cylinder lock, furnish two keys per lock and key all locks alike.
2. Coordinate with DART system keying.

2.6 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish metal fabrications after assembly.

C. Metallic-Coated Steel Finishes:
   1. Galvanizing: Hot-dip galvanize items indicated to comply with applicable standard listed below:
      a. ASTM A123/A123M, for galvanizing steel and iron products.
      b. ASTM A153/A153M, for galvanizing steel and iron hardware.
   2. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. For galvanized surfaces, apply, after cleaning, a conversion coating suited to the organic coating to be applied over it. For metallic-coated surfaces, clean welds, mechanical connections, and abraded areas, and apply galvanizing repair paint specified below to comply with ASTM A780.
   3. Factory Priming for Field-Painted Finish: Apply shop primer immediately after cleaning and pretreating.

D. Steel Finishes:
   1. Surface Preparation: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed metal fabrications:
      a. Exteriors (SSPC Zone 1B): SSPC-SP 6, "Commercial Blast Cleaning-NACE No. 3."
      b. Interiors (SSPC Zone 1A): SSPC-SP 3, "Power Tool Cleaning."

E. Stainless-Steel Finishes:
   1. Remove tool and die marks and stretch lines or blend into finish.

2. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

3. Bright, Directional Polish: No. 4 finish. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

PART 3 - EXECUTION

3.1 PREPARATION

A. Advise installers of other work about specific requirements relating to access door and floor door installation, including sizes of openings to receive access door and frame, as well as locations of supports, inserts, and anchoring devices.

3.2 INSTALLATION

A. Comply with manufacturer's written instructions for installing access doors and frames.

B. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces or recessed to receive finish material.

3.3 ADJUSTING AND CLEANING

A. Adjust doors and hardware after installation for proper operation.

B. Remove and replace doors and frames that are warped, bowed, or otherwise damaged.

3.4 SCHEDULE

A. Provide access doors, where indicated on the drawings, and where scheduled below.
   1. Provide access doors at concealed valves and controls for plumbing and HVAC.
   2. Provide fire rated access doors at rated walls and ceilings.
   3. Provide access doors at fire dampers above non-accessible ceilings.
   4. Provide access doors to motor operated doors and grilles above non-accessible ceilings.
   5. Provide access doors to attics with electrical junction boxes and system elements, concealed catwalks and maintenance platforms above ceilings.
   6. Provide zinc coated steel access doors at exterior locations.
7. Provide stainless steel access doors at ceramic tile and other damp locations.

8. Provide fire rated floor access doors at rated floors.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for access doors and frames per location indicated wherein no measurement will be made.

END OF SECTION 08313
PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes aluminum-framed windscreens and supplementary items necessary to complete their installation.

B. Exterior aluminum-framed wall system at elevators is specified in Section 08913, "Glazed Aluminum Elevator Enclosures".

1.2 REFERENCE STANDARDS

A. American Architectural Manufacturers Association (AAMA):
   1. AAMA 611 - Voluntary Standards for Anodized Architectural Aluminum

B. American Welding Society (AWS):
   1. AWS A5.10/A5.10M - Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   3. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   4. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
   5. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

D. Porcelain Enamel Institute (PEI):
   1. PEI ARCH S-100 - Specification for Architectural Porcelain Enamel on Steel for Exterior Use

E. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC PS Guide 12.00 - Guide to Zinc-Rich Coating Systems
   2. SSPC SP COM - Surface Preparation Commentary for Steel and Concrete Substrates

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide aluminum-framed windscreens capable of withstanding loads and thermal and structural movement requirements indicated without failure, based on testing manufacturer's standard units in assemblies similar to those indicated for this Project.

   1. Deflection of framing members normal to wall plane is limited to 1/175 of clear span for spans up to 13 feet 6 inches and to 1/240 of clear span plus 1/4 inch for spans greater than 13 feet 6 inches or an amount that restricts edge deflection of individual glazing lites to 3/4 inch whichever is less.

B. Wind Loads: Provide aluminum-framed windscreens capable of withstanding wind-load design pressures calculated according to requirements of latest adopted Local Building Code.

C. Thermal Movements: Provide aluminum-framed windscreens that accommodate thermal movements of supporting elements resulting from the following maximum change (range) in ambient and surface temperatures without buckling, damaging stresses on glazing, damaging loads on fasteners, failure of doors or other operating units to function properly, and other detrimental effects.

   1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

1.4 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of product indicated.

B. Shop Drawings: Show details of fabrication and installation. Include plans, elevations, sections, details, and attachments to other work.

   1. Include setting drawings, templates, and directions for the installation of anchor bolts and other anchorages installed as a unit of work under other sections.

   2. Indicate where and how the system deviates from Contract Documents.

   3. Shop Drawings: Prepared by or under the supervision of a qualified professional engineer
1.6 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of structural supports for aluminum-framed systems by field measurements before fabrication and indicate measurements on Shop Drawings.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating aluminum-framed systems without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are "acceptable" only if manufacturer can provide evidence product compliance with requirements of Contract Documents.

2. Kawneer Company, Inc.
3. Tubelite Inc.
4. United States Aluminum Corp.
5. Vistawall Architectural Products.
6. Or approved equal.

2.2 MATERIALS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221.
4. Structural Profiles: ASTM B 308/B308M.
5. Welding Rods and Bare Electrodes: AWS A5.10.
B. Steel Reinforcement: With manufacturer's standard corrosion-resistant primer complying with SSPC PS Guide 12.00 applied immediately after surface preparation and pretreatment. Select surface preparation methods according to recommendations in SSPC SP COM and prepare surfaces according to applicable SSPC standard.

1. Structural Shapes, Plates, and Bars: ASTM A36/A36M.
2. Cold-Rolled Sheet and Strip: ASTM A1008/A1008M.
3. Hot-Rolled Sheet and Strip: ASTM A1011/A1011M.

C. Framing Members: Manufacturer's standard extruded-aluminum framing members of thickness required and reinforced as required to support imposed loads.

D. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

E. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

F. Glazing: As specified in Division 8 Section "Glazing."

G. Glazing Gaskets: Manufacturer's standard compression types, replaceable, molded or extruded, that maintain uniform pressure and seal.

H. Spacers and Setting Blocks: Manufacturer's standard elastomeric types.

I. Porcelain Enamel Steel Panels:

1. Porcelain enamel steel panels: substantially vitreous, or glassy inorganic coating bonded to metal by fusion at a temperature above 800 deg. F, double sided panel with all edges finished.
2. Porcelain enamel steel panels shall meet the requirements of PEI ARCH S-100.
3. Steel panels are to be specially designed and fabricated for use in architectural porcelain enamel steel panels.
4. Finished faces of porcelain enamel panels shall have a maximum variation of 1/8 inch in both the convex and concave direction when measured perpendicular to the nominal plane of the panel face.
5. Surface hardness of porcelain enamel steel panels is to be 3.5 to 6 (Moh’s Scale).
6. Sizes and shapes of porcelain enamel steel panels are to be as indicated on the drawings.

7. Color of porcelain enamel steel panels is to match Benjamin Moore #1600, unless noted otherwise.

J. Hinges and Locks:

1. Hinges used at operable doors are to be heavy duty stainless steel continuous Markar FM-300 hinges.
2. Locks used at operable doors are to be Adams Rite #4712-628, with standard cylinder with Adams Rite style cam.
3. Coordinate keying with DART system keying.

K. Attachments shall have secure or vandal and tamper-resistant heads.

L. Neoprene Stops:

1. Neoprene stops shall be closed-cell, Type II.
2. Neoprene stops shall be continuous around frame opening.
3. Stops shall be installed with fasteners; adhesive may only be used to facilitate installation.

2.3 FABRICATION

A. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.

B. Framing Members: Fabricate components that, when assembled, have the following characteristics:

1. Profiles that are sharp, straight, and free of defects or deformations.
2. Accurately fitted joints with ends coped or mitered.
3. Physical and thermal isolation of glazing from framing members.
4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
5. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.

C. Door Frames: Reinforce as required to support loads imposed by door operation and for installing hardware.

1. Provide silencers at stops to prevent metal-to-metal contact. Install three silencers on strike jamb of single-door frames and two silencers on head of frames for pairs of doors.
D. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.4 **ALUMINUM FINISHES**

A. General: Comply with NAAMM’s “Metal Finishes Manual for Architectural and Metal Products” for recommendations for applying and designating finishes.

B. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

C. Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.

**PART 3 - EXECUTION**

3.1 **EXAMINATION**

A. Examine substrate surfaces to receive glazed aluminum partitions and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as installer’s acceptance of surface conditions.

3.2 **INSTALLATION**

A. General: Comply with manufacturer’s written instructions.

1. Do not install damaged components.

2. Fit joints to produce hairline joints free of burrs and distortion.

3. Rigidly secure nonmovement joints.

4. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration.

B. Metal Protection:

1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape or installing nonconductive spacers as recommended by manufacturer for this purpose.

2. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components plumb and true in alignment with established lines and grades, without warp or rack.

D. Install glazing as specified in Division 8 Section "Glazing."

E. Erection Tolerances: Install aluminum-framed systems to comply with the following maximum tolerances:

1. Location and Plane: Limit variation from true location and plane to 1/8 inch in 12 feet; 1/4 inch over total length.

2. Alignment: Limit offset from true alignment to:

   a. Where surfaces abut in line, 1/16 inch.

   b. Where surfaces meet at corners, 1/32 inch.

3. Diagonal Measurements: Limit difference between diagonal measurement to 1/8 inch.

**PART 4 - MEASUREMENT AND PAYMENT**

4.1 **GENERAL**

A. The work described in this section will be paid for on a lump sum basis for aluminum-framed windscreens per location indicated wherein no measurement will be made.

END OF SECTION 08413
1.1 DESCRIPTION

A. This section specifies providing door hardware as shown.

B. Any opening shown on plans requiring hardware and not specifically mentioned shall be furnished with hardware corresponding to that of similar openings. Any item of hardware not specifically called for in the hardware groups but obviously required for proper operation of the openings or compliance with the applicable codes, including handicapped requirements, if not brought to the attention of the Contracting Officer prior to bid date, is assumed to be included in the suppliers proposal.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A413/A413M - Standard Specification for Carbon Steel Chain

B. International Code Council (ICC):
   1. ICC/ANSI A117.1 - Accessible and Usable Buildings and Facilities

C. National Fire Protection Association (NFPA):
   1. NFPA 80 - Standard for Fire Doors and Fire Windows

D. Builders Hardware Manufacturers Association (BHMA):
   1. BHMA A156.1 - Butts and Hinges
   2. BHMA A156.3 - Exit Devices
   3. BHMA A156.4 - Door Controls - Closers
   4. BHMA A156.5 - Auxiliary Locks & Associated Products
   5. BHMA A156.8 - Door Controls - Overhead Stops and Holders
   6. BHMA A156.13 - Mortise Locks & Latches
   7. BHMA A156.16 - Auxiliary Hardware
   8. BHMA A156.18 - Materials and Finishes

1.3 SUBMITTALS

A. Shop Drawings: Include finish hardware schedule, prepared by a current certified AHC (Architectural Hardware Consultant), based on same set numbers as used on drawings and in hardware Schedule bound herein, manufacturer's literature, catalog cuts, model numbers, and other information necessary to identify and delineate in detail lockset functions, types of strike plates, hand and back set of locks, degree of closer openings, lengths of kick plates, lengths of flush bolts, types of stops, and other such pertinent data, following the criteria listed below.

   1. Finish Hardware Schedules: Based on finished hardware indicated, organize hardware schedule into groups or sets showing complete designations of every item required for each door opening. Horizontal hardware schedules are not acceptable and will not be reviewed by the Contracting Officer. Include the following:
      a. Number, locations, hand, and material of each door opening. (Hands and swings to be determined in relation to key side of opening.)
      b. Type, style, function, size, finish, and quantity of each hardware item.
      c. Name and manufacturer of each item.
      d. Fastening requirements.
      e. Explanation of abbreviations used.
      f. Special mounting locations and instructions.
      g. Keying Schedule: Submit separate detailed schedule indicating clearly how Authority's final instructions on keying of locks has been fulfilled.

   2. Furnish an index cross referencing door number, drawing hardware group, and suppliers hardware group. Schedule shall be vertical layout. Lines shall be double spaced; pages numbered and dated.

B. Samples:

   1. Finish: Manufacturer's standard, but not less than one 1 inch by 3 inch sample of each finish to be furnished. Submit with shop drawings.
2. The Contracting Officer reserves the right to require actual samples of each hardware item to be furnished. Samples will be returned to the Contractor for installation in the project.

3. Provide finishes so that color and surface finish or polish of various items match throughout the work. Nonmatching finishes will be rejected.

C. Documentation: Construction keying schedule.

D. Product Data:
   1. Submit catalog cuts of all items used in the suppliers schedule.
   2. Operating Instructions: Furnish Contracting Officer with two complete sets of installation instructions, including the manufacturer's catalog and maintenance instructions. One complete catalog shall be furnished for each manufacturer listed in the approved hardware schedule.

E. Six-Month Adjustment: Submit report upon completion of observations.

1.4 QUALITY ASSURANCE

A. Manufacturer: Obtain each kind of hardware (latch and locksets, hinges, closers, etc.) from one manufacturer even though several may be listed as acceptable.

B. Supplier: Subcontract the furnishing of hardware only to a recognized builders hardware supplier who has been furnishing hardware for a period of not less than 5 years and who has in his full time employed an Architectural Hardware Consultant to supervise the execution of this section. Consultant will be available at all reasonable time, during the course of the work, for project consultation with the Contracting Officer.

C. Contractor: Assign the installation of hardware to tradesmen experienced in the installation of commercial finish hardware.

D. Scheduled Designations: Except as otherwise indicated, the use of one manufacturer's numeric designation system in schedules does not imply other manufacturer's products will not be acceptable.

E. Fire-Rated Openings: Provide hardware for fire-rated openings in compliance with NFPA 80. This requirement takes precedence over other requirements for such hardware. Provide only hardware which has been tested and listed by UL and bears appropriate label or symbol for the types and sizes of doors required and compliance with the requirements of the required label and function of the opening.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products to Worksite in original unopened packages, clearly labeled with manufacturer's name, brand, specification identification data, and identification as shown on approved hardware schedule.

B. Store products in an approved dry area, protect from contact with soil, and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.6 WARRANTY

A. Warranty: All hardware shall be warranted by the manufacturer to be free from defects in materials and workmanship for a period of two years from substantial completion of the Project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Uniformity: Provide hardware devices of each type, such as hinges, locking devices, bolts, and stops by the same manufacturer.

B. Template Hardware: Use templates to locate holes and mounting locations of hardware.
   1. Furnish templates and reinforcing units to hollow metal manufacturer.
   2. Make hardware to be applied to metal doors and frames to template and secure with machine screws.
   3. Manufacture hardware to conform to published templates generally prepared for machine screw installation. Do not provide hardware which has been prepared for self-tapping sheet metal screws.
C. Fastenings: Furnish finish hardware with all necessary bolts, screws, and other fastenings in suitable size, quantity, and type for heavy use and durability. Provide fastenings to match the hardware material and finish or, if exposed in surfaces of other work, to match the finish of such other work as closely as possible, including “prepared for paint” for surfaces to receive painted finish. Provide fastenings meeting the following requirements:

1. Furnish items for application to concrete or masonry with machine screws and expansion shields.
2. Furnish exit devices or other items for application to hollow or mineral core doors with hex bolts, unless otherwise specified.
3. Furnish items for application on applied veneer finishes with screws of sufficient length to provide solid connection to framing or backing behind them.
4. Furnish items for application to wood with wood screws.
5. Use Phillips head screws, countersunk, oval headed, for exposed screws.
6. Use full-threaded screws.
7. Provide concealed fasteners for hardware units which are exposed when the door is closed, except to the extent no standard units of the type specified are available with concealed fasteners. Do not use through bolts for installation where the bolt head or the nut on the opposite face is exposed in other work, except where it is not feasible to adequately reinforce the work and such through bolts are approved by the Contracting Officer.

D. Splicing of electrical wires for electrical items, to achieve specified lengths is not acceptable.

E. Hand of Door: The drawings show the direction of swing of each door leaf. Furnish each item of hardware for proper installation and operation of the door movement as shown.

F. Manufacturer’s Name Plate: Do not use manufacturer’s products which have manufacturer’s name or trade name displayed in a visible location (omit removable nameplates), except in conjunction with required UL labels and as otherwise acceptable to the Contracting Officer. Permit manufacturer’s identification on rim of lock cylinders only.

G. Base Metals: Produce hardware units of the basic metal and forming method indicated, using the manufacturer’s standard metal alloy, composition, temper and hardness, but in no case of lesser commercially recognized quality than BHMA A156.18. Do not furnish other materials or forming methods than those indicated, except as otherwise specified.

H. Tools for Maintenance: Furnish a complete set of specialized tools as needed for Contracting Officer’s use for adjustment, maintenance, and removal and replacement of hardware.

2.2 HARDWARE TYPES

A. General Requirements:

1. UL listing required for hardware applied to UL-labeled doors and frames.
2. Finish designations are U.S. Standards and are subject to approval for color, texture and appearance. Furnish finishes to match samples available from the Contracting Officer.

B. Common Requirements of All Hinges for Construction: Five knuckle, eight screw, full mortise, template type, flat button tip except where otherwise scheduled, non-rising pin.

C. Butt Hinges:

1. Permanently lubricated concealed bearings.
3. Height: 4-1/2 inches minimum.
4. Finish: As scheduled.

D. Intrusion Switch Hinge Feature (Switch Hinge): Where switch hinge is indicated on finish hardware schedule, provide one hinge at middle of jamb for each leaf, matching other hinges, having a weatherproof single pole magnetic switch and wires at least 18 inches long, designed to activate alarm or indicator when door is opened, 24 volts DC.

E. Electric Hinge Feature: Where electric hinges are indicated on finish hardware schedule, provide one hinge at middle of jamb for each leaf, matching other hinges, having concealed 24 volts DC power conduction capability and wires at least 18 inches long.
F. Hinges: BHMA A156.1 for Butt hinges: Button tips, types, and sizes as specified.

1. Quantity required per door leaf:
   a. Doors 61 inches to 90 inches in height: 1-1/2 pairs.
   b. Doors 91 inches to 120 inches in height: Two pairs.

2. Types:
   a. Exterior doors and doors from public passageways: Butts, Type A2111. Finish as shown (in the Schedule).
   b. Interior doors: Steel butts, Type A8112, plated. Finish as indicated (in the hardware schedule).

G. Locksets and Latchsets:

1. Construction: Heavy duty mortise lockset.
3. Latch bolt: 3/4 inch minimum throw, anti-friction type, brass with nylon split cam.
4. Guardbolt or triggerbolt (for deadlocking latch bolt): Brass.
5. Deadbolt: One inch throw, with rotating armor pin or hardened steel anti-saw insert.
7. Strike: Of same material as levers, curved extended lip with wrought strike box of anti-corrosive steel.
9. Construction cylinders: Key control system cylinders.
10. UL listing: Provide UL listed locksets at openings indicated to receive UL rated hardware.
11. Finish: As indicated in the Hardware Schedule.

H. Keying:

1. Cylinders: Lock cylinders shall be suitable for use in system wide Authority key control.
   a. For locksets: BHMA A156.5, with finish as indicated in the Hardware Schedule. Provide keying system which permits a rapid change-out of keys. As a minimum, provide a multiple level master key system to permit ease of use and convenience in changing key combinations when necessary.
   b. Provide key system to establish commonality of key-lock combinations, to the greatest possible extent, while still maintaining acceptable security.

2. Keys and keying:
   a. Stamped with the Authority inscription as provided by the Contracting Officer, and the words: DART AUTHORITY - DO NOT DUPLICATE, and with visual key control data.
   b. Quantity: Three keys for each core plus blanks equal to 10 percent of total keys furnished.

3. Key tags and holders: BHMA A156.5, Type A, Class 1, inscribed with key-change number and key-control symbol.

I. Push Plates and Door Pulls: Finish as indicated in the Hardware Schedule, and with the following additional requirements:

1. Push Plate: 3/16 inch by 10 inches by 20 inches, unless otherwise shown, with edges beveled.
2. Door pull: 3/4 inch round bar, 8 inches center to center, concealed fasteners; escutcheon plate same as push plate.

J. Door Closers: BHMA A156.4, Type CO2021, streamlined design, with the following additional requirements:

1. Surface-mounted.
2. Parallel arms.
3. Cover plate: Finish as indicated in the Hardware Schedule.
4. Parallel arms and drop brackets as necessary. Where hold-open feature is specified for closers, use type that permits doors to open 140 degrees, conditions permitting.

5. Qualities:
   a. Exposed: Overhead type, hydraulically controlled full rack and pinion operation, with separate adjustable regulator of closing speed, latching speed, backcheck control, and spring power. Provide parallel arm type closer for reverse bevel exterior doors. Closers mounted on non-public side of doors only.

6. Size: Provide in sizes according to manufacturer's published recommendation for each door size and weight with consideration for wind velocity at each location.

7. Case Material: Cast iron or aluminum case.

8. Cover Finish: As indicated in the Hardware Schedule.

9. Sources of exposed door closers: LCN, Sargent Yale, Russwin.

10. Where door closers are indicated for doors required to be accessible to the physically handicapped, provide adjustable units complying with both ICC/ANSI A117.1 and State of Texas Program for the Elimination of Architectural Barriers provisions and ADAAG for door opening force and delayed action closing.

K. Stops:
   1. Overhead-type, wall-type, or floor-type, and as follows:
      a. Overhead: BHMA A156.8, Type CO2511. Finish as indicated in the Hardware Schedule.
      b. Wall: BHMA A156.16, Type L12101. Finish as indicated in the Hardware Schedule.
      c. Floor: BHMA A156.16, Type L12141. Finish as indicated in the Hardware Schedule.

L. Flush Extension Bolts: BHMA A156.16, with finish as indicated in the Hardware Schedule.

   1. Dustproof strikes, Type L14021, provided for bolts located at bottom of doorleaf, except where metal thresholds are specified. Cut opening to suit bolt.
   2. Operating mechanism located approximately 6 feet from floor for top bolts and approximately 12 inches from floor for bottom bolts.
   3. Bolts located in edge of inactive leaf of pair of doors.
   4. Automatic flush bolts: BHMA A156.3, 4.4 Type 25. UL-listed for 1-1/2 hour, B-labeled double doors with strikes. Finish as indicated in the Hardware Schedule.

M. Weather Stripping:
   1. Sill: National Guard l5DKBN or approved equal.
   2. Head and jamb: National Guard l33NDKB or approved equal.


O. Padlock:
   1. Removable core with 2 keys, keyed and master keyed as directed. Key to match part of Authority systemwide keying.
   3. Five-pin tumblers.

P. Deadlock: BHMA A156.5, Type 190, with interchangeable-core cylinder.

2.3 SILENCERS

A. Provide each single leaf door with three silencers, or mutes. Provide each pair of doors with four silencers.

B. Material: Rubber.
2.4 HARDWARE FINISHES

A. Provide matching finishes for hardware units at each door or opening, to the greatest extent possible, and except as otherwise indicated. Reduce differences in color and textures as much as commercially possible where the base metal or metal forming process is different for individual units of hardware exposed at the same door or opening. In general, match items to the manufacturer's standard finish for the latch and lock set (or push-pull units if no latch-lock sets) for color and texture.

B. Provide finishes which match those established by BHMA.

C. Provide quality of finish, including thickness of plating or coating, composition, hardness, and other qualities complying with manufacturer's standards, but in no case less than specified for the applicable units of hardware by referenced standards or named products.

D. The designations scheduled to indicate hardware finishes are those listed in BHMA A156.18, including coordination with the traditional U.S. finishes shown by certain manufacturers for their products.

2.5 SCHEDULED HARDWARE QUALITY STANDARD

A. Requirements: The design, grade, function, finish, size, and other distinctive qualities of each type of builders' hardware is indicated in the Hardware Schedule. Products are identified by using hardware designation numbers of proprietary companies. These named products become the standard by which hardware is judged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install finish hardware in accordance with manufacturer's templates and instructions. Fit hardware accurately and properly then fasten fixed parts securely for smooth, trouble-free and nonbinding operation. Fit faces of mortised parts snugly and flush. Install operating parts for free and smooth operation without binding, sticking or excessive clearance. Make maximum use of concealed fastenings for security.

B. Mount hardware units at heights recommended in "Recommended Locations for Builders' Hardware", published by the Door and Hardware Institute, except as otherwise specifically indicated or required to comply with governing regulations.

C. Set items level, plumb, and true to line and location. Adjust and reinforce the attachment substrate as necessary for proper installation and operation.

D. Drill and countersink units which are not factory-prepared for anchorage fasteners. Space anchors and fasteners in accordance with industry standards.

E. Locks, Latches, and Bolts: Install locks, latches, and bolts to automatically engage in strike or keeper, whether activated by closer or by manual push. Do not require additional manual pressure to engage latch or bolt.

F. Closers: Carefully adjust closers to operate evenly and noiselessly ensuring compliance with accessibility standards.

G. Mortar Shield Junction Box: Provide mortar shield junction boxes to hollow metal fabricator for use at electric and switch hinge locations; and connect conduit before frames are grouted.

H. Coordinate work of this section with work of other trades.

I. Apply finish hardware in a neat and workmanlike manner.

J. Prior to Final Acceptance, replace missing hardware.

K. Cut mortises neat, clean, and of proper net size.

L. Adjust hardware to operate as designed and replace hardware that is scratched, marred non-functioning, or otherwise damaged.

M. Provide keying in accordance with master keying schedule prepared by the hardware manufacturer. Deliver keying schedule and keys to the Contracting Officer prior to Final Acceptance.

N. Install UL-labeled hardware at doors indicated as rated.

3.2 ADJUSTING, CLEANING, AND DEMONSTRATING

A. Adjust and check each operating item of hardware and each door, to ensure proper operation or function of every unit. Replace units which cannot be adjusted to operate freely and smoothly as intended for application made.

B. Wherever hardware installation is made more than one month prior to acceptance or occupancy of space or area, return to work during week prior to acceptance or occupancy, and make final check and adjustment of hardware items. Clean operating items as necessary to restore proper function and finish of hardware and doors. Adjust
door control devices to compensate for final operation of heating and ventilating equipment.

C. Clean adjacent surfaces soiled by hardware installation.

D. Instruct Agency's personnel in proper adjustment and maintenance of hardware and hardware finishes, during final adjustment of hardware.

E. Six-Month Adjustment: Approximately six months after date of Final Acceptance, Installer, accompanied by representatives of manufacturers of latchsets and locksets and of door control devices, and of other major hardware suppliers, shall return to Project to perform following work:

1. Examine and re-adjust each item of door hardware as necessary to restore function of doors and hardware to comply with specified requirements.

2. Consult with and instruct Agency's personnel in recommended additions to maintenance procedures.

3. Replace hardware items that have deteriorated or failed due to faulty design, materials, or installation of hardware units.

4. Prepare written report of current and predictable problems (of substantial nature) in performance of hardware.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described under this section will not be measured directly, but shall be considered as incidental to other items of work.

B. The work described under this section will not be paid for directly, but the cost shall be allowed for in the cost of other related items of work for which finish hardware have been specified.

END OF SECTION 08710
1.1 DESCRIPTION

A. This Section specifies providing glass and sealing of glass areas.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. ANSI Z97.1 - Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM C158 - Standard Test Methods for Strength of Glass by Flexure (Determination of Modulus of Rupture)
2. ASTM C864 - Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
4. ASTM C1036 - Standard Specification for Flat Glass
5. ASTM C1048 - Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass
6. ASTM E774 - Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units

1.3 SUBMITTALS

A. Samples of three each of the following:

1. Glass and safety plastic: 12 inches square, each material and type.
2. Cast glass blocks: One each type.
3. Glazing compound: One tube of each type.
4. Setting blocks and edge blocks.
5. Sealant: Cured color samples.
6. Gasket material: 12 inches long.

B. Product Data: Submit manufacturer’s product data for each of the glass types indicated. Include product description and performance criteria.

C. Certification: When glass is not cut to size by manufacturer and is furnished unlabeled from local stock, submit certification stating quality, thickness, type, and manufacturer of glass furnished.

1.4 QUALITY ASSURANCE

A. High-Impact Laminated Safety Glass shall comply with the following Testing Standards:

1. ANSI Z97.1
2. ASTM C158
3. ASTM C1036

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the Worksite in original unopened containers clearly labeled with manufacturer’s name and brand designation, referenced specification number, type, class, and rating as applicable. Deliver glass with each light bearing manufacturer’s label showing strength, grade, thickness, type, quality, and safety marking. Do not remove labels from glass until it has been set and inspected.

B. Store products in approved dry area, protect from contact with soil, and from exposure to the elements. Keep products dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.6 JOB CONDITIONS

A. Environmental Requirements:

1. Do not install glass when the ambient temperature is below 40 deg. F or expected to fall below 40 deg. F, unless otherwise approved by the Contracting Officer.
2. Do not apply glazing materials to unprotected surfaces in wet weather or to surfaces on which ice, frost, water, or dampness is visible.

1.7 WARRANTY

A. In addition to General Provisions, Paragraph 21, "Warranty of Construction", provide warranty for a period of 5 years for all materials and workmanship.
PART 2 - PRODUCTS

2.1 GLASS

A. Sheet glass: ASTM C1036, glazing select quality; 1/4 inch thick minimum.

B. Float glass: ASTM C1036, glazing select quality; 1/4 inch thick minimum.

C. Safety glass:
   1. Tempered: ASTM C1048, kind FT, glazing select quality, clear or colored as shown.
   2. Chemically Strengthened Laminated: ASTM C1048, kind HS, glazing select quality, 0.050 inch thick polyvinyl butyl sheet factory-laminated between two pieces of tempered safety glass, with protective edgecoat, clear or colored as shown.

D. Chemically Strengthened Laminated Safety Glass for Windscreens: Laminated glass panels, nominally 3/8 inch thick comprised of a layer each of 1/4 inch and 1/8 inch thick clear chemically strengthened glass with an interlayer of 0.050 inch clear poly vinyl butyl (PVB) and protective edgecoat. The 1/4 inch thick side shall be installed as the outer layer unless directed otherwise. Laminated safety glass panels shall have a minimum Modulus of Rupture (MOR) of 30,000 pounds per square inch (PSI). Glass panels shall be factory cut and laminated to exact dimensions required prior to shipment and labeled with same designation indicated on shop drawings to facilitate placement. Field cutting of glass panels will not be permitted.

   1. Each panel (including samples) shall be permanently marked prior to shipment to indicate: name of glass manufacturer; production date (day/month/year); Modulus of Rupture (MOR). Glass markings shall be located in the lower left corner of the panel and shall be clearly visible and legible after installation of panels.

   E. Insulated Glass at Elevators: Preassembled units complying with ASTM E774, Class CBA; two 1/4 inch nominal thickness clear laminated glass sheets separated by a 1/2 inch dehydrated space filled with air for a 1 inch nominal overall thickness of the unit. Provide spandrel glass at outer sheet where indicated. Each light shall have a permanent marking in accordance with ANSI Z97.1. Align markings in same corner of unit placed to be visible after installation. Laminated glass shall have polyvinyl butyl sheet interlayer and comply with ANSI Z97.1 and ASTM C1172. With low-emissivity sputtered on No. 2 surface.

2.2 GLAZING ACCESSORIES

A. Sealant: Polyurethane: ASTM C920, Type I and II, Class A. Color to match framing system in which installed.

B. Sealant: Silicone: ASTM C920, Type II, Class A. Color: Black.

C. Glazing compound: ASTM C920, Type I. Color to match framing system in which installed.

D. Glazing tape: Preformed 100 percent solids, polyisobutylenebutyl, pressure sensitive, pre-shimmed with built-in spacer of synthetic rubber size as shown or required. Flame spread 20 and smoke density 10 when tested in accordance with ASTM E84. Minus 40 deg. F to plus 200 degrees F service temperature range. Density 1.40 plus or minus 0.05 grams/cc. Comply with AAMA requirements for static, dynamic water infiltration and structural testing. Color, as directed. Tremco 440 Pre-shimmed tape or equal.

E. Pressure sensitive tape: Vinyl electrical tape, 3-M or approved equal.

F. Neoprene gasket: Extruded closed-cell neoprene, ASTM C864, 55 durometer Shore A hardness, profile shown or required.

G. Setting blocks: Neoprene, 70-90 durometer, shore A hardness approximately full channel width, 4 inches long and high enough to afford correct cover and 3/8 inch edge clearance for the glass.

H. Edge blocks (Spacers): Neoprene 40-50 durometer, shore A hardness approximately full channel width, 3 inches long and providing 3/8 inch edge clearance for the glass.

I. Glazing Gasket:
   1. Preformed 100 percent solids, polyisobutylenebutyl, pressure sensitive, of synthetic rubber size as shown or required.
   2. Flame spread 20 and smoke density 10 when tested in accordance with ASTM E84.
   4. Density 1.40 plus or minus 0.05 grams/cc.
   5. Comply with AAMA requirements for static, dynamic water infiltration and structural testing.
   6. Color as directed.
   7. Tremco NA-9119F or NA-9120F, or approved equal.
J. **Dielectric screw shield:** Nylon expansion anchor, round head, sized to ensure snug fit in predrilled hole and to accommodate size of screw used.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

A. Verify dimensions before proceeding; obtain measurements at structure for work to be fitted to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.

B. Remove foreign substances from surfaces to receive glass and glazing accessories.

#### 3.2 INSTALLATION

A. Coordinate work of this section with installation of supporting substrates.

B. Size glass by measuring actual frames or sash. Sizes shown are approximate. Cut glass to form 3/8 inch bite on all sides.

C. Install glass or plastic using glazing gaskets or other glazing accessories as shown.

D. Set glass on setting blocks at each quarter point of sill with equal bearing for entire width of each panel. Accurately cutting glass to fit frames and provide smooth edges with no sharp or ragged surfaces.

E. Unless otherwise shown, set glass in metal interior frames and doors or by back face glazing with glazing compound; tape to prevent rattling. Reset glazing beads, if necessary, without marring or injuring finish.

F. Perform tape glazing of metal sash or frame after metal is cleaned of foreign material, including dust, dirt, grease, and moisture. Clean glass surfaces and wipe dry.

G. Place tape approximately 1/16 inch below sight line on fixed stops and apply around entire perimeter of opening. Cut tape with sharp shears. Do not overlap butt corners. Place spacer or centering shims, 3 inches in length, 3/16 inch in height and 3/32 inch in thickness, every 18 inches under tape. Hold spacers in position by gently placing them in contact with under edge of tape. Position setting blocks for installation of glass. Use setting blocks 1/4 inch in height.

H. Align glass carefully to opening and press glass firmly in place. Apply removable stops and repeat application of spacers of centering shims. Ensure that they are seated as deeply as possible in channel. Fill interior opening in conventional manner with glazing compound.

I. Set glass in exterior metal windows and doors with neoprene setting blocks at 1/4 points and neoprene spacers 2 inches long placed 18 inches on center, and glaze with sealants.

J. Install glass and glazing accessories in accordance with manufacturer's recommendations. Neatly apply sealants, compounds, and tapes in straight lines parallel with glazing rebates and as shown.

K. Perform direct glazing in dry weather, 40 deg. F or warmer.

L. Tape edges of laminated safety glass with pressure-sensitive tape, if sealant or glazing tape is incompatible with inner layer. Do not expose edges of laminated glass to solvents, cleaners or prolonged contact with water.

M. Set lead shim rings on lips at bottom of openings and blocks. Set glass blocks to bring flat face level with the top of frame, centered in openings. Use spacers to maintain blocks in position while filling the annular space with sealant as shown.

#### 3.3 INSTALLATION OF ELEVATOR HOISTWAYS

A. Install glazing at elevator hoistways as shown and in accordance with applicable requirements for glass and glazing.

B. Size screw holes for dielectric screw shields to permit installation so as to prevent metal-to-metal contact between screws and frame.

C. Apply sealant around entire frame, inside and outside, and at other areas where metals are joined resulting in unfilled space.

#### 3.4 FIELD QUALITY CONTROL

A. **Hose Tests:**

   1. Upon completion of glazing and sealing, perform hose test against exterior glazing, and framing members in the presence of the Contracting Officer.

   2. Use 3/8 inch minimum diameter hose operated at approximately 50 psi pressure, and a flow rate of not less than 25 gallons per minute for a duration time of 15 minutes. Hold hose at maximum distance of 15 feet from glazing to produce a circle of impact of not less than 5 feet, nor more than 6 feet in diameter, directed at glazing seals, framing members and joints. Repair leaks as soon as surfaces are dry; retest until approved.

B. **Breakage:** Prior to final acceptance, replace damaged glass.
C. Dielectric Testing:

1. After installation at elevator hoistways, test for electrical isolation between screws and hoistway metal, using ohmmeter.

2. Resistance requirement: 10,000 ohms.

3. Replace screws and shields that do not meet resistance requirements and retest as for initial installation. Repeat as necessary until all screws meet resistance requirement.

3.5 CLEAN-UP

A. At completion of work, remove labels, clean glass, and remove excess glazing compound and sealant from frames and surrounding finish work.

B. Remove from the Worksite rubbish and debris resulting from work of this section.

C. Leave areas surrounding work in broom-clean condition.

3.6 GLASS SCHEDULE

A. GL-1: 3/8 inch thick chemically strengthened laminated safety glass; clear.

B. GL-2: 1 inch thick insulating glass unit; both lights laminated, tinted and color to match Contracting Officer’s sample as shown.

C. GL-3: 1/4 inch thick float glass, clear.

D. GL-4: 9/16 inch thick laminated safety glass, clear.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis per location indicated wherein no measurement will be made.

END OF SECTION 08800
PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes decorative plastic glazing, including supplementary items necessary to complete their installation.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
   4. ASTM D2843 - Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics

1.3 SUBMITTALS

A. Product Data: Indicate product description, fabrication information, compliance with specified performance requirements.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Samples for Initial Selection: Submit minimum 6 inch by 6 inch samples. Indicate full color and pattern variation.

D. Samples for Verification: Submit minimum 18 inch by 18 inch sample for each type, texture, pattern and color of solid polymer.

E. Maintenance Data: Submit manufacturer’s care and maintenance data, including care, repair and cleaning instructions. Include in Project close-out documents.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Provide original fire test reports to ensure compliance with the following requirements:
   1. Rate of Burning (ASTM D635): Class CC1 for a nominal thickness of 1.5 mm (0.060 in.)
   2. Self-Ignition Temperature (ASTM D1929): Greater than 650 deg F
   3. Density of Smoke (ASTM D2843): Less than 75 percent
   4. Flammability Classification (ASTM E84): Smoke less than 450, flamespread less than 75.

B. Impact Resistance: Provide decorative plastic glazing that comply with the following requirements:
   1. Impact Strength, Un-notched (23 degrees) (ASTM D4812): No breakage
   2. Impact Strength, Notched (23 degrees) (ASTM D256): 88J/m (1/16)

C. Allowable Tolerances:
   1. Maximum deflection: 1/16 inch over 12 inches.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Do not deliver decorative plastic glazing, system components and accessories to Project site until areas are ready for installation.

B. Handle materials to prevent damage to finished surfaces. Provide protective coverings to prevent damage or staining following installation for duration of project.

C. Before installing decorative plastic glazing, permit them to reach site temperature.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
   1. 3-Form, Inc., Varia™
2. Or approved equal

2.2 MATERIALS

A. EcoResin™ Resin Sheet
   1. Engineered polyester resin, Glycol modified.
   2. Sheet Size: Maximum 4 feet x 10 feet
   3. Thickness: Minimum 1/16 inch

B. Interlayer Materials: Compatible with Polyester and bonding process to create a monolithic sheet of material when complete.

2.3 SELECTION

A. Product: Varia Collection, Custom Encapsulated Print
B. Gauge: 1/2 inch (two 1/4 inch layers).
C. Surface Finish: Stucco
D. UV Protection: Required
E. Edge Seal: Not required
F. Orientation: Vertical

2.4 FABRICATION

A. General: Fabricate decorative plastic glazing to designs, sizes and thicknesses indicated and to comply with indicated standards. Sizes, profiles and other characteristics are indicated on the drawings.
B. Arrange panels in shop or other suitable space in proposed sequence for examination by Artist. Mark units with temporary sequence numbers to indicate position in proposed layout.
   1. Lay out one elevation at a time if approved by Artist.
   2. Notify Artist seven days in advance of the date and time when layout will be available for viewing.
   3. Provide lighting of similar type and level as that of final installation for viewing layout, unless otherwise approved by Artist.
   4. Rearrange panels as directed by Artist until layout is approved.
   5. Obtain Artist's approval of layout before start of assembly. Mark units and Shop Drawings with assembly sequence numbers based on approved layout.
C. Comply with manufacturer's written recommendations for fabrication.
D. Machining: Acceptable means of machining are listed below. Ensure that material is not chipped or warped by machining operations.
   1. Sawing: Select equipment and blades suitable for type of cut required.
   2. Drilling: Drills specifically designed for use with plastic products.
   4. Routing
   5. Tapping
   6. Shearing and Punching: Acceptable only on 1/16 inch material.
   7. Die Cutting: Acceptable only on material 1/8 inch or less.
E. Forming: Form products to shapes indicated using the appropriate method listed below. Comply with manufacturer's written instructions.
   1. Cold Bending
   2. Hot Bending
   3. Thermoforming: Acceptable only on uncoated material.
   4. Drape Forming
   5. Matched Mold Forming
   6. Mechanical Forming
F. Laminating: Laminate to substrates indicated using adhesives and techniques recommended by manufacturer.

2.5 MISCELLANEOUS MATERIALS

A. General: Provide products of material, size, and shape required for application indicated, and with a proven record of compatibility with surfaces contacted in installation.
B. Cleaner: Type recommended by manufacturer.
C. Fasteners: Use screws designed specifically for plastics. Self-threading screws are acceptable for permanent installations.
D. Bonding Cements: Solvent or adhesives, suitable for use with product and application.

E. Drilled Panel Wall Anchors: Décor Cable, FMSPVC Wall Anchor or approved equal. Provide extensions to accommodate thicknesses scheduled or illustrated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions where installation of decorative plastic glazing will occur, with Installer present, for compliance with manufacturer’s requirements. Verify that substrates and conditions are satisfactory for installation and comply with requirements specified.

3.2 INSTALLATION

A. General: Comply with manufacturer’s written instructions for the installation of decorative plastic glazing.

B. Shop fabricate items to the greatest degree possible.

C. Utilize fasteners, adhesives and bonding agents recommended by manufacturer for type of installation indicated. Material that is chipped, warped, hazed or discolored as a result of installation or fabrication methods will be rejected.

D. Install components plumb, level and rigid, scribed to adjacent finishes, in accordance with approved shop drawings and product data.

E. Form field joints using manufacturer’s recommended procedures. Locate seams in panels so that they are not directly in line with seams in substrates.

3.3 PROTECTION AND CLEANING

A. Protect decorative plastic glazing from contact with contaminating substances from construction operations. If, despite such protection, contaminating substances do come into contact with decorative plastic glazing, remove immediately and wash by method recommended by decorative plastic glazing manufacturer.

B. Remove and replace decorative plastic glazing that is broken, chipped, cracked, abraded, or damaged in other ways during construction period, including natural causes, accidents, and vandalism.

C. Wash plastic glazing on both faces before date scheduled for inspections intended to establish date of Substantial Completion in each area of Project. Wash plastic glazing by method recommended by decorative plastic glazing manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for decorative plastic glazing per location indicated wherein no measurement will be made.
SECTION 08913
GLAZED ALUMINUM ELEVATOR ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes glazed aluminum elevator enclosures and supplementary items necessary to complete their installation.

B. Windscreens are specified in Section 08413, "Aluminum-Framed Windscreens".

1.2 REFERENCE STANDARDS

A. American Architectural Manufacturers Association (AAMA):

1. AAMA 501 - Methods of Test for Exterior Walls

2. AAMA 611 - Voluntary Standards for Anodized Architectural Aluminum

3. AAMA 2605 - Voluntary Specifications, Performance Requirements and Test Procedures for Superior Performing Organic Coatings and Aluminum Extrusions and Panels

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel

2. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

3. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

4. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

5. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate


8. ASTM C719 - Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants under Cyclic Movement (Hockman Cycle)


10. ASTM C1184 - Standard Specification for Structural Silicone Sealants


12. ASTM E283 - Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen


C. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

1. SSPC Paint 12 - Cold-Applied Asphalt Mastic (Extra Thick Film)

1.3 PERFORMANCE REQUIREMENTS

A. General: Provide glazed aluminum curtain-wall systems, including anchorage, capable of withstanding, without failure, the effects of the following:

1. Structural loads.

2. Movements of supporting structure indicated on Drawings including, but not limited to, story drift, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.

3. Dimensional tolerances of building frame and other adjacent construction.
4. Failure includes the following:
   a. Deflection exceeding specified limits.
   b. Thermal stresses transferred to building structure.
   c. Framing members transferring stresses, including those caused by thermal and structural movements, to glazing.
   d. Noise or vibration created by wind and thermal and structural movements.
   e. Loosening or weakening of fasteners, attachments, and other components.
   f. Sealant failure.

G. Structural Sealant: Provide structural sealant capable of withstanding tensile and shear stresses imposed by curtain-wall systems without failing adhesively or cohesively. Provide sealant that fails cohesively before sealant releases from substrate when tested for adhesive compatibility with each substrate and joint condition required.

   1. Adhesive failure occurs when sealant pulls away from substrate cleanly, leaving no sealant material behind.
   2. Cohesive failure occurs when sealant breaks or tears within itself but does not separate from each substrate because sealant-to-substrate bond strength exceeds sealant’s internal strength.
   3. Design structural-sealant joints to produce tensile or shear stress in structural-sealant joints of less than 20 psi.

1.4 SUBMITTALS

A. Product Data: For each product indicated.

B. Shop Drawings: Prepared by or under the supervision of a qualified professional engineer licensed in State of Texas detailing fabrication and assembly of glazed aluminum curtain-wall systems.

   1. Include structural analysis data signed and sealed by the qualified professional engineer licensed in State of Texas responsible for their preparation.

C. Samples: For each exposed finish.

D. Product test reports.

E. Structural Sealant Test Reports: Compatibility and adhesion test reports from sealant manufacturer indicating that materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with sealants; include sealant manufacturer’s interpretation of test results for sealant performance and recommendations for primers and substrate preparation needed to obtain adhesion.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Acceptable to manufacturer and capable of preparing data for glazed aluminum curtain-wall systems including Shop Drawings based on testing and engineering analysis of manufacturer’s standard units in assemblies similar to those indicated for this Project.
B. Preinstallation Conference: Conduct conference at Project site.

C. Structural Sealant Testing: Perform sealant manufacturer's standard tests for compatibility and adhesion of sealants with each material that will come in contact with sealants and each condition required by curtain-wall systems.

1. Test a minimum of five samples of each metal, glazing, and other material.
2. Prepare samples using techniques and primers required for installed systems.
3. Perform tests under environmental conditions that duplicate those under which systems will be installed.
4. For materials that fail tests, determine corrective measures required to prepare each material to ensure compatibility with and adhesion of sealants.
5. After performing corrective measures on the minimum number of samples required for each material, retest materials.

1.6 WARRANTY

A. Finish Warranty on fluoropolymer finish: Manufacturer's standard form in which manufacturer agrees to repair or replace components on which finishes fail within specified warranty period. Warranty does not include normal weathering.

1. Warranty Period: 20 years from date of Final Acceptance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are “acceptable” only if manufacturer can evidence product compliance with requirements of Contract Documents.

2. Kawneer Company, Inc.
3. Tubelite Inc.
4. United States Aluminum Corp.
5. Vistawall Architectural Products.
6. Or approved equal.

2.2 FRAMING SYSTEMS

A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.

2. Extruded Bars, Rods, Shapes, and Tubes: ASTM B221.

B. Steel Reinforcement: With manufacturer's standard corrosion-resistant primer.

1. Structural Shapes, Plates, and Bars: ASTM A36/A36M.
2. Cold-Rolled Sheet and Strip: ASTM A1008/A1008M.
3. Hot-Rolled Sheet and Strip: ASTM A1011/A1011M.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

D. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.

1. Where fasteners are subject to loosening or turn out from thermal and structural movements, wind loads, or vibration, use self-locking devices.
2. Reinforce members as required to receive fastener threads.
3. At movement joints, use slip-joint linings, spacers, and sleeves of material and type recommended by manufacturer.

E. Anchors: Three-way adjustable anchors that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.

F. Concealed Flashing: Dead-soft, 0.018-inch thick stainless steel, ASTM A240/A240M of type recommended by manufacturer.

G. Framing Gaskets: As recommended by manufacturer for joint type.

H. Framing Sealants: As recommended by manufacturer for joint type.
2.3 GLAZING SYSTEMS

A. Glazing: As specified in Section 08800, "Glass and Glazing."

B. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.

C. Structural Glazing Sealants: As recommended by manufacturer for joint type and as follows:

   1. Structural Sealant: ASTM C1184, neutral-curing silicone formulation compatible with system components with which it comes in contact, specifically formulated and tested for use as structural sealant, and approved by structural-sealant manufacturer for use in curtain-wall systems indicated.
      a. Color: Black unless otherwise indicated.
      b. Type: Manufacturer's standard single component.
      c. Minimum Tensile Strength: 100 psi.
      d. Modulus of Elasticity: As required by structural-sealant-glazed curtain-wall system design to meet performance requirements.

   2. Weatherseal Sealant: ASTM C920 for Type S, Grade NS, Class 25, neutral-curing silicone formulation compatible with structural sealant and other system components with which it comes in contact; and recommended by structural- and weatherseal-sealant manufacturers for this use.
      a. Joint Movement Capability: Accommodates a 50 percent increase or decrease in joint width at time of application when measured according to ASTM C719.
      b. Color: Matching structural sealant.

2.4 ACCESSORY MATERIALS

A. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC Paint 12 requirements except containing no asbestos, formulated for 30-mil thickness per coat.

2.5 FABRICATION

A. Form aluminum shapes before finishing.

B. Fabricate components that, when assembled, have the following characteristics:

   1. Sharp profiles, straight and free of defects or deformations.
   2. Accurately fitted joints with ends coped or mitered.
   3. Internal guttering systems or other means to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.
   4. Physical and thermal isolation of glazing from framing members.
   5. Accommodations for thermal and mechanical movements of glazing and framing to prevent glazing-to-glazing contact and to maintain required glazing edge clearances.

C. Factory-Assembled Frame Units:

   1. Rigidly secure nonmovement joints.
   2. Seal joints watertight, unless otherwise indicated.
   3. Pressure equalize system at its interior face.
   4. Install glazing to comply with requirements in Section 08800, "Glass and Glazing."

D. After fabrication, clearly mark components to identify their locations in Project according to Shop Drawings.

2.6 ALUMINUM FINISHES

A. General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

C. Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.

D. High-Performance Organic Finish (2-Coat Fluoropolymer): AA-C12C40R1x (Chemical Finish:
cleaned with inhibited chemicals; Chemical Finish: conversion coating; Organic Coating: manufacturer's standard 2-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with AAMA 2605 and with coating and resin manufacturers' written instructions.

1. Color and Glass: As scheduled on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Fit joints to produce hairline joints free of burrs and distortion.
2. Rigidly secure nonmovement joints.
3. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
4. Seal joints watertight, unless otherwise indicated.

B. Metal Protection:

1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or by applying sealant or tape or installing nonconductive spacers as recommended by manufacturer for this purpose.
2. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.

D. Install components plumb and true in alignment with established lines and grades.

E. Install glazing as specified Section 08800, "Glass and Glazing."

F. Structural Sealant Glazing: Prepare surfaces that will contact structural sealant according to sealant manufacturer's written instructions to ensure compatibility and adhesion.

1. Preparation includes, but is not limited to, cleaning and priming surfaces.
2. Install weatherseal sealant according to sealant manufacturer's written instructions to produce weatherproof joints.
3. Install joint filler behind sealant as recommended by sealant manufacturer.

G. Install sealants as specified in Section 07900 "Seal and Sealants."

H. Erection Tolerances: Install glazed aluminum curtain-wall systems to comply with the following maximum tolerances:

1. Plumb: 1/8 inch in 10 feet.
2. Level: 1/8 inch in 20 feet.
3. Alignment:
   a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch wide, limit offset from true alignment to 1/16 inch.
   b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch wide, limit offset from true alignment to 1/8 inch.
   c. Where surfaces are separated by reveal or protruding element of 1 inch wide or greater, limit offset from true alignment to 1/4 inch.

4. Location: Limit variation from plane to 1/8 inch in 12 feet; 1/2 inch over total length.

3.2 FIELD QUALITY CONTROL

A. Water Spray Test: After the installation of minimum area of 75-feet-by-2-story glazed aluminum curtain-wall system has been completed but before installation of interior finishes has begun, test a 2-bay area of system designated by Architect according to AAMA 501.2.

1. Repair or remove work where test results indicate water penetration of systems.
2. Perform additional testing to determine resistance to water penetration of replaced or additional work.
B. Structural Sealant Compatibility and Adhesion:
Structural sealant shall be tested, inspected and evaluated according to recommendations in ASTM C1401.

1. Destructive test method, Method A, Hand Pull Tab (Destructive) in ASTM C1401, Appendix X2 shall be used.

2. A minimum of two areas on each elevator enclosure shall be tested.

3. Repair installation areas damaged by testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for glazed aluminum elevator enclosures per location indicated wherein no measurement will be made.

END OF SECTION 08913
PART 1 - GENERAL

1.1 DESCRIPTION
A. Work required for this section includes gypsum sheathing attached to steel framing members in exterior walls (behind exterior finish) and supplementary items necessary to complete their installation.
B. Refer to Section 06100, “Rough Carpentry” for other types of sheathing boards.
C. Refer to Section 07150, "Dampproofing" for air or vapor retarders applied over sheathing.

1.2 DEFINITIONS
A. Gypsum Board Construction Terminology Standard: Refer to ASTM C11 for definitions of terms for gypsum sheathing board construction not defined in this Section or in other referenced standards.

1.3 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus
   2. ASTM C11 - Standard Terminology Relating to Gypsum and Related Building Materials and Systems
   3. ASTM C954 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs From 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness
   4. ASTM C1002 - Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs
   5. ASTM C1396/C1396M – Standard Specification for Gypsum Board
B. Gypsum Association (GA):
   1. GA-253 - Application of Gypsum Sheathing
   2. GA-600 - Fire Resistance Design Manual Sound Control

1.4 SUBMITTALS
A. Product Data: For each type of gypsum sheathing and accessory material specified.
B. Samples: 6 inch square of gypsum sheathing.

1.5 QUALITY ASSURANCE
A. Fire-Resistance-Rated Assemblies: Where gypsum sheathing boards are part of fire-resistance-rated assemblies, provide assemblies as follows:
   1. Assemblies comply with requirements of fire-response-tested assemblies indicated by GA File Numbers in GA-600, or by design designations in UL's "Fire Resistance Directory" or in certification listings of another testing and inspecting agency acceptable to authorities having jurisdiction.
   2. Fire-resistance ratings were determined by fire-response testing assemblies according to ASTM E119.

1.6 COORDINATION
A. Coordinate sheathing installation with exterior cladding installation to comply with following requirements unless otherwise recommended by sheathing manufacturer:
   1. Do not leave paper-surfaced gypsum sheathing board exposed to weather for more than 30 days.
   2. Do not leave paper-surfaced gypsum sheathing board exposed to weather for more than 30 days or for more than 180 days if protected with dampproofing barrier.

PART 2 - PRODUCTS

2.1 GYPSUM SHEATHING
A. Paper-Surfaced Gypsum Sheathing Board: ASTM C1396/C1396M with water-resistant material incorporated into the gypsum core and with water-repellent paper bonded to the core's face, back, and long edges.
   1. Fire-rated board: Type X, 5/8 inch thick, 48 x 96 inches, square edge and ends.

2.2 ACCESSORY MATERIALS
A. Fasteners: Steel drill screws, in length recommended by sheathing manufacturer for thickness of sheathing board to be attached, with organic-polymer or other corrosion-protective
coating having a salt-spray resistance of more than 800 hours according to ASTM B117, and as follows:

1. ASTM C1002 when attaching sheathing to steel framing less than 0.0329 inch thick.

2. ASTM C954 when attaching sheathing to steel framing from 0.033 to 0.112 inch thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive gypsum sheathing and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

3.2 INSTALLATION

A. General: Install gypsum sheathing to comply with GA-253 and manufacturer's written instructions.

B. Cut boards at penetrations, edges, and other obstructions of the work; fit tightly against abutting construction, except provide a 3/8 inch setback where sheathing abuts structural elements or materials that may retain moisture.

C. Coordinate sheathing installation with flashing and joint sealant installation so these materials are installed in the sequence and manner that prevent exterior moisture from passing through completed exterior wall assembly.

D. Apply fasteners so screw heads bear tightly against face of sheathing boards but do not cut into facing.

E. Do not bridge building expansion joints with sheathing; cut and space edges to match spacing of structural support elements.

F. Vertical Installation: Install 48 inch wide gypsum sheathing boards vertically with vertical edges centered over flanges of steel studs. Abut ends and edges of each board with those of adjacent boards. Screw-attach boards at perimeter and within field of board to each steel stud.

G. Space Fasteners approximately 8 inches o.c. and set back a minimum of 3/8 inch from edges and ends of boards.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for gypsum sheathing per location indicated wherein no measurement will be made.

END OF SECTION 09253
PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this section includes gypsum board wall and ceiling assemblies, finishing of gypsum board (taping and bedding) and supplementary items necessary to complete their installation.

B. Refer to Section 05415, “Cold-Formed Steel Stud Framing” for structural load-bearing steel stud framing.

C. Refer to Section 09253, “Gypsum Sheathing” for sheathing installations over exterior steel stud framing.

1.2 DEFINITIONS

A. Gypsum Board Construction Terminology: Refer to ASTM C 11 for definitions of terms for gypsum board assemblies not defined in this Section or in other referenced standards.

B. Accessories: Metal beads, trim, or molding used to protect or conceal corners, edges, or abutments of gypsum board construction.

C. Critical Lighting:

1. Strong sidelighting from windows or surface-mounted light fixtures. Synonym: Severe lighting.

2. Wall and ceiling areas abutting window mullions or skylights, long hallways, or atriums with large surface areas flooded with artificial or natural lighting are few examples of critical lighting areas.


E. Primer/Sealer:

1. Paint material formulated to fill pores and equalize suction difference between gypsum board surface paper and compound used on finished joints, angles, fastener heads, and accessories, and over skim coatings.

2. Specified in Section 09920, "Interior Painting".

F. Skim Coat: Thin coat of joint compound over entire surface to fill imperfections in joint work, smooth paper texture, and provide uniform surface for decorating.

G. Spotting: To cover fastener heads with joint compound.

H. Texture: Decorative treatment of gypsum board surfaces. Specified in Section 09920, "Interior Painting".

I. Texturing:

1. Regular or irregular patterns typically produced by applying mixture of joint compound and water, or proprietary texture materials including latex base texture paint, to gypsum board surface previously coated with primer/sealer. Specified in Section 09920, "Interior Painting".

1.3 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A641 – Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire

2. ASTM C11 - Standard Terminology Relating to Gypsum and Related Building Materials and Systems

3. ASTM C475 - Specification for Joint Compound and Joint Tape for Finishing Gypsum Board

4. ASTM C636 – Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels

5. ASTM C645 – Standard Specification for Non-Load Bearing (Axial) Steel Studs, Runners (Tracks), and Rigid Furring Channels for Screw Application of Gypsum Board


7. ASTM C754 - Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Board


9. ASTM C840 - Specification for Application and Finishing of Gypsum Board

10. ASTM C919 – Standard Practice for Use of Sealants in Acoustical Applications
11. ASTM C954 - Specification for Steel Drill Screws for the Application of Gypsum Board or Metal Plaster Bases to Steel Studs From 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness

12. ASTM C1002 - Specification for Steel Drill Screws for the Application of Gypsum Board or Metal Plaster Bases

13. ASTM C1047 - Specifications for Accessories for Gypsum Wallboard and Gypsum Veneer Base

14. ASTM C1396/C1396M - Standard Specification for Gypsum Board


17. ASTM E413 – Classification for Rating Sound Insulation


19. ASTM E497 - Practice for Installing Sound-Isolating Lightweight Partitions


B. Gypsum Association (GA):

1. GA 214 - Recommended Levels of Gypsum Board Finish

2. GA 216 - Application and Finishing of Gypsum Board

3. GA 600 - Fire Resistance Design Manual Sound Control

1.4 SUBMITTALS

A. Product Data: For each type of product indicated on Contract Drawings.

B. Shop Drawings: Show locations, fabrication, and installation of control and expansion joints including plans, elevations, sections, details of components, and attachments to other units of Work.

1.5 QUALITY ASSURANCE

A. Perform gypsum board systems work in accordance with recommendations of ASTM C754, ASTM C840 and GA 216 unless otherwise specified in this section.

B. Comply with requirements of GA 216 and ASTM C840.

C. Single-Source Responsibility for Finishing Materials: Obtain finishing materials from either same manufacturer that supplies gypsum board and other panel products or from manufacturer acceptable to gypsum board manufacturer.

D. Fire-Test-Response Characteristics: For gypsum board assemblies with fire-resistance ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing and inspecting agency acceptable to authorities having jurisdiction.


E. Sound Transmission Characteristics: For gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated according to ASTM E90 and classified according to ASTM E413 by a qualified independent testing agency.


1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.

B. Store materials inside under cover and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes. Stack gypsum panels flat to prevent sagging.

C. Handle gypsum board to prevent damage to edges, ends, and surfaces. Do not bend or otherwise damage metal corner beads and trim.

1.7 PROJECT CONDITIONS

A. Environmental Conditions: Establish and maintain environmental conditions for finishing gypsum board to comply with ASTM C840 and with gypsum board manufacturer's written recommendations, whichever are more stringent.
B. Ventilation: Ventilate building spaces, as required, for drying joint treatment materials. Avoid drafts during hot dry weather to prevent finishing materials from drying too rapidly.

PART 2 - PRODUCTS

2.1 STEEL FRAMING FOR SUSPENDED CEILINGS

A. General: Provide components of sizes indicated but not less than that required to comply with ASTM C754 for conditions indicated.

B. Tie Wire: ASTM A641, Class 1 zinc coating, soft temper, 0.0625 inch diameter wire, or double strand of 0.0475 inch diameter wire.

C. Hanger Attachments to Concrete: As follows:
   1. Anchors: Fabricated from corrosion-resistant materials with holes or loops for attaching hanger wires and capable of sustaining, without failure, a load equal to 5 times that imposed by construction as determined by testing according to ASTM E488 by a qualified independent testing agency.
      a. Cast-in-place anchor, designed for attachment to concrete forms.
      b. Post installed, chemical anchor.
      c. Post installed, expansion anchor.
   2. Powder-Actuated Fasteners: Suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other devices for attaching hangers of type indicated, and capable of sustaining, without failure, a load equal to 10 times that imposed by construction as determined by testing according to ASTM E1190 by a qualified independent testing agency.

D. Wire Hangers: ASTM A641, Class 1 zinc coating, soft temper, 0.162 inch diameter.

2.2 METAL FRAMING FOR WALLS AND PARTITIONS

A. General: Provide metal framing members of sizes and spacings indicated but not less than that required to comply with ASTM C754 under the following maximum deflection and lateral loading conditions:
   1. Maximum Deflection - Typical: L/240 at 5 lbf/sq. ft.
   2. Maximum Deflection - At Ceramic Tile Walls: L/120 at 5 lbf/sq. ft.

B. Metal Studs and Runners: ASTM C645, with flange edges of studs bent back 90 deg and doubled over to form 3/16 inch wide lip (return) and minimum thickness of base (uncoated) metal of 20 Gauge (0.0312 inch) unless otherwise indicated.

C. Deep-Leg Deflection Track: ASTM C645 top runner with 2 inch deep flanges.

D. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

E. Furring Channels: ASTM C645, hat-shaped, depth of 7/8 inch and minimum thickness of base (uncoated) metal of 0.0312 inch (20 gauge) unless otherwise indicated.

F. Fasteners for Metal Framing: Provide fasteners of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel framing and furring members securely to substrates involved; complying with the recommendations of
GYPSUM BOARD ASSEMBLIES

gypsum board manufacturers for applications indicated.

2.3 GYPSUM BOARD PRODUCTS

A. General: Provide gypsum board in maximum lengths available that will minimize end-to-end butt joints in each area indicated to receive gypsum board application.

B. Gypsum Wallboard: ASTM C1396/C1396M, Type X, tapered edges, 5/8 inch thick unless otherwise indicated.

C. Water-Resistant Gypsum Backing Board: ASTM C1396/C1396M, Type X, 5/8 inch thick, unless otherwise indicated.

2.4 TRIM ACCESSORIES

A. Standard Accessories: Corner beads, edge trim, and control joints complying with ASTM C1047 and requirements indicated below:


2. Shapes indicated below by reference to Fig. 1 designations in ASTM C1047:
   a. Cornerbead for outside corners.
   b. LC-bead with both face and back flanges; face flange formed to receive joint compound. Provide LC-beads for exposed edge trim.
   c. L-bead with face flange only; face flange formed to receive joint compound. Provide L-bead for non-exposed edge trim.
   d. One-piece control joint formed with V-shaped slot, with removable strip covering slot opening.
   e. Provide other trim or special shapes where indicated.

2.5 JOINT TREATMENT MATERIALS

A. Provide joint treatment materials complying with ASTM C 475 and recommendations of both manufacturers of sheet products and of joint treatment materials for each application indicated.

B. Joint Tape:
   2. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Wallboard: For each coat use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.

2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound or drying-type, all-purpose compound.
   a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.

4. Finish Coat: For third coat, use drying-type, all-purpose compound.

5. Skim Coat: For final coat of Level 5 finish, use drying-type, all-purpose compound.

2.6 ACOUSTICAL SEALANT

A. Acoustical Sealant for Exposed Joints: Non sag, paintable, non-staining latex sealant complying with ASTM C 834 that is effective in reducing airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies per ASTM E 90.

1. Acceptable Manufacturers and Products:
   a. Pecora Corp. - “AC-20 FTR Acoustical and Insulation Sealant”.
   b. United States Gypsum Co. - “SHEETROCK Acoustical Sealant”.
   c. Or approved equal.

B. Acoustical Sealant for Concealed Joints: Nondrying, non hardening, non skinning, non staining, gunnable, synthetic rubber sealant recommended for sealing interior concealed joints to reduce airborne sound transmission.

1. Acceptable Manufacturers and Products:
   a. Pecora Corp. - “BA-98”
   b. Tremco, Inc. - “Tremco Acoustical Sealant”
   c. Or approved equal.
2.7 MISCELLANEOUS MATERIALS

A. General: Provide auxiliary materials for gypsum board construction that comply with referenced standards and recommendations of gypsum board manufacturer.

B. Spot Grout: ASTM C475, setting-type joint compound recommended for spot grouting hollow metal door frames.

C. Steel drill screws complying with ASTM C1002 for fastening gypsum board to steel members less than 0.03 inch thick.

D. Steel drill screws complying with ASTM C954 for fastening gypsum board to steel members from 0.033 to 0.112 inch thick.

E. Sound Attenuation Blankets: Unfaced mineral-fiber blanket insulation produced by combining mineral fibers of glass or slag with thermosetting resins to comply with ASTM C665 for Type I (blankets without membrane facing), 3 inch thick unless otherwise indicated.

1. Comply with assembly mineral fiber requirements for fire-resistance rated assemblies.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates to which gypsum board assemblies attach or abut, with Installer present including hollow metal frames, cast-in-anchors, and structural framing for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Do not proceed with installation until unsatisfactory conditions have been corrected. Starting work within a particular area will be construed as applicator's acceptance of surface conditions.

3.2 PREPARATION

A. Suspended Ceilings: Coordinate installation of ceiling suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive ceiling hangers at spacing required to support ceilings and that hangers will develop their full strength.

1. Furnish concrete inserts and other devises indicated to other trades for installation in advance of time needed for coordination and construction.

3.3 INSTALLING METAL FRAMING, GENERAL

A. Installation Standard: Install steel framing to comply with ASTM C754 and ASTM C840 requirements that apply to framing installation.

B. Install supplementary framing, blocking, reinforcing, and bracing in gypsum board assemblies to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, handrails, furnishings, or similar construction. Comply with details and recommendations of gypsum board manufacturer.

C. Isolate metal framing from building structure to prevent transfer of loading imposed by structural movement.

1. Isolate ceiling assemblies where they abut or are penetrated by building structure.

2. Isolate partition framing and wall furring where it abuts structure, except at floor.

3. Install slip type joints at head assemblies that avoid axial loading of assembly and laterally support assembly.

4. Use firestop assembly where fire rated partitions are indicated.

5. Use proprietary deflection track or deep leg deflection track as detailed.

D. Do not bridge building expansion and control joints with steel framing or furring members. Frame both sides of joints independently with framing or furring members.

E. Ceiling System: Suspend ceiling hangers from building structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or ceiling suspension system. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with the location of hangers required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.

3. Secure wire hangers by looping and wire-tying, either directly to structures or to inserts, eye screws, or other devices and
fasteners that are secure and appropriate for substrate, and in a manner that will not cause them to deteriorate or otherwise fail.

4. Install steel framing components for suspended ceilings so that cross-furring members or grid suspension members are level to within 1/8 inch in 12 feet as measured both lengthwise on each member and transversely between parallel members.

5. Do not support ceilings directly from permanent metal forms. Fasten hangers to cast-in-place hanger inserts, or drilled-in anchors that extend through forms into concrete. Do not attach hangers to steel deck tabs.

7. Do not attach hangers to steel roof deck. Attach hangers to structural members.

8. Do not connect or suspend steel framing from ducts, pipes or conduit.

9. Do not install hangers to prevent access doors from being correctly operated.

3.4 CEILING GRID SUSPENSION SYSTEM

A. Install suspension system in accordance with ASTM C636. Lay out spaces and arrange suspension system in a regular pattern, parallel or perpendicular to surrounding walls.

B. Attach perimeter wall track or angle where grid suspension system meets vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

C. Main Beams:

1. Suspend main beams spaced 48 inches on center from structure with wire hangers spaced 48 inches on center.

2. Install main beams level within 1/8 inch in 12 feet with hanger wire taut and tightly wrapped to prevent vertical movement or rotation.

3. Do not make local kinks or bends in hanger wires as a means of leveling.

D. Cross Tees:

1. Install cross tees at right angles to main beams, space at 24 inches on center and join to main beams with positive interlock.

2. Install cross tees to within 1/32 inch of their required location and within 0.015 inch of the same horizontal plane as main beam, and never below continuous member.

3. Install cross tees at right angles to beams and cross tees to support ends of recessed light fixtures, diffusers or grilles.

E. Angle Moldings: Lay ends of main beams and cross tees on angle moldings at vertical surfaces.

F. Concentrated Load Conditions: Provide additional hanger wires at each corner of recessed light troffers and other concentrated load conditions to prevent excess deflection.

3.5 METAL STUD PARTITION FRAMING

A. Install runners (tracks) at floors, ceilings, and structural walls and columns where gypsum board stud assemblies abut other construction.

B. Installation Tolerances: Install each metal stud steel framing and furring member so that fastening surfaces do not vary more than 1/8 inch from the plane formed by the faces of framing members.

C. Extend partition framing full height to structural supports or substrates above suspended ceilings, except where partitions are indicated to terminate at suspended ceilings. Continue framing over framing for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.

1. Cut studs 3/4 inch short of full height to provide perimeter relief.

2. For STC-rated, smoke-rated and fire-resistive-rated partitions that extend to the underside of floor/roof slabs and decks or other continuous solid structural surfaces to obtain ratings, install framing around structural and other members extending below floor/roof slabs and decks, as needed, to support gypsum board closures and make partitions continuous from floor to underside of solid structure.

D. Space studs at 16 inches on center unless otherwise indicated. Install studs so that flanges point in the same direction. Lap studs a minimum of 8 inches where splicing is necessary and secure with screws.
E. At partition intersections and corners, locate studs no more than 2 inch from partition intersections and corners and secure with screws through both flanges of studs and tracks.

F. Chase Wall: Install framing as follows:
1. Position double row of metal studs vertically in runners, opposite each other in pairs with flanges pointing in the same direction.
2. Space studs 24 inches on centers unless otherwise indicated.
3. Attach with screws through each stud flange and runner flange.
4. Cross brace between rows of studs with 5/8 inch wallboard, 12 inches by chase width, or with metal studs.
5. Screw-attach to stud webs at 48 inches on center maximum in partition height with minimum of three screws per web.

G. Furred Wall: Install framing as follows:
1. Erect furring channels vertically, spaced 24 inches on centers.
2. Attach to surface with concrete nails spaced 24 inches on centers, staggered on flanges.
3. Splice ends by nesting channels 8 inches and securely anchoring to surface.
4. Miter 24 inches long horizontal furring channels at corners and space 24 inches on centers vertically.
5. Locate furring channels around perimeter of openings and secure to surfaces.

H. Door Openings: Frame door openings to comply with GA-600, and with applicable written recommendations of gypsum board manufacturer. Screw attach vertical studs at jambs to jamb anchor clips on door frames.
1. Install two metal studs on each side of doorframes.
2. Install runner track section (for cripple studs) at head and secure to jamb studs.
3. Install short intermediate studs 16 inches on center between ceiling runner and doorframe head runner.

3.6 APPLYING GYPSUM BOARD

A. Gypsum Board Application Standards: Install gypsum panels to comply with ASTM C840 and GA 216.

B. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

C. Single-Layer Partition Application: Apply gypsum panels vertically (parallel to framing), to minimize end joints unless otherwise indicated or required by fire-resistance-rated assembly.
1. Stagger abutting end joints not less than one framing member in alternate courses of board.
2. At stairwells and other high walls, install panels horizontally, unless otherwise indicated or required by fire-resistance-rated assembly.

D. Multilayer Partition Application: Apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.

E. Ceiling Application: Install ceiling board panels at right angles to framing to minimize the number of abutting end joints and avoid abutting end joints in the central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member. Install ceiling board panels before partition board application.

F. Install gypsum panels with face side out. Do not install imperfect, damaged, or damp panels. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.

G. Locate both edge or end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

H. Attach gypsum panels to metal studs so that the leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

I. Attach gypsum panels to framing provided at openings and cutouts. Install gypsum panel over door heads and extend to one stud (16 inches) each side of door.

J. Spot grout hollow metal doorframes for solid core wood doors, hollow metal doors, and doors over 32 inches wide. Apply spot grout at each jamb anchor clip and immediately insert gypsum panels into frames.
K. Form control joints and expansion joints at locations indicated with space between edges of adjoining gypsum panels.

L. Cover both faces of metal stud partition framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chase walls that are braced internally.
   1. Fit gypsum panels around ducts, pipes, and conduits.
   2. Where partitions intersect open concrete coffers, concrete joists, and other structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by coffers, joists, and other structural members; allow 1/4 to 3/8 inch wide joints to install sealant.

M. Isolate perimeter of non-load-bearing gypsum board partitions at structural abutments, except floors. Provide 1/4 inch to 1/2 inch wide spaces at these locations and trim edges with edge trim where edges of gypsum panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

N. Seal construction at perimeters, behind control and expansion joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C919 and manufacturer's written recommendations for locating edge trim and closing off sound-flanking paths around or through gypsum board assemblies, including sealing partitions above acoustical ceilings.

O. Space fasteners in gypsum panels according to referenced gypsum board application and finishing standard and manufacturer's written recommendations.
   1. Attach gypsum board to metal supports with self-drilling screws.
   2. Drive screws to slightly dimple surface but not to break paper.
   3. Space screws as recommended by GA-216 for non-fire rated partitions and ceilings.
   4. Start field screwing near center and work towards edges.
   5. Space screws not less than 3/8 inch from gypsum board edges.
   6. Space screws for fire rated partitions as required by fire test.
   7. Do not attach gypsum board to top runner where partition extends to structure unless required by fire test.

P. Wall Tile Substrates: For substrates indicated to receive thin-set ceramic tile and similar rigid applied wall finishes, comply with the following:
   1. Install water-resistant gypsum backing board panels at walls to receive thin set tile and walls containing plumbing fixtures ("wet walls") and walls adjacent to plumbing fixtures.

3.7 INSTALLING TRIM ACCESSORIES

A. Fasten trim accessories according to accessory manufacturer's directions for type, length, and spacing of fasteners.

B. Install corner beads at external corners.

C. Install edge trim where gypsum board abuts dissimilar material and where edge of gypsum panels would otherwise be exposed.
   1. Install LC-bead where gypsum panels are tightly abutted to other construction and back flange can be attached to framing or supporting substrate.
   2. Install L-bead where edge trims can only be installed after gypsum panels are installed.

D. Install control joints as follows and in locations approved by Architect for visual effect.
   1. Not to exceed 24 feet in either direction for ceilings and partitions.
   2. Where gypsum board abuts any dissimilar wall or ceiling assembly.
   3. Where gypsum board construction changes within the same plane.
   4. Where framing system changes direction.
   5. Where gypsum board construction abuts an exterior wall.
   6. Where wall of different fire ratings abut or align in the same plane.
   7. Make joint 1/4 inch wide with supports non continuous over joint.

3.8 FINISHING GYPSUM BOARD ASSEMBLIES

A. Treat gypsum board joints, interior angles, flanges of corner bead, edge trim, and control joints; penetrations; fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration and levels of gypsum board finish indicated.

B. Prefill open joints, rounded or beveled edges, and damaged areas using setting-type joint compound.
C. Apply joint tape and compound over gypsum board to prevent cracks from developing in joint treatment at flange edges.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below, according to ASTM C840. Sand between coats and after last coat to produce a surface free of defects and ready for decoration.

1. Level 1: Embed tape at joints unless a higher level of finish is required for fire-resistance-rated assemblies.

2. Level 2: Embed tape and apply separate first coat of joint compound to tape, fasteners, and trim flanges.

3. Level 3: Embed tape and apply separate first and fill coats of joint compound to tape, fasteners, and trim flanges.

4. Level 4: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges.

5. Level 5: Embed tape and apply separate first, fill, and finish coats of joint compound to tape, fasteners, and trim flanges, and apply skim coat of joint compound over entire surface.

E. Schedule of Gypsum Board Finish: Provide following levels of gypsum board finish per ASTM C840 and GA 214.

1. Level 1: Plenum areas above ceilings.

2. Level 2: Moisture resistant gypsum board used as substrate for ceramic tile.

3. Level 3: Mechanical, electrical and elevator equipment rooms.

4. Level 4: Typical.

5. Level 5: Not used.

3.9 PROTECTION

A. Promptly remove any residual joint compound from adjacent surfaces.

B. Provide final protection and maintain conditions, in a manner suitable to Installer that ensures gypsum board assemblies remain without damage or deterioration at time of Substantial Completion.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for gypsum board assemblies per location indicated wherein no measurement will be made.

END OF SECTION 09260
1.1 DESCRIPTION

A. This Section includes specifications for exposed-grid suspended acoustical ceilings, including metal suspension system and acoustical panels, as indicated.

B. Coordinate the work of this Section with the work under Division 15 - Mechanical for above-ceiling ductwork and for ceiling-mounted air diffusers.

C. Coordinate the work of this Section with the work under Division 16 - Electrical for above-ceiling electrical conduits and raceways and for ceiling-mounted lighting fixtures and speaker boxes.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A641/A641M - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
   3. ASTM C636 - Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
   5. ASTM E1264 - Standard Classification for Acoustical Ceiling Products

1.3 SUBMITTALS

A. Product Data: For each type of product specified.

B. Samples for Verification: Full-size units of each type of ceiling assembly indicated; in sets for each color, texture, and pattern specified, showing the full range of variations expected in these characteristics.
   1. 12 inch square samples of each acoustical panel type, pattern, and color.
   2. Set of 12 inch long samples of exposed suspension system members, including moldings, for each color and system type required.

C. Product Test Reports: Indicate compliance of acoustical panel ceilings and components with requirements based on comprehensive testing of current products.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has completed acoustical panel ceilings similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

B. Source Limitations: Obtain each acoustical ceiling panel and each suspension system from one source with resources to provide products of consistent quality in appearance and physical properties without delaying the Work.
   1. Obtain both acoustical ceiling panels and suspension system from the same manufacturer if both are offered by the manufacturer.

C. Fire-Test-Response Characteristics: Provide acoustical panel ceilings that comply with the following requirements:
   1. Fire-response tests were performed by UL or another independent testing and inspecting agency that is acceptable to authorities having jurisdiction and that perform testing and follow-up services.
   2. Surface-burning characteristics of acoustical panels comply with ASTM E1264 for Class A materials as determined by testing identical products per ASTM E84.
   3. Products identified with appropriate markings of applicable testing and inspection agency.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weatherproof, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1.6 COORDINATION

A. Coordinate layout and installation of acoustical panels and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC
ACOUSTICAL PANEL CEILINGS

equipment, fire-suppression system, and partition assemblies.

B. Center penetrations in panels including fire sprinkler heads, can lights, fire alarm devices.

1.7 EXTRA MATERIALS

A. Deliver to Contracting Officer, extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Acoustical Ceiling Units: Full-size units equal to 2.0 percent of amount installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acoustical Ceiling Panels.

1. ASTM E1264, Type III, Pattern D, high-density mineral-fiber lay-in panels, Class 25 NRC 60, LR1.

2. Size: 5/8 inch minimum thickness by 24 inches by 48 inches, with square edges.

3. Finish: Manufacturer’s standard factory-applied white paint finish, with light reflectance value of more than 75 percent.

4. Surface design: Fissured, unless noted otherwise.

5. Thermal conductance K-factor: 0.35.

B. Ceiling Suspension System:

1. Main and cross runners: ASTM C635, direct-hung, heavy-duty, interlocking double-web steel, matte white baked enamel finish. Width 15/16 inch.

2. Moldings: 1 inch by 1 inch steel angle, with smooth, matte white baked enamel finish, unless noted otherwise.

3. Attachment Devices: Size for five times design load indicated in ASTM C635, Table 1, Direct Hung, unless otherwise indicated.

4. Wire Hangers, Braces, and Ties: Provide wires complying with the following requirements:


b. Size: Select wire diameter so its stress at three times hanger design load (ASTM C 635, Table 1, Direct Hung) will be less than yield stress of wire, but provide not less than 0.106-inch diameter wire.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates surfaces to receive acoustical ceiling system and associated work and conditions under which work will be installed. Do not proceed with installation until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

3.2 PREPARATION

A. Coordination: Furnish layouts for cast-in-place anchors, clips, and other ceiling anchors. Furnish cast-in-place anchors and similar devices to other trades for installation well in advance of time needed for coordinating other work.

B. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans.

3.3 INSTALLATION

A. General: Install acoustical panel ceilings to comply with publications referenced below per manufacturer’s written instructions and CISCA’s “Ceiling Systems Handbook.”


B. Suspend ceiling hangers from building’s structural members and as follows

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.

2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support
standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.

4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure; that are appropriate for substrate; and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.

5. Do not support ceilings directly from permanent metal forms. Fasten hangers to cast-in-place hanger inserts, power-actuated fasteners, or drilled-in anchors that extend through forms into concrete.

6. Do not attach hangers to steel deck tabs.

7. Do not attach hangers to steel roof deck. Attach hangers to structural members.

8. Space hangers not more than 48 inches o.c. along each member supported directly from hangers, unless otherwise indicated; and provide hangers not more than 8 inches from ends of each member.

C. Install edge moldings and trim at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.

1. Screw attach moldings to substrate at intervals not more than 16 inches o.c. and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely.

2. Do not use exposed fasteners, including pop rivets, on moldings and trim.

3. Provide control joints where joints occur in abutting surfaces.

4. Hold tees in place with concealed clips.

D. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

1. Space steel main runners at 48 inches on center.

E. Install acoustical panels with undamaged edges and fitted accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.

1. Arrange directionally patterned acoustical panels with pattern running in one direction parallel to long axis of space.

2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension system runners and moldings.

3. Install hold-down clips in areas indicated, in areas required by authorities having jurisdiction, and for fire-resistance ratings; space as recommended by panel manufacturer's written instructions, unless otherwise indicated or required.

3.4 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for acoustical panel ceilings per location indicated wherein no measurement will be made.

END OF SECTION 09512
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes steel acoustical snap-in metal pans for ceilings.
B. For framing system above, see Section 05430, “Slotted Channel Framing”.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C636 - Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels

1.3 SUBMITTALS

A. Product Data: Manufacturer’s published literature, including specifications.
B. Shop Drawings; showing:
   1. Reflected Ceiling Plan(s): Indicating metal ceiling tile layout, ceiling mounted items, and penetration locations.
   2. Suspension System and Component Layout.
   3. Details of system assembly and connections to building components.
C. Samples; submit:
   1. Ceiling tile: Minimum 8 inch piece of each type and finish.
   2. Suspension system components and moldings/trim.
   3. Acoustical material sample.
D. Quality Assurance / Control Submittals:
   1. Test Reports: Certified reports from independent agency substantiating structural compliance to governing requirements.
   2. Certificates:
      a. Data substantiating manufacturer and installer qualifications.
      b. Certified data attesting fire rated materials comply with specifications.

1.4 QUALITY ASSURANCE

A. Manufacturer/Installer Qualifications:
   1. Provide tile components produced by a single manufacturer with resources to provide consistent quality in appearance and physical properties, without delaying the work.
   2. Provide suspension system components produced by a single manufacturer to provide compatible components for a complete metal tile ceiling system installation.
   3. Perform installations using a firm with installers having no less than 3 years of successful experience on projects of similar size and requirements.
B. Regulatory Requirements:
   1. Fire Rating Performance Characteristics: Install system to provide a flame spread of 0 - 25, complying with certified testing to ASTM E84.
   2. Structural Criteria: Install and certify system to comply with structural and wind uplift requirements of governing codes.
C. Mock-Up: Prior to beginning installation erect a mock-up section, where directed, using all system components.
D. Pre-installation Conference: Conduct a conference, prior to start of installation, to review system requirements, shop drawings, and all coordination needs.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver system components in manufacturer’s original unopened packages, clearly labeled.
B. Store components in fully enclosed dry space. Carefully place on skids to prevent damage from moisture and other construction activities.
C. Handle components to prevent damage to surfaces and edges, and to prevent distortion and other physical damage.
ACOUSTICAL SNAP-IN METAL PAN CEILINGS

1.6 COORDINATION
A. Coordinate layout and installation of acoustical snap-in metal pans and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1.7 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Acoustical Snap-in Metal Pans: Full-size units equal to 2.0 percent of quantity installed.
   2. Suspension System Components: Quantity of each concealed grid and exposed molding and trim equal to 2.0 percent of quantity installed.

PART 2 - PRODUCTS

2.1 MANUFACTURER

2.2 SYSTEM MATERIALS
A. Metal Tile Ceiling System for exterior installations:
   1. Tile:
      a. Profile: Square edged.
      b. Size: 24 inches x 24 inches.
      c. Material / thickness: 0.040 inch aluminum.
      d. Tile Type: Snap-In tile formed with two sides raised and dimpled for secure engagement into runners.
   2. Snap-in Suspension System:
      a. Structural Classification: Heavy duty.
      b. Primary runners: 1-1/2 inches deep, 16 Ga., galvanized steel “C” channels.
      c. Hanger wire: 12 Ga. pre-stretched galvanized steel.
      d. Secondary runners: 24 Ga. galvanized steel, 1-1/2 inches (38 mm) deep inverted V shaped profile providing interlocking snap-in capability.
      e. Clamps: Manufacturer’s standard die-formed primary/secondary runner connector two-piece clamps.
   B. Wind Uplift Compression Struts: 1-1/2 inch deep, 16 Ga., cold rolled steel “C” channels.
   C. Perforations: Provide metal tile with nominal 1/4 inch solid border and perforation pattern 103, 20 percent open.
   D. Color and Finish: Cotton White baked-on polyester enamel.

2.3 ACCESSORY MATERIALS
A. Suspension System Carrier/Channel Splices: Manufacturer’s standard splices with matching profile and attachment holes.
B. Wall Moldings / Trim: Box mold design.
C. Clips: Manufacturer’s standard hold-down and security clips.
D. Access Panels: Manufacturer’s standard hinged style at locations indicated.
E. Acoustic Material: 1 inch thick glass fiber, 1-1/2 pcf density, enclosed in black polyethylene of sizes to completely fill ceiling panel.
F. Custom Panels and Trim Pieces: Fabricate panels for dropped soffit returns and similar conditions from materials and finishes to match selected ceiling tile.
G. Plenum Access Tool: Manufacturer’s standard for removing snap-in type panels.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine areas receiving metal tile ceiling system for conditions that might adversely affect installation.
B. Verify that all work above ceiling system has been satisfactorily completed prior to start of ceiling installations.
C. Do not start ceiling installations until all unsatisfactory conditions affecting ceiling systems have been corrected.

3.2 PREPARATION
A. Provide layouts for inserts, clips and other support items required to be installed by other trades. Furnish inserts, clips and related items to other trades in a timely manner to preclude construction delays.
B. Coordinate with other trades for proper installation of inserts and related items.

C. Verify ceiling layouts by actual field measurements.
   1. Establish ceiling layout to balance borders and minimize out-of-square conditions. Coordinate all work that penetrates tile.

3.3 INSTALLATION

A. Install metal tile system in accordance with manufacturer’s printed installation instructions, submittals, applicable industry standards, and governing regulatory requirements for the work.

B. Suspend ceiling hangers from slotted channel framing specified in Section 05430, “Slotted Channel Framing” and as follows:
   1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
   2. Splay hangers only where required to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
   3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards and publications.
   4. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly either to structures or to inserts, eye screws, or other devices that are secure; that are appropriate for substrate; and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
   5. Do not support ceilings directly from permanent metal forms. Fasten hangers to cast-in-place hanger inserts, power-actuated fasteners, or drilled-in anchors that extend through forms into concrete.
   6. Do not attach hangers to steel deck tabs.
   7. Do not attach hangers to steel roof deck. Attach hangers to structural members.

C. Snap-in Metal Tile Suspension System Installation:
   1. Primary runners: Install C channels at maximum spacing of 48 inches.
      a. Install wind uplift struts at spacings to comply with structural requirements of governing codes. Attach securely to runner channels and structure above.
   2. Assemble snap-in suspension system by clamping primary and secondary runners together to form a mounting grid.
   3. Install snap-in metal tile by holding level and applying pressure on panel dimple points. Examine dimples on panel edge to ensure positive lock into secondary runner.
   4. Install lock-clips at exterior locations to prevent lifting of panels due to wind pressure.

D. Plenum Access: Install hinged access panels at locations shown.

E. Install acoustical material to completely fill each ceiling panel.

F. Install custom panels and trim pieces for dropped soffit returns, and other required locations, with neat, tight joints and to comply with approved details.

G. Install specified perimeter trim edge molding at all locations required to conceal edges of ceiling system.

H. Install air distribution devices and lighting fixtures at indicated locations.
   1. Support devices and fixtures from building structure above, independent from ceiling suspension system.
   2. Field fabricate ceiling panels to accommodate air distribution devices.
   3. Verify that only fixtures with Modular Type “M” or “MT” flanges will be installed.

3.4 ADJUST AND CLEAN

A. Adjust components to provide uniform tolerances.

B. Replace tile that are scratched, dented or otherwise damaged.

C. Clean exposed surfaces with non-solvent, non-abrasive commercial type cleaner.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for acoustical snap-in metal pans ceilings per location indicated wherein no measurement will be made.

END OF SECTION 09513
SECTION 09660
RESILIENT FLOORING

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing resilient flooring, resilient base, and accessories.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D2047 - Standard Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
   4. ASTM F710 - Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring
   5. ASTM F1066 - Standard Specification for Vinyl Composition Floor Tile
   7. ASTM F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

1.3 SUBMITTALS
A. Samples include three of each type and color of the following materials used in the work: Tile, 12 inches square; base, six inches long; edge strips, six inches long; and adhesive, 1/2 pint container.

1.4 QUALITY ASSURANCE
A. Installer Qualifications: Engage an experienced installer to perform work of this Section who has specialized in installing resilient products similar to those required for this Project and with a record of successful in-service performance of at least 5 years.

B. Slip Resistance: Provide products identical to those tested for slip resistance per ASTM D2047 with a static coefficient of friction not less than 0.6 for level surfaces and 0.8 for ramped surfaces.

C. Fire-Test-Response Characteristics: Provide products with the following fire-test-response characteristics as determined by testing identical products per test method indicated below by a testing and inspecting agency acceptable to authorities having jurisdiction:
   1. Critical Radiant Flux: Class I, 0.45 W/sq. cm or greater when tested per ASTM E648.
   2. Smoke Density: Maximum specific optical density of 450 or less when tested per ASTM E662.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Deliver materials to the Worksite in original unopened containers, clearly labeled with manufacturer's name and brand designation, referenced specification number, type, and color.

B. Store and protect materials so as to prevent damage. Keep materials dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.6 JOB CONDITIONS
A. Environmental Requirements:
   1. Maintain temperature of materials stored on Worksite at above 70 deg. F minimum for at least 24 hours before installation.
   2. Maintain temperature of rooms or spaces in which work is to be installed at 70 deg. F for 24 hours before, during and 24 hours after installation.
   3. Do not install tile unless floors are completely dry with no trace of dampness. Test by laying approximately 2 feet square of rubber sheeting on floor in stationary location. After 24 hours, lift sheeting. Show no dampness after test. If dampness is still present, allow floor to dry further and retest until dry.

1.7 MAINTENANCE MATERIALS
A. After completion of the work, furnish and store, where directed by the Contracting Officer, at least
1 percent of the total quantity of tile and 1 percent of base material for future maintenance.

B. Include proportional quantities of each type and color in original containers clearly marked to show contents and area of placement of each type and color.

PART 2 - PRODUCTS

2.1 VINYL COMPOSITION TILE
A. ASTM F1066, Class 2, 12 inches square, 1/8 inch thick, color as scheduled on Contract Drawings.

2.2 BASE
A. Vinyl, 4 inches high, Type II, 1/8 inch thick, with molded top, in longest practicable lengths. Color as scheduled on Contract Drawings.

2.3 EDGE STRIP
A. ASTM F1700, Type IV, vinyl, beveled, 1 inch wide, 1/8 inch thick. Color to match base.

2.4 ADHESIVE
A. Water-resistant type, as recommended by manufacturer for surface to which tile is to be cemented.

2.5 PRIMER
A. As recommended by the adhesive manufacturer.

2.6 BASE CEMENT
A. Water-resistant, type recommended by manufacturer of base.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine substrate surfaces to receive resilient tile flooring and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

B. Concrete Subfloors: Verify that concrete slabs comply with ASTM F710 and the following:

1. Slab substrates are dry and free of curing compounds, sealers, hardeners, and other materials that may interfere with adhesive bond. Determine adhesion and dryness characteristics by performing bond and moisture tests recommended by flooring manufacturer.

2. Subfloor finishes comply with requirements specified in Section 03350, “Concrete Finishing” for slabs receiving resilient flooring.

3. Subfloors are free of cracks, ridges, depressions, scale, and foreign deposits.

PREPARATION

A. Prepare substrates according to manufacturer’s written recommendations and with oversight by manufacturer’s representative to ensure adhesion of floor coverings and conductive continuity of floor covering systems.

B. Concrete Substrates: Prepare concrete slabs according to ASTM F710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners. Remove substrate coatings and other substances that are incompatible with floor covering adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.

2. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

3. Moisture Testing:
   a. Perform anhydrous calcium chloride test, ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft in 24 hours.
   b. Also perform concrete internal relative humidity test, ASTM F2170. Proceed with installation only after substrates have maximum relative humidity of 75 percent.
   c. Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

C. Use trowelable leveling and patching compound to fill cracks, holes, and depressions in substrates.

D. Broom and vacuum clean substrates to be covered immediately before product installation. After cleaning, examine substrates for moisture, alkaline salts, carbonation, or dust. Do not proceed with installation until unsatisfactory conditions have been corrected.

E. Prime surfaces, as recommended by adhesive manufacturer.
3.3 INSTALLATION

A. General: Comply with tile manufacturer's written installation instructions.

B. Centering:
   1. Establish center lines for tile patterns parallel to principal walls in areas or rooms. Start laying tile from center lines, keeping joints parallel to centerlines.
   2. Lay out the pattern so that perimeter tiles are not smaller than half tiles.

C. Application of Primer: If adhesive manufacturer recommends primer, apply at rate and by method recommended.

D. Uniformity of Color: Use tile alternately from at least two cartons so that pattern will be uniform and not spotty due to variation that may be found in different cartons.

E. Application of Adhesive:
   1. Evenly spread adhesive on surfaces as recommended by tile manufacturer. While adhesive is tacky, embed each tile firmly in place to ensure proper bond.
   2. Cover only that amount of area which can be covered by tile within recommended working time of adhesive.

F. Laying Tile:
   1. Cut tiles to fit neatly and snugly around pipes and other vertical projections.
   2. Provide hairline joints; cut straight and true. Seal tile joints at pipes and penetrations through tile, with waterproof cement.
   3. Embed tiles level, flush with surface and tightly against adjoining tiles.
   4. Immediately remove stains, spots and adhesive smears.

G. Installing Base:
   1. Do not install base until plaster or other backing material has thoroughly dried. Install bases on walls, including walls behind movable equipment.
   2. Install bases around fixed equipment bases unless otherwise shown. Extend bases into closets and offsets adjoining areas scheduled to receive base.
SECTION 09663
STATIC DISSIPATIVE RESILIENT FLOORING

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies resilient floor coverings (static dissipative vinyl composition tile) designed to control electrostatic discharge (ESD).

B. Refer to Section 16876, “Grounding and Bonding – Communications System” for connecting grounding strips to ground.

1.2 REFERENCED STANDARDS
A. The American Association of Textile Chemists and Colorists (AATCC):
   1. AATCC-134 - Electrostatic Propensity of Carpets

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D2047 - Standard Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine
   5. ASTM F710 - Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring
   6. ASTM F1066 - Standard Specification for Vinyl Composition Floor Tile
   7. ASTM F1700 - Standard Specification for Solid Vinyl Floor Tile
   8. ASTM F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

C. Electrical Overstress/Electrostatic Discharge Association Inc. (EOS/ESD):
   1. EOS/ESD DS7.1 - Floor Materials - Resistive Characterization of Materials

D. Military Specification (MIL):
   1. MIL-STD-3010 - Test Procedures for Packaging Materials

1.3 SUBMITTALS
A. Product Data: For each type of product indicated.
B. Samples for Initial Selection: For each type of floor covering and exposed accessory indicated.
C. Samples for Verification: For each type of floor covering indicated and of size indicated below:
   1. Tile: Full-size units.
   2. Accessories: In length equal to length of floor covering samples.

D. Qualification Data: For Installer.
E. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for floor coverings.
F. Maintenance Data: For floor coverings to include in maintenance manuals.

1.4 QUALITY ASSURANCE
A. Installer Qualifications: A qualified installer who employs workers for this Project that are competent in techniques required by manufacturer for static-control floor covering installation indicated.

1. Engage an installer who employs workers for this Project that are trained or certified by floor covering manufacturer for installation techniques required.

B. Static-Control Properties: Provide floor coverings with static-control properties indicated as determined by testing identical products per test method indicated by an independent testing and inspecting agency.

C. Slip Resistance: Provide products identical to those tested for slip resistance per ASTM D2047 with a static coefficient of friction not less than 0.6 for level surfaces and 0.8 for ramped surfaces.
D. Fire-Test-Response Characteristics: Provide products with the following fire-test-response characteristics as determined by testing identical products per test method indicated below by a testing and inspecting agency acceptable to authorities having jurisdiction.

1. Critical Radiant Flux: Class I, 0.45 W/sq. cm or greater when tested per ASTM E648.

2. Smoke Density: Maximum specific optical density of 450 or less when tested per ASTM E662.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Worksite in original unopened containers, clearly labeled with manufacturer's name and brand designation, referenced specification number, type, and color.

B. Store and protect materials so as to prevent damage. Keep materials dry.

C. Handle products so as to prevent breakage of containers and damage to products.

1.6 JOB CONDITIONS

A. Environmental Requirements:

1. Maintain temperature of materials stored on Worksite at above 70 degrees F minimum for at least 24 hours before installation.

2. Maintain temperature of rooms or spaces in which work is to be installed at 70 degrees F for 24 hours before, during and 24 hours after installation.

3. Do not install tile unless floors are completely dry with no trace of dampness. Test by laying approximately 2 feet square of rubber sheeting on floor in stationary location. After 24 hours, lift sheeting. Show no dampness after test. If dampness is still present, allow floor to dry further and retest until dry.

1.7 MAINTENANCE MATERIALS

A. After completion of the work, furnish and store, where directed by the Contracting Officer, at least 1 percent of the total quantity of tile and 1 percent of base material for future maintenance.

B. Include proportional quantities of each type and color in original containers clearly marked to show contents and area of placement of each type and color.

PART 2 - PRODUCTS

2.1 STATIC DISSIPATIVE RESILIENT FLOOR COVERINGS

A. Static Dissipative Vinyl Composition Tile (VCT): ASTM F 1066 (VCT, nonasbestos formulated), Class 2 (through-pattern tile); tiles 12 x 12 inches, 0.125 inch thick.

1. Armstrong World Industries, Inc.; Excelon SDT.

2. Or approved equal.

B. Static-Control Properties:

1. Electrical Resistance: Test per ASTM F150 with 100-V applied voltage and ESD-S7.1.

   a. Average greater than 1 megohm and less than or equal to 1000 megohms when test specimens are tested surface to ground.

   b. Average no less than 1 megohm and less than or equal to 1000 megohms when installed floor coverings are tested surface to ground.

2. Static Generation: Less than 300 V when tested per AATCC-134 at 20 percent relative humidity with conductive footwear.

3. Static Decay: 5000 to 0 V in less than 0.25 seconds when tested per MIL-STD-3010, Method 4046.

C. Color: As scheduled on Contract Drawings.

2.2 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland cement or blended hydraulic cement based formulation provided or approved by floor covering manufacturer for applications indicated.

B. Static-Control Adhesive: Adhesive product of floor covering manufacturer that produces conductive continuity of floor covering system.

C. Grounding Strips: Provided and approved by floor covering manufacturer and that produce conductive continuity of floor covering system to ground connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer and manufacturer's representative present, for compliance with requirements for installation
tolerances, moisture content, and other conditions affecting performance.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion or static-control characteristics of floor coverings.

2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written recommendations and with oversight by manufacturer's representative to ensure adhesion of floor coverings and conductive continuity of floor covering systems.

B. Concrete Substrates: Prepare concrete slabs according to ASTM F710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners. Remove substrate coatings and other substances that are incompatible with floor covering adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.

2. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

3. Moisture Testing:
   a. Perform anhydrous calcium chloride test, ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft in 24 hours.
   b. Also perform concrete internal relative humidity test, ASTM F2170. Proceed with installation only after substrates have maximum relative humidity of 75 percent.
   c. Perform tests recommended by manufacturer. Proceed with installation only after substrates pass testing.

C. Use trowelable leveling and patching compound to fill cracks, holes, and depressions in substrates.

D. Access Flooring Panels: Remove protective film of oil or other coating using method recommended by access flooring manufacturer.

E. Move floor coverings and installation materials into spaces where they will be installed at least 48 hours in advance of installation.

1. Do not install floor coverings until they are same temperature as space where they are to be installed.

F. Broom and vacuum clean substrates to be covered by floor coverings immediately before installation. After cleaning, examine substrates for moisture, alkaline salts, carbonation, and dust. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION, GENERAL

A. Arrange for manufacturer's representative to oversee installation of static-control resilient floor coverings.

B. Embed grounding strips in static-control adhesive. Extend strips beyond perimeter of static-control resilient floor covering surfaces to ground points.

C. Scribe and cut floor coverings to butt neatly and tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings.

D. Extend floor coverings into toe spaces, door reveals, closets, and similar openings.

E. Maintain reference markers, holes, or openings that are in place or marked for future cutting by repeating on floor coverings as marked on substrates. Use chalk or other nonpermanent-marking device.

F. Install floor coverings on covers for telephone and electrical ducts, and similar items in installation areas. Maintain overall continuity of color and pattern with pieces of floor coverings installed on covers. Tightly adhere floor covering edges to substrates that abut covers and to cover perimeters.

G. Adhere floor coverings to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

3.4 TILE INSTALLATION

A. Lay out tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.
1. Lay tiles square with room axis.

2. Match tiles for color and pattern by selecting tiles from cartons in same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.

3. Lay static-dissipative VCT with grain direction alternating in adjacent tiles (basket-weave pattern).

3.5 FIELD QUALITY CONTROL

A. Testing: Contractor shall engage a qualified independent testing and inspecting agency to test electrical resistance of static-control resilient floor covering systems for compliance with requirements.

1. Arrange for testing after installation adhesives have fully cured and floor covering systems have stabilized to ambient conditions.

2. Arrange for testing of floor coverings before and after performing polish procedures.

B. Remove and replace static-control floor coverings where test results indicate that they do not comply with specified requirements.

C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.6 CLEANING AND PROTECTION

A. Perform the following operations immediately after completing floor covering installation:

1. Remove adhesive and other surface blemishes from floor covering surfaces.

2. Sweep and vacuum floor coverings thoroughly.

3. Damp-mop floor coverings to remove marks and soil.

a. Do not wash floor coverings until after time period recommended by manufacturer.

B. Protect floor coverings from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period. Use protection methods indicated or recommended in writing by manufacturer.

1. If recommended in writing by static-control resilient floor tile manufacturer, apply protective static-control floor polish formulated to maintain or enhance tile's electrical properties to tile surfaces that are free from soil, adhesive, and surface blemishes.

a. Verify that both polish and its application method are approved by tile manufacturer and that polish will not leave an insulating film that reduces tile's effectiveness for static control.

2. Cover floor coverings with undyed, untreated building paper until final acceptance.

3. Do not move heavy and sharp objects directly over floor coverings. Place plywood or hardboard panels over floor coverings and under objects while they are being moved. Slide or roll objects over panels without moving panels.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for static dissipative resilient flooring per location indicated wherein no measurement will be made.

END OF SECTION 09663
1.1 SUMMARY

A. Work required for this section includes surface preparation and field painting of exposed interior items and surfaces.

1. Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatment specified in other Sections.

B. Exterior and interior steel surfaces coatings are specified and scheduled in Section 09970, "Coatings for Steel", except for galvanized sheet metal, which is specified in this Section.

C. Exterior concrete and masonry surfaces coatings are specified and scheduled in Section 09980, "Coatings for Concrete and Masonry".

D. Paint exposed surfaces, except where indicated that the surface or material is not to be painted or is to remain natural. If an item or a surface is not specifically mentioned, paint the item or surface the same as similar adjacent materials or surfaces. If a color of finish is not indicated, Contracting Officer will select from standard colors and finishes available.

1. Painting includes field painting of exposed bare and covered pipes and ducts, hangers, exposed steel and iron supports, and surfaces of mechanical and electrical equipment that do not have a factory-applied final finish.

E. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.

1. Prefinished items include the following factory-finished components:


b. Acoustical materials.

c. Prefinished Architectural woodwork and cabinets.

d. Elevator equipment.

e. Finished mechanical and electrical equipment.

f. Light fixtures.

g. Distribution cabinets.

h. Baked enamel coated items.

i. Fluorocarbon coated items.

2. Concealed surfaces include walls or ceilings in the following generally inaccessible spaces:

a. Foundation spaces.

b. Furred areas.

c. Ceiling plenums.

d. Utility tunnels.

e. Pipe spaces.

f. Duct shafts.

3. Finished metal surfaces include the following:

a. Anodized aluminum.

b. Stainless steel.

c. Chromium plate.

d. Copper and copper alloys.

e. Bronze and brass.

4. Operating parts include moving parts of operating equipment and the following:

a. Valve and damper operators.

b. Linkages.

c. Sensing devices.

d. Motor and fan shafts.

5. Labels: Do not paint over UL, FMG, or other code-required labels or equipment name, identification, performance rating, or nomenclature plates.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME):

1. ASME A13.1 - Scheme for the Identification of Piping Systems

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications

1.3 DEFINITIONS

A. General: Standard coating terms defined in ASTM D16 apply to this Section.

1. Flat refers to a lusterless or matte finish with a gloss range below 15 when measured at an 85-degree meter.

2. Eggshell refers to low-sheen finish with a gloss range between 20 and 35 when measured at a 60-degree meter.

3. Semigloss refers to medium-sheen finish with a gloss range between 35 and 70 when measured at a 60-degree meter.

4. Full gloss refers to high-sheen finish with a gloss range more than 70 when measured at a 60-degree meter.

B. Consumer Line Paint: Paint products that are usually sold to consumers through normal retail outlets such as company paint stores and independent dealers.

C. Professional Line Paint: Paint products specially manufactured primarily for professional painters.

D. Interior Painting: Generally includes surfaces located in conditioned spaces.

1.4 SUBMITTALS

A. Product Data: For each paint system indicated. Include block fillers and primers.

1. Material List: An inclusive list of required coating materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.

2. Manufacturer's Information: Manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material.

3. Certification by manufacturer that products supplied comply with local regulations controlling use of volatile organic compounds (VOCs).

4. Product performance characteristics for paint materials upon request.

B. Detailed Painting Schedule:

1. Furnish "Detailed Painting Schedule" indicating type of surface, type of paint material, and number of coats required, as set forth in "Painting Requirements".

2. Submit brand designation and grade of indicated type produced by approved manufacturer for each application listed or required.

C. Samples: For each color and material to be applied, with texture to simulate actual conditions, on representative Samples of the actual substrate, 8 inches by 10 inches.

1. Provide stepped Samples, defining each separate coat, including block fillers and primers. Use representative colors when preparing Samples for review. Resubmit until required sheen, color, and texture are achieved.

2. Provide a list of materials and applications for each coat of each Sample. Label each Sample for location and application.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Meet Federal, State and Local EPA requirements for maximum VOC.

B. Applicator Qualifications: An individual with 5 years experience in applying paints and coatings similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

C. Source Limitations: Obtain block fillers and field applied primers for each coating system from the same manufacturer as the finish coats.

1.6 DELIVERY AND STORAGE

A. Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label.

B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature recommended by manufacturer. Maintain storage containers in a clean condition, free of foreign materials and residue.

1.7 PROJECT CONDITIONS

A. Apply paint only when temperatures of surfaces to be painted and surrounding air are between
minimum and maximum range recommended by manufacturer.

B. Do not apply paint in snow, rain, fog, or mist; or when relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

1. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature and humidity limits specified by manufacturer during application and drying periods.

1.8 EXTRA MATERIALS

A. Furnish extra paint materials from the same production run as the materials applied and in the quantities described below. Package with protective covering for storage and identify with labels describing contents. Deliver extra materials to Owner.

1. Quantity: Furnish the Owner with an additional 3 percent, but not less than 1 gal. or 1 case, as appropriate, of each material and color applied.

2. Label each container with color, color number, texture and room locations, in addition to manufacturer’s label.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are “acceptable” only if manufacturer can evidence product compliance with requirements of Contract Documents.

1. Benjamin Moore & Co. (Benjamin Moore).

2. ICI Paint Stores, Inc. (ICI Dulux Paint).

3. PPG Industries, Inc. (Pittsburgh Paints).


5. Or approved equal.

2.2 PAINT MATERIALS, GENERAL

A. Material Compatibility: Provide block fillers, primers, and finish-coat materials that are compatible with one another and with the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

B. Material Quality: Provide manufacturer’s best-quality “Consumer Line” paint material of the various coating types specified that are factory formulated and recommended by manufacturer for application indicated. Manufacturer’s “Professional Line” products are NOT acceptable. Paint-material containers not displaying manufacturer’s product identification will not be acceptable.

1. Proprietary Names: Use of manufacturer’s proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other listed acceptable manufacturers.

C. Colors: As indicated.

2.3 TEXTURE/COATINGS

A. Orange Peel Effect Texture: USG Multi-Purpose Texture Finish, “orange peel” effect created with spray gun application.

2.4 MASONRY BLOCK FILLERS

A. Concrete Unit Masonry Block Filler: Factory-formulated high-performance latex block fillers.


2. ICI Dulux Paint; Bloxfil 4000-1000 Interior/Exterior Heavy Duty Acrylic Block Filler.

3. Pittsburgh Paints; 6-7 SpeedHide Interior/Exterior Masonry Latex Block Filler.


2.5 PRIMERS

A. Concrete and Masonry Primer: Factory-formulated alkali-resistant acrylic-latex interior primer for interior application.

1. Benjamin Moore; Regal FirstCoat Interior Latex Primer & Underbody No. 216.

2. ICI Dulux Paint; 1000-1200 Dulux Ultra Basecoat Interior Latex Wall Primer.

3. Pittsburgh Paints; 6-2 SpeedHide Interior Quick-Drying Latex Sealer.

4. Sherwin-Williams; PrepRite Masonry Primer B28W300.
INTERIOR PAINTING

2.6 FINISH COATS

A. Flat Acrylic Paint: Factory-formulated flat acrylic-emulsion latex paint for interior application.

1. Benjamin Moore; Regal Wall Satin No. 215 Premium Interior Finishes Flat Finish.

B. Low-Luster Acrylic Enamel: Factory-formulated eggshell acrylic-latex interior enamel.

1. Benjamin Moore; Moore's Regal AquaVelvet No. 319.

C. Semigloss Acrylic Enamel: Factory-formulated semigloss acrylic-latex enamel for interior application.


D. Semi-Gloss Epoxy Coating: Factory-formulated waterbased epoxy coating for interior application.

1. Benjamin Moore; Acrylic Epoxy Coating M43/M44.

E. Heat Resistant Paint: High-heat silicone aluminums for protection against weather, moisture, heat and fumes, to 600 deg. F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Applicator present, for compliance with
requirements for paint application. Comply with procedures specified by the paint manufacturer.

1. Proceed with paint application only after unsatisfactory conditions have been corrected in manner acceptable to installer and surfaces receiving paint are thoroughly dry.

2. Start of painting will be construed as Applicator's acceptance of surfaces and conditions within a particular area.

B. Coordination of Work: Review other Sections in which shop applied primers are provided to ensure compatibility of the total system for various substrates. Furnish information on characteristics of finish materials to shop applicators to ensure use of compatible primers.

3.2 PREPARATION

A. General: Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of size or weight of the item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

B. Surface Preparation: Prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition. Clean substrates of substances that could impair the bond of the various coatings.

1. Provide barrier coats recommended by paint manufacturer over incompatible primers or remove and reprime.

2. Cementitious Materials: Prepare surfaces to remove loose material, stains and unsuitable surface conditions. Roughen, as required, to remove glaze.
   a. Use mechanical methods of surface preparation recommended by paint manufacturer.
   b. Determine alkalinity and moisture content of surfaces by performing appropriate tests.
   c. Do not paint surfaces where moisture content exceeds that permitted in manufacturer's printed directions.

3. Ferrous Metals: Clean ungalvanized ferrous-metal surfaces that have not been shop coated; to remove foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.
   a. Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by paint manufacturer, and touch up with same primer as the shop coat.

4. Galvanized Surfaces: Clean galvanized surfaces free of oil and surface contaminants. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

C. Material Preparation: Mix and prepare paint materials according to manufacturer's written instructions.

1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.

2. Use only thinners approved by paint manufacturer and only within manufacturer's recommended limits.

D. Tinting: Tint each undercoat a lighter shade to simplify identification of each coat when multiple coats of same material are applied. Tint undercoats to match the color of the finish coat, but provide sufficient differences in shade of undercoats to distinguish each separate coat.

3.3 APPLICATION

A. General: Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.

1. Paint colors, surface treatments, and finishes are indicated in the paint schedules.

2. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.

3. Provide finish coats that are compatible with primers used.

4. Paint surfaces behind movable equipment and furniture the same as similar exposed surfaces.
5. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only.

6. Paint interior surfaces of ducts with a flat, nonspecular black paint where visible through registers or grilles.

7. Paint back sides of access panels and removable or hinged covers to match exposed surfaces.

8. Sand lightly between each succeeding enamel coat on metals.

9. Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation.

10. The number of coats and film thickness required are the same regardless of application method.

11. Do not apply succeeding coats until previous coat has cured as recommended by manufacturer.

12. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.

13. Omit primer over metal surfaces that have been shop primed and touchup painted.

14. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance.

15. Ensure that edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.

16. Allow sufficient time between successive coats to permit proper drying.

B. Minimum Coating Thickness: Apply paint materials no thinner than manufacturer's recommended spreading rate to achieve total dry film thickness of the entire system as recommended by manufacturer.

C. Mechanical and Electrical Work: Painting of mechanical and electrical work is limited to items exposed to view in occupied spaces.

D. Block Fillers: Apply block fillers to concrete masonry block at a rate to ensure complete coverage with pores filled.

E. Prime Coats: Before applying finish coats, apply a prime coat, as recommended by manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no blemish or other defects due to insufficient sealing.

F. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

G. Stipple Finish: Roll and redistribute paint to an even and fine texture. Leave no evidence of rolling, such as laps, irregularity in texture, skid marks, or other surface imperfections.

H. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.4 CLEANING

A. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping without scratching or damaging adjacent finished surfaces.

3.5 PROTECTION

A. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repainting, repairing or replacing. Coordinate corrections with other trades involved.

B. Provide "Wet Paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.

C. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 INTERIOR PAINTING SCHEDULE

A. PAINT AND COATINGS SYSTEM NO. 5: Galvanized Sheet Metal

1. Semigloss Acrylic-Enamel Finish: Two finish coats over primer.
   a. Primer: Galvanized metal primer.
b. Finish Coats: Interior semigloss acrylic enamel.

B. PAINT AND COATINGS SYSTEM NO. 6: Gypsum Board Walls - Typical
1. Low-Luster (Eggshell) Acrylic-Enamel Finish: Two finish coats over primer.
   a. Primer: Interior gypsum board primer.
   c. Texture: Roll to “Orange Peel” texture.

C. PAINT AND COATINGS SYSTEM NO. 7: Gypsum Board Ceilings - Typical
1. Flat Acrylic Finish: Two finish coats over primer and texture.
   a. Primer: Interior gypsum board primer.
   b. Texture: “Orange Peel”.
   c. Finish Coats: Interior flat acrylic paint.

D. PAINT AND COATINGS SYSTEM NO. 8: Gypsum Board Walls and Ceilings - Epoxy
1. Locations: Rest Rooms and Janitor Closets
2. Semigloss Epoxy Finish: Two finish coats over primer.
   a. Primer: Interior gypsum board primer.
   b. Finish Coats: Interior semi-gloss epoxy coating.

E. PAINT AND COATINGS SYSTEM NO. 9: CMU Walls - Typical
   a. Block Filler: Concrete unit masonry block filler.
   b. Finish Coats: Interior semigloss acrylic enamel.

F. PAINT AND COATINGS SYSTEM NO. 10: CMU Walls - Epoxy
1. Locations: Janitor Closets
2. Semigloss Epoxy Finish: Two finish coats over block filler.
   a. Block Filler: Concrete unit masonry block filler.
   b. Finish Coats: Interior semigloss epoxy coating.

G. PAINT AND COATINGS SYSTEM NO. 11: Concrete Walls
1. Semigloss Acrylic-Enamel Finish: Two finish coats over primer.
   b. Finish Coats: Interior semigloss acrylic enamel.

H. PAINT AND COATINGS SYSTEM NO. 12: Concrete Ceilings
1. Low-Luster (Eggshell) Acrylic-Enamel Finish: Two finish coats over primer.

I. PAINT AND COATINGS SYSTEM NO. 13: Canvas, Pipe Wrapping, and Mechanical Insulation
1. Flat Acrylic Finish: Two finish coats over primer.
   a. Primer: Interior gypsum board primer.
   b. Finish Coats: Interior flat acrylic paint.

J. PAINT AND COATINGS SYSTEM NO. 14: Color Coding and Identification Painting
1. Low-Luster (Eggshell) Acrylic-Enamel Finish: Two finish coats over a primer.
   a. Primer: Interior ferrous-metal primer unless shop primed.
K. PAINT AND COATINGS SYSTEM NO. 15: Heat Resistant Coating


L. PAINT AND COATINGS SYSTEM NO. 16: Dustproofing of Concrete Floors, sealed concrete floors:

1. Type of Coating: Colorless, transparent odorless, nontoxic, nonflammable, and noncombustible silicate solution or water-based sealer as manufactured by: Curecrete Chemical Co., “Ashford Formula” or Cehmpore Coating Systems, L.P., “CTDensifier 201”.

2. Surface Preparation: Clean concrete surfaces free from dust, dirt, and other foreign materials.

3. Application and Mix: Apply dustproofing material on freshly finished surface sprayed with a low pressure to assure proper curing. Apply the product in accordance with the manufacturer's directions when the surface is firm enough to walk on and before checking and temperature cracking begins. Keep the entire surface wet for 30 minutes by brooming excess product onto the dry spots or respraying the dry spots immediately. As the product begins to dry into the surface and become slippery underfoot, lightly sprinkle the surface with water to aid penetration and to bring alkali to the surface when dry, flush the surface with water, and squeegee the surface totally dry. Remove all excess product and alkali brought to the surface.

3.7 COLOR CODING OF PIPING AND EQUIPMENT

A. General Requirements:

1. Color coding is required for accessible piping systems and related equipment in accordance with Paragraph 3.7.C of this section.

2. Identify piping systems and related equipment to be color coded in accordance with ASME A13.1 and as follows:
   a. Apply color to entire length of piping.
   b. Lettered legends indicating the name of the contents of the system as specified.

3. Paint associated supports, brackets, hangers, and similar accessories as identified for interior steel, and not as required for color coding.

B. Location of Legends and Bands:

1. Stencil lettered legends on the piping at the horizontal or vertical center line. Where pipe lines are too close together and where located above the operator's normal line of vision, place the lettering below the horizontal center line at a point which will be easily visible.

2. Position lettered legends and bands at joints where pipes enter and leave rooms or spaces, at junction points, points of distribution, close to valves and equipment, at changes in direction, and at intervals along piping where necessary for identification.

3. Stencil piping to show service and direction of flow. Space stencils within sight of each other and approximately 20 feet apart on long runs.

C. Schedule of Colors and Legends: See Section 01086, "Color Codes and Color Standards" or as noted on drawing.

3.8 FIRE AND SMOKE BARRIER IDENTIFICATION

A. Corridor partitions, smokestop partitions, horizontal exit partitions, exit enclosures and fire walls shall be effectively and permanently identified with signs, labels or stencils in a manner acceptable to authority having jurisdiction.

1. Identification shall be above decorative ceiling and in concealed spaces.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for interior painting per location indicated wherein no measurement will be made.

END OF SECTION 09920
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes exterior and interior, steel fabricator shop and field applied, high-performance coatings for steel, other than galvanized sheet metal and supplementary items necessary to complete the installation.

B. Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatment specified under other Sections.

C. Exterior concrete and masonry surfaces coatings are specified and scheduled in Section 09980, "Coatings for Concrete and Masonry".

D. Interior surfaces, including galvanized sheet metal, receiving conventional paint are specified and scheduled in Section 09920, "Interior Painting".

E. Do not paint UL labels.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications
2. ASTM D2092 - Standard Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting
3. ASTM D2244 - Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
5. ASTM D4417 - Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel

B. NACE International (Formerly known as National Association of Corrosion Engineers):

1. NACE Certified Inspector Program

C. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):

1. SSPC-PA 2 - Measurement of Dry Coating Thickness with Magnetic Gages
2. SSPC PAINT 20 - Zinc-Rich Coating Type I Inorganic and Type II Organic
3. SSPC PAINT 27 - Basic Zinc Chromate-Vinyl Butyral Wash Primer
4. SSPC-SP 1 - Solvent Cleaning
5. SSPC-SP 6/NACE No. 3 - Commercial Blast Cleaning
6. SSPC-SP 11 - Power Tool Cleaning to Bare Metal
7. “Good Painting Practice, SSPC Painting Manual Volumes I and II”

1.3 DEFINITIONS

A. Qualification: Should particular conditions not be definable according to these definitions, request clarification from the Architect.

B. Interior: Defined as surfaces that are within heated and air-conditioned spaces, areas and rooms. Ceiling cavities and plenums above conditioned spaces and within the confines of the exterior walls shall be considered as interior.

C. Exterior: Defined as surfaces that are exposed to temperature and humidity variations, precipitation, and ultraviolet light. Exterior shall include spaces and areas that are covered by roof structures but are not heated and air-conditioned.

D. Coatings Terminology: Refer to ASTM D16 for definitions of terms related to coating work not otherwise defined in this Section.

1.4 SUBMITTALS

A. Standards: Submit trade association and independent testing agency standards (i.e. ASTM, etc.) Stated within the specification.

B. Product Data: Submit for each coating system specified, including each coating required.

1. Material List: Inclusive list of required coating materials identifying each by manufacturer's product number and general classification.
2. Manufacturer's Information: Technical information, including label analysis and instructions for handling, storing, and applying each coating material. Include instructions for preparation for and field touch up of primer and finish coats.

3. Manufacturer's Certification: Stating that products supplied will comply with local regulations controlling use of volatile organic compounds (VOC).

C. Detailed Coating Schedule: Submit schedule detailing type of surface, specific data for each coating material, and number of coats required.

D. Samples for Verification Purposes: Submit for each substrate, separate coat, coating color and material to be applied, with texture to simulate actual conditions, on 8 inch by 10 inch stepped samples of the actual substrate to be coated. Use representative colors when preparing samples for review. Label each sample with product data defining each separate coat, including primers. Resubmit until required sheen, color, and texture are achieved.

E. Manufacturer's Project Acceptance Document: Submit certification and acceptance of compatibility and suitability of materials scheduled with substrate and project conditions indicated.

F. Maintenance Instructions: For inclusion in operation and maintenance manual required by Division 1, submit manufacturer's instructions for maintenance of installed work, including methods and frequency for maintaining optimum condition under anticipated use. Include precautions against cleaning materials and methods which may be detrimental to finishes and performance.

G. Applicator's Qualification: Submit applicator's resume, include list of a minimum of 5 completed projects of similar size and complexity to this Work. Include for each project:
   1. Project name and location.
   2. Name of owner.
   3. Name of contractor.
   4. Name of architect.
   5. Name of coating manufacturer.
   6. Approximate area of coatings applied.
   7. Date of completion.

H. Manufacturer's Qualifications: Submit resume.

I. Contractor's Field Quality Control: Submit specified reports.

J. Manufacturer Representative's Reports: Submit reports of representative's periodic inspections.


1.5 QUALITY ASSURANCE

A. Material Requirements:
   1. Compatibility: Provide materials that are compatible with one another under conditions of service and application required, as demonstrated by manufacturer based on testing and field experience.
   2. Single-Source Responsibility: Provide primers and undercoat material produced by the same manufacturer as the finish coats for each type of coating. Use only thinners recommended by the manufacturer and only within recommended limits.

B. Applicator Qualifications: Applicator shall be experienced in performing high-performance coating work, shall have completed not less than 10 years with coating system applications similar in material and extent to those indicated for Project, and have a record of successful in-service performance.

C. Manufacturer's Technical Representative Qualifications: Direct employee of technical services department of manufacturer with minimum of 5 years experience in providing recommendations, observations, evaluations, and problem diagnostics. Sales representatives are not acceptable.

D. Independent (third party) painting (coating) inspector shall be certified under NACE Certified Inspector Program as a Certified Coating Inspector. Also Coating Inspector shall have documented experience in the inspection of the system of type specified for projects of similar size and character.

E. Quality Standard for Steel Preparation: Surface preparation and painting practices shall conform to the SSPC - Steel Structures Painting Manual, Volumes 1 and 2.

F. Field Applied Mock-Ups: Provide a full-coat finish mock-up of each type of coating and substrate required on the Project. Mock-ups may be actual substrates of the Work. Duplicate finish of approved prepared samples.
   1. Select 1 surface, approved by the Contracting Officer, to represent surfaces and conditions for each type of coating and substrate to be painted.
2. Apply coatings to each surface according to the Schedule or as specified. Provide required sheen, color, and texture on each surface.

3. After finishes are accepted, the surface will be used to evaluate coating systems of a similar nature.

G. Pre-Application Meeting: Convene a pre-application meeting three weeks before start of application of coating systems. Require attendance of parties directly affecting work of this Section, including Contractor, Authority’s representative and inspector, applicator, and manufacturer’s representative. Review the following:

1. Environmental requirements.
2. Protection of surfaces not scheduled to be coated.
4. Application.
5. Repair.
6. Field quality control.
7. Cleaning.
8. Protection of coating systems.
9. One-year inspection.
10. Coordination with other work.

1.6 DELIVERY, STORAGE, AND PROTECTION

A. Delivery: Deliver coating materials to the job site in manufacturer's original, new, unopened packages and containers bearing manufacturer's name and label and following information:

1. Name or title of material.
2. Manufacturer's name, stock number, and date of manufacture.
3. Contents by volume.
4. Thinning instructions (if permitted).
5. Application instructions.
6. Color name and number.
7. Handling instructions and precautions.

B. Storage: Store materials not in actual use in accordance with weather, temperature, humidity and substrate conditions recommended by material manufacturer, in tightly covered containers at a minimum ambient temperature of 45 degrees F in a well-ventilated area. Maintain containers used in storage of coatings in clean condition, free of foreign materials and residue.

C. Protection: Protect work of other trades and vehicles, structures, landscaping, paving, and other surfaces on and off the site from marking or injury from coating application and from field surface preparation.

1.7 PROJECT CONDITIONS

A. Weather Condition Limitation:

1. Proceed with coating work only when existing and forecasted weather conditions will permit application of coating material in accordance with manufacturers' recommendations and warranty requirements.
2. Work may continue during inclement weather if surfaces and areas to be coated are enclosed and heated within temperature and humidity limits specified by manufacturer during application and drying periods and job site conditions are acceptable to the manufacturer and applicator.
3. If anticipated time of coating application is such that weather would likely restrict coating application, the Contractor may, with the approval of the Contracting Officer, apply complete finish system within shop.

B. Enclosures to permit coating of surfaces during inclement weather may be used provided that the environmental conditions specified are maintained throughout coating and curing periods.

1.8 WARRANTY

A. Manufacturers Extended Special Warranty: Furnish warranty for a period of 5 years from date of substantial completion agreeing to repair or replace defects, signed by an authorized representative of manufacturer, on the form that was published with product literature as of date of Contract Documents.

B. Defects shall include, but not be limited to, the following:

1. Fading or color change in excess of 8 delta E units (Hunter) as measured in accordance with ANSI/ASTM D2244.
2. Chalking in excess of 6 or less in accordance with ASTM D4214.
3. Cracking.
4. Checking.
5. Adhesion loss (delamination).

1.9 MAINTENANCE MATERIALS

A. Field Touch-Up Kits: Furnish to the Authority field touch-up kits complete with preparation, mixing, and application instructions for each coat and color used. Kits shall consist of quart containers. Larger containers may be acceptable if approved by the Contracting Officer. Quantity of kits shall equal one gallon for each 5,000 square feet of coating.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Specific product or material manufactured by following listed manufacturers is “acceptable” only if specific product or material can evidence compliance with requirements of Contract Documents.

1. Ameron International
2. Carboline
3. International Protective Coatings
4. Or approved equal

2.2 PRODUCTS

A. Material Compatibility: Provide primers, intermediate coat materials, finish coat materials, and related materials that are compatible with one another and the substrates indicated under conditions of service and application as demonstrated by the manufacturer based on testing and field experience.

B. Colors: As indicated.

C. System:

1. Type of Coating:
   a. Epoxy zinc-rich primer shop applied.
   b. Polysiloxane finish coat.
   c. Gloss sheen.

2. Dry Film Thickness (DFT): As specified by the approved manufacturer.

D. Epoxy Zinc-Rich Primer: Shop or field applied as scheduled.

1. Generic Product Description:
   a. Two component, metallic zinc rich epoxy primer which complies with composition and performance requirements of SSPC PAINT 20
   b. Extended overcoating interval of at least 6 months for specified topcoat.
   c. Recommended by manufacturer as suitable for specified topcoat.

2. Acceptable Manufacturers and Products:
   b. Carboline - “Carbozinc 859 EZ”, DFT 2-3 mils.


1. Generic Product Description:
   a. Two component, metallic zinc rich epoxy primer which provides rapid cure and overcoating even under low temperature conditions.
   b. Recommended by manufacturer as suitable for specified topcoat.

2. Acceptable Manufacturers and Products:
   a. International Protective Coatings (Akzo Nobel) - “Interzinc 315”, DFT 2 to 3 mils.

F. Thick Finish Coat: Field applied.

1. Generic Product Description:
   a. Thick coat (4 to 6 mils) high performance, two component, high solid inorganic hybrid polysiloxane finish
   b. Isocyanate free.
   c. With extended recoatability.

2. Sheen: Gloss.
3. Acceptable Manufacturers and Products:
   a. Ameron International - “PSX 700”, DFT 3 to 5 mils.
   c. International Protective Coatings (Akzo Nobel) - “Interfine 979”, DFT 4 to 6 mils.

G. Thin Finish Coat: Shop or field applied, as scheduled.
   1. Generic Product Description:
      a. Thin coat (2 to 3mils) high performance, two component, high solid inorganic hybrid polysiloxane finish
      b. Isocyanate free.
      c. With extended recoatability.

2. Sheen: Gloss.

3. Acceptable Manufacturers and Products:
   a. International Protective Coatings (Akzo Nobel) - “Interfine 878”, DFT 2 to 3 mils.
   b. Other manufacturers may furnish their thick coat system specified above in lieu of thin coat system, however system must be applied at rate listed in manufacturer’s literature.

2.3 SHOP QUALITY CONTROL

A. The requirements specified herein in the Article entitled “Field Quality Control” apply to surface preparation and shop application of prime coat and, if applicable, other shop coats.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive high performance coatings for steel and associated work and conditions under which work will be installed. Do not proceed until unsatisfactory conditions have been corrected in a manner complying with the Contract Documents and acceptable to the Installer. Starting of work within a particular area will be construed as installer's acceptance of surface conditions.

3.2 PREPARATION

A. Coordination of Work: Review other Sections in which shop applied primers are provided to ensure compatibility of the total system for various substrates. Furnish information on characteristics of finish materials to shop applicators to ensure use of compatible primers.

B. General: Remove plates, machined surfaces, and similar items already in place that are not to be coated, or provide surface-applied protection prior to surface preparation and coating. Remove these items, if necessary, to completely coat the items and adjacent surfaces. Following the coating operations in each space or area, have removed items reinstalled by workers skilled in the trades involved. After completing coating operations, reinstall items that were removed.

   1. Areas which may become inaccessible or difficult to coat after erection shall be coated prior to assembly or erection.

C. Cleaning: Before applying coatings or other surface treatments, clean the substrates of substances that could impair bond of the various coatings. Remove oil and grease prior to cleaning. Schedule cleaning and coating application so dust and other contaminants from the cleaning process will not fall on wet, newly coated surfaces.

   1. Marks for color coding of bulk materials and erection marking which are not compatible with coating system shall be removed or sealed as instructed in the coating system manufacturer's instructions.

D. Ferrous Metals Surface Preparation: Clean and prepare surfaces to be coated according to the manufacturer's instructions for each particular substrate condition as scheduled in either the fabricator's shop or in field.

   1. Uncoated Metal Surfaces:
      a. Fabrication Defects: Correct steel and fabrication defects revealed by surface preparation.
         1) Scrape or grind protrusions flush with surface.
         2) Remove weld spatter and slag.
         3) Round sharp edges and corners of welds to a smooth contour.
         4) Smooth weld undercuts and recesses.
         5) Grind down porous welds to pinhole-free metal.
6) Remove weld flux from surface.

b. Remove oil, grease, dirt, loose mill scale and other foreign substances using methods that comply with SSPC/NACE recommendations.

c. Blast-clean steel surfaces as recommended by the coating system manufacturer and according to the requirements of SSPC/NACE Specification referenced herein.

1) Achieve surface profile recommended by the primer manufacturer.

2) Coat abrasive blast-cleaned surfaces with primer before visible rust forms on surface. Do not leave blast-cleaned surfaces uncoated for more than 8 hours.

d. Ensure surfaces are dry.

e. Treat cleaned metal with a metal treatment wash coat prior to priming.

2. Coated Metal Surfaces: Remove foreign substances using methods that comply with coating system manufacturer recommendations. Touch-up bare areas and previous coatings that have been damaged.

E. Material Preparation: Carefully mix and prepare coating materials according to the manufacturer’s directions.

1. Maintain containers used in mixing and application of coatings according to the manufacturer’s directions.

2. Stir materials before applying to produce a mixture of uniform density; stir as required during application. Do not stir surface film into the material. Remove film and, if necessary, strain the coating material before using.

3. Use only the type of thinners approved by the manufacturer and only within recommended limits.

F. Tinting:

1. Tinting at the site is not permitted.

2. Tint undercoats to match color of finish coat, but provide sufficient difference in shade to distinguish each separate coat.

3.3 APPLICATION

A. General: Apply high performance coatings according to manufacturer’s instructions, approved submittals and Contract Documents, as scheduled in either the fabricator’s shop or in field.

B. Application Requirements:

1. Use application techniques best suited for the coating materials being applied. Apply shop coatings by brush, roller, spray, or other applicators according to coating manufacturer’s instructions. Apply field coatings by brush or roller according to coating manufacturer’s instructions, no spray application of field coatings.

a. Brush Application: Use brushes best suited for material applied and of appropriate size for surface or item being coated. Brush out and work brush coats into surfaces in an even film.

b. Roller Application: Use rollers of carpet, velvet back, or high-pile sheep’s wool as recommended for material applied.

c. Spray Application:

1) Spray application may only be used for shop application.

2) Use mechanical methods to apply coatings if permitted by manufacturer and governing regulations. Use spray equipment with orifice size as recommended by manufacturer for material being applied. Do not double back with spray equipment building up film thickness of 2 coats in one pass, unless recommended by manufacturer.

2. The number of coats and film thickness required is the same regardless of the application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. Where sanding is required, according to the manufacturer’s directions, sand between applications to produce a smooth, even surface.

3. Apply coating systems to provide an opaque, smooth surface of uniform finish, color, appearance and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness or other surface imperfections will not be accepted.
4. Make edges of coatings adjoining other materials clean and sharp with no overlapping. Work material into surfaces voids and hairline cracks.

5. Do not apply coatings over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to forming a durable coating film.

6. Do not use materials that are beyond the manufacturers recommended pot life.

7. Do not apply initial coating until moisture content of surface is within limitations recommended by coating manufacturer according to moisture meter testing.

8. Do not apply succeeding coats until previous coat has cured as recommended by coating manufacturer. Do not exceed manufacturer’s recommended maximum time limit for re-coating. If the manufacturer’s recommended maximum time limit has been exceeded, prepare surface as required by manufacturer prior to applying next coat.

9. Dry film thickness of each coat shall be according to the requirements specified herein or manufacturer’s recommendation, whichever is greater.

C. Primer Application: Apply primer coats to surfaces, in fabricator’s shop or in field as indicated in schedules below, that have been cleaned, pretreated (if required), or otherwise prepared for coating as soon as practical after preparation and before subsequent surface deterioration.

D. Finish Coats:

1. Recoat primed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.

2. When undercoats or other conditions show through the final coat, apply additional coats until the cured film has a uniform coating finish, color, and appearance. Give special attention to edges, corners, crevices, welds, exposed fasteners, and similar surfaces to ensure that they receive a dry film thickness equivalent to that of flat surfaces.

E. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or recoat work that does not comply with specified requirements.

3.4 REPAIR

A. Repair defects such as overspray, runs, sags, voids, blistering, peeling, rusting, inadequate cure, and lack of adhesion according to the touch-up and repair procedures accepted by the Authority.

B. Remove mud cracking on steel, except sheet metal by blasting. Remove mud cracking on sheet metal per SSPC-SP 11; take care to avoid deformation of the metal. Suitably restore the surface profile for the specified paint material.

3.5 FIELD QUALITY CONTROL

A. Independent Inspection Agency: Authority reserves the right to invoke testing by an independent testing laboratory whenever and as often as deemed necessary during coating applications.

1. Samples of materials delivered to site will be taken, identified, sealed, and certified in presence of Contractor.

2. Tests include, but are not limited to, the following:
   a. Quantitative materials analysis.
   b. Absorption.
   c. Accelerated weathering.
   d. Accelerated yellowness.
   e. Color retention.
   f. Alkali and mildew resistance.
   g. Abrasion resistance.
   h. Apparent reflectivity.
   i. Washability.
   j. Dry Opacity.
   k. Recoating.
   l. Skinning.

3. If results indicate materials being used does not conform with Contract Documents, Contractor may be directed to remove nonconforming materials, pay for testing, recoat surfaces coated with rejected materials, or remove rejected materials from previously coated surfaces if, upon recoating with specified materials, the two coatings are not compatible.

B. Contractor’s Field Quality Control: The Contractor shall furnish the necessary testing and inspection
COATINGS FOR STEEL

instruments, calibrated and maintained. Such equipment shall be available for use by the Contracting Officer upon request. Verify, in the presence of the Contracting Officer, that the following are as specified and document using the form at the end of this Section or form approved by the Contracting Officer. Obtain Contracting Officer's sign-off of forms.

1. Coatings and other materials.

2. Surface preparation and application.

3. Environmental conditions prerequisite for each coat.

4. Surface conditions prerequisite for each coat.

5. Minimum and maximum re-coating time limitations and pot life expiration times.

6. Mixing, thinning, and induction time.

7. DFT of each coat and total DFT of coating system using wet film and dry film gauges.

8. Coating Defects: Check coatings for film characteristics or defects that would adversely affect performance or appearance of coating systems.

9. Report:
   a. Complete Surface Preparation and Coating Inspection Record for each portion of the work for each system as agreed to by the Authority.
   b. Written reports describing inspections made and actions taken to correct nonconforming work.
   c. Nonconforming work not corrected.

C. Independent Painting Inspector: In addition to the Contractor's Quality Control, the Contractor shall provide an independent painting inspector to verify the items listed under Contractor's Field Quality Control.

D. Determination of Dry Film Thickness (DFT):

1. The specified DFT shall be a minimum of the profile depth of the coating, when dry, as measured from the face of the surface to be coated. The specified DFT over blasted or otherwise roughened surface requires a dry film thickness gage reading on the bare surface prior to painting. The bare surface gage reading shall then be deducted from the coated surface gage readings.

2. Measure film thickness as follows:
   a. Magnetic surfaces by use of a Mikrotest or Elcometer thickness gauge in accordance with SSPC-PA 2.
   b. Nonmagnetic surfaces by wet film thickness readings, thus verifying the calculated wet film thickness required to achieve the specified dry film thickness.
   c. Disputed thickness shall have a final check using the Tooke gage.

E. Surface Preparation and Coating Inspection:

1. Determine dew point and relative humidity following procedures of ASTM E337.

2. Readings are required prior to application and approximately every four hours or at other time intervals approved in writing by the Contracting Officer. Alternatively, continuous monitoring shall be performed using systems established and/or accepted by the Contracting Officer in writing.

3. Review temperature, humidity, and dew point readings upon noticeable deterioration of conditions or as requested by the Contracting Officer.

4. Compare blast cleaned surfaces with SSPC Vis 1, visual standards. Verify the anchor pattern profile depth in accordance with ASTM D4417.

5. Use grease-free chalk to mark local areas which do not meet specified standards.

6. Take surface temperature and humidity reading prior to application of each coat. The work shall not proceed if the ambient temperature parameters are outside the specified requirements. If more stringent, the coating manufacturer's requirements shall dictate.

7. Visually inspect the coating for defects such as overspray, runs, sags, voids, blistering, peeling, rusting, mud cracking, inadequate cure, and lack of adhesion.

F. Manufacturers Field Service:

1. Manufacturer shall provide qualified technical representative.

2. Representative shall periodically inspect material and application to insure installation is proceeding in accordance with manufacturers designs,
COATINGS FOR STEEL

recommendations and warranty requirements.

3. Representative shall submit reports as indicated in the "Quality Assurance" Article above.

3.6 CLEANING

A. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping.

3.7 PROTECTION AND TOUCH UP

A. Protect surfaces, structures, landscaping, and vehicles including those of adjacent property owners from damage by painting including over spray.

B. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repainting, repairing or replacing. Coordinate corrections with other trades involved.

C. Provide "Wet Paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Prepare areas requiring touch up as required by coating manufacturer. Touch up with materials used in the work. In the case of shop primer, primer shall be product recommended in writing by coating manufacturer for field touch up.

3.8 COATINGS FOR STEEL (HIGH PERFORMANCE COATINGS) SCHEDULE

A. PAINT AND COATINGS SYSTEM NO. 1: Thick Polysiloxane Coating System for exterior steel and ferrous metals:

1. Locations:
   a. Exterior architectural exposed structural steel (AESS) and steel bridges.

2. Steel Surface Preparation: As recommended by coating manufacturer, but not less than SSPC-SP 6/NACE No. 3

3. Coatings:
   b. 2nd Coat: Field applied touch-up of Epoxy Zinc-Rich Primer Coat. Brush or roller applied.

B. PAINT AND COATINGS SYSTEM NO. 2: Thin Polysiloxane Coating System for steel and ferrous metals, other than galvanized sheet metal:

1. System No. 2A:
   a. Locations (including, but limited to):
      1) Miscellaneous metal fabrications.
      2) Metal stairs
      3) Pipe and tube railings.
      4) Non-galvanized sheet metal.
   b. Steel Surface Preparation: As recommended by coating manufacturer, but not less than SSPC-SP 6/NACE No. 3.
   c. Coatings:
      1) 1st Coat: Shop applied Epoxy Zinc-Rich Primer Coat.
      2) 2nd Coat: Shop applied Thin Finish Coat.
      3) 3rd Coat: Field applied touch-up Thin Finish Coat. Brush or roller applied. Note: Brush applying may require 2 coats to achieve required coverage.

2. System No. 2B:
   a. Locations (including, but limited to):
      1) Structural steel (other than AESS)
   b. Steel Surface Preparation: As recommended by coating manufacturer, but not less than SSPC-SP 6/NACE No. 3.
   c. Coatings:
      1) 1st Coat: Shop applied Epoxy Zinc-Rich Primer Coat.
      2) 2nd Coat: Field applied touch-up of shop primer with Rapid Recoat Epoxy Zinc-
3) 3rd Coat: Field applied Thin Finish Coat. Brush or roller applied. Note: Brush applying may require 2 coats to achieve required coverage.

3. System No. 2C:
   a. Locations (including, but limited to):
      1) Hollow metal doors and frames.
      2) Other metal items specified to be shop primed by manufacturer.
   b. Steel Surface Preparation: As recommended by coating manufacturer, but not less than SSPC-SP 1.
   c. Coatings:
      1) 1st Coat: Field applied touch-up of shop primer with Rapid Recoat Epoxy Zinc-Rich Primer or Epoxy Zinc-Rich Primer Coat. Brush or roller applied.
      2) 2nd Coat: Field applied Thin Finish Coat. Brush or roller applied. Note: Brush applying may require 2 coats to achieve required coverage.

4. System No. 2D:
   a. Locations (including, but limited to):
      1) Exposed view galvanized mechanical and electrical items including pipe, conduit, junction boxes and hangers.
      2) Interior slotted channel framing system specified in Section 05430, “Slotted Channel Framing”.
   b. Surface Preparation: ASTM D2092 and as required by coating manufacturer.
   c. Coatings:
      1) 1st Coat: SSPC PAINT 27 or as required by coating manufacturer.
      3) 3rd Coat: Field applied Thin Finish Coat. Brush or roller applied. Note: Brush applying may require 2 coats to achieve required coverage.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. The work described in this section will be paid for on a lump sum basis for coatings for steel per location indicated wherein no measurement will be made.

END OF SECTION 09970
**SURFACE PREPARATION AND COATING INSPECTION RECORD**

<table>
<thead>
<tr>
<th>ENVIRONMENTAL CONDITIONS:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COATING WORK ACTIVITY</strong></td>
</tr>
<tr>
<td><strong>TIME</strong></td>
</tr>
<tr>
<td>DRY BULB TEMP. °F</td>
</tr>
<tr>
<td>WET BULB TEMP. °F</td>
</tr>
<tr>
<td>RELATIVE HUMIDITY, %</td>
</tr>
<tr>
<td>DEW POINT °F</td>
</tr>
<tr>
<td>SURFACE TEMP. °F</td>
</tr>
<tr>
<td>BLOTTER TEST</td>
</tr>
</tbody>
</table>

**PRE-SURFACE PREPARATION**

SSPC-SP1: ___________  MASKING/PROTECTION: ___________

SURFACE DEFECTS: ___________

**SURFACE PREPARATION**

METHOD: ___________  ABRASIVE TYPE/SIZE/STORAGE: ___________

CLEANLINESS SPEC: ________  ACTUAL: ________  PROFILE SPEC: ________  ACTUAL: ________

EQUIPMENT: ___________

**COATING MATERIALS & MIXING**

PRODUCT(S) ___________  BATCH NO(S)/QUANTITIES/EXPIRATION DATE: ___________

STORAGE: ___________  THINNERS/BATCH NO(S)/THINNING RATIO: ___________

MIXING: ___________  INDUCTION TIME: ___________

MATERIAL TEMPERATURE: ___________  POT LIFE EXPIRATION TIME: ___________

COATING/LINING APPLICATION START TIME: ___________  COATING/LINING APPLICATION FINISH TIME: ___________


METHOD: ___________  WFT: ___________  RECOAT TIME/TEMP: ___________  CURE TIME/TEMP: ___________

EQUIPMENT: ___________

**APPLIED COATING**

DRY FILM THICKNESS: SPEC: ___________  ACTUAL: ___________  METHOD: ___________

HOLIDAY TEST: ___________  METHOD: ___________  OTHER TESTING: ___________  METHOD: ___________

VISUAL COATING INSPECTION (FILM IMPERFECTIONS): ___________

TOUCH-UP AND REPAIR: ___________  FINAL CURE: ___________

**COMMENTS:** (Use reverse side or separate sheet if necessary) ___________

INSPECTOR'S SIGNATURE: ___________  DATE: ___________

END OF ATTACHMENT
PART 1 - GENERAL

1.1 DESCRIPTION
   A. Work required for this Section includes coatings for exterior concrete and masonry and supplementary items necessary to complete their installation.

   B. Exterior and interior steel surfaces coatings are specified and scheduled in Section 09970, "Coatings for Steel".

   C. Interior painting is specified in Section 09920, "Interior Painting".

1.2 REFERENCED STANDARDS
   A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

      1. ASTM D16 - Standard Terminology for Paint, Related Coatings, Materials, and Applications

1.3 SUBMITTALS
   A. Product Data: For each coating system specified.

   B. Samples for Verification: Of each color and material to be applied, with texture to simulate actual conditions, on representative samples of actual substrate.

      1. Submit samples on the following substrates for the Contracting Officer’s review of color and texture only:

      2. Provide two 4-inch square samples of actual substrate material for each color and texture.

1.4 QUALITY ASSURANCE
   A. Applicator Qualifications: Engage an experienced applicator who has completed coating system applications similar in material and extent to those indicated for this Project with a record of successful in-service performance.

   B. Control Samples (Mockups): Provide full-coat control finish samples of each type of coating and substrate required on the Project. Duplicate finish of approved prepared samples.

      1. The Contracting Officer will select one exterior wall surface at least 100 sq. ft. to represent surfaces and conditions for each substrate.

      2. After control samples are approved, these surfaces will be used to evaluate coating systems.

      3. Obtain the Contracting Officer’s approval of control samples before starting application of coatings.

      4. Final approval of colors will be from control samples, not samples submitted for verification.

1.5 PROJECT CONDITIONS
   A. Temperature Conditions: Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are within range permitted by manufacturer’s written instructions.

   B. Weather Conditions: Do not apply coatings in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; or at temperatures less than 5 degrees F above the dew point; or to damp or wet surfaces.

      1. Allow wet surfaces to dry thoroughly and attain temperature and conditions recommended by manufacturer before starting or continuing coating operation.

PART 2 - PRODUCTS

2.1 PRODUCTS
   A. Clear Sealer:

      1. Acceptable Manufacturers and Products:


         c. Sherwin-Williams SW244-40L VOC Silane Sealer Water Proofer.

         d. Or approved equal.

   B. Penetrating Acrylic Stain:

      1. Acceptable Manufacturers and Products:

         a. United Coatings - "Canyon Tone Stain".

         b. Chemprobe Coating Systems, L.P. - “Conformal Stain”.

         c. Tnemec Co., Inc. - “Series 180 Tneme-Crete”.

DART Standard Specifications – July 2014
d. Sherwin-Williams - SWD Bridge and Highway Heavy Waterbased Stain, B97 Series.
e. Or approved equal.

C. Anti-Graffiti Coatings (Permanent, Water-Cleanable):
   1. Acceptable Manufacturers and Products:
      a. CSL Silicones, Inc
         1) Si-Coat 530 (Clear)
         2) Si-Coat 579 (Pigmented)
      b. Sherwin-Williams - “B97C00150”
      c. Monopole, Inc – “Permashield Premium”
      d. Prosco
         1) Sure Klean Weather Seal Blok-Guard and Graffiti Control
e. Or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates surfaces to receive elastomeric coating system and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to installer. Starting work within a particular area will be construed as applicator’s acceptance of surface conditions.

3.2 PREPARATION

A. General: Remove items already installed that are not to be coated. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and coating. After completing coating operations in each area, reinstall items removed, using workers skilled in trades involved.

B. Cleaning: Before applying coatings or other surface treatments, clean substrates of substances that could impair bond of coating systems. Remove oil and grease before cleaning. Schedule cleaning and coating application so dust and other contaminates will not fall on wet, newly coated surfaces.

C. Surface Preparation: Clean and prepare surfaces to be coated according to manufacturer’s written instructions for the particular substrate conditions and as specified.
   1. For Clear Sealer: Remove efflorescence and roughen surfaces where necessary to improve adhesion. Point up holes.
   2. For Penetrating Acrylic Stain: Methods and materials used for cleaning of substrate shall be as recommended by the manufacturer of the water repellent stain.

D. Material Preparation: Mix and prepare materials according to coating manufacturer’s written instructions.
   1. Stir materials before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film that may form into material. Remove film and, if necessary, strain coating material before using.
   2. If manufacturer permits thinning, use only thinners recommended by manufacturer, and only within limits recommended by manufacturer.

3.3 APPLICATION

A. General: Apply coatings to exposed surfaces indicated, according to manufacturer’s written instructions.

B. Application Procedures: Apply coatings by brush, roller, or spray according to manufacturer’s written instructions.
   1. Brushes: Use brushes best suited for material being applied.
   2. Rollers: Use professional-quality quick-release rollers of carpet, velvet back, or high-pile sheep’s wool covers as recommended by the manufacturer for material and texture required.
   3. Spray Equipment: Use airless spray equipment with orifice size as recommended by the manufacturer for material and texture required.
   4. Minimum Coating Thickness: Apply each material no thinner than manufacturer’s recommended spreading rate.
   5. Wherever spray application is used, apply each coat to provide equivalent hiding of brush-applied coats. Do not double back with spray equipment, building up film thickness of 2 coats in 1 pass.
C. Brush Application: Brush out and work brush coats into surfaces in an even film. Eliminate cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Neatly draw glass lines and color breaks.

D. Roller Application: Keep the cover wet at all times; do not dry roll. Work in sections. Lay on required amount of material, working material into grooves and rough areas; then level material, working it into surface.

E. Spray Application: Use spray equipment for application only when required by manufacturer’s written recommendations and authorities having jurisdiction.

F. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or recoat work not complying with specified requirements.

3.4 CLEANING

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from the Project site.

B. After completing coating work, clean glass and spattered surfaces. Remove spattered coatings by washing, scraping, or other methods, being careful not to scratch or damage adjacent finished surfaces.

3.5 PROTECTION

A. Protect work of other trades from damage whether being coated or not. Correct damage by cleaning, repairing, replacing, and recoating as approved by the Contracting Officer. Leave in an undamaged condition.

B. Provide "Wet Paint" signs to protect newly coated finishes. Remove temporary protective wrappings provided by others to protect their work after completing coating operations.

C. After construction activities of other trades are complete, touch up and restore damaged or defaced coated surfaces.

3.6 COATINGS FOR CONCRETE AND MASONRY SCHEDULE

A. PAINT AND COATINGS SYSTEM NO. 3: Clear Sealer.
   1. Locations: All exterior concrete and masonry.
   2. Coatings:
      a. Two Coats: Clear Sealer.

B. PAINT AND COATINGS SYSTEM NO. 4: Penetrating Acrylic Stain.
   1. Locations: Where indicated.
   2. Coatings:
      a. Two Coats: Clear Sealer. Only one coat required on Sherwin-Williams system.
      b. Two Coats: Penetrating Acrylic Stain. For first coat on CMU, use heavy-duty product.

C. Anti-Graffiti Permanent, Water-Cleanable:
   1. Locations: Where indicated.
   2. Application:
      a. Apply anti-graffiti coatings on dry concrete surfaces only, when the temperature of the substrate surface and material is 50 degrees F or above.
      b. Do not apply anti-graffiti coatings when impending weather conditions might result in injury to fresh coating.
      c. Do not apply anti-graffiti coatings over any existing appearance coating unless otherwise noted on plans.

3. Coatings:
   a. Apply a primer, when required by the manufacturer, in accordance with manufacturer's recommendations.
   b. Do not thin the coating without prior approval.
   c. Replace permanent anti-graffiti coatings not meeting with ASTM D4752.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for coatings for concrete and masonry per location indicated wherein no measurement will be made.
PART 1 - GENERAL

1.1 SUMMARY

A. Work required for this Section includes wall louvers and supplementary items necessary to complete their installation.

1.2 REFERENCE STANDARDS

A. Air Movement and Control Association (AMCA):
   1. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating
   2. AMCA 501 - Application Manual for Air Louvers

B. American Architectural Manufacturers Association (AAMA):
   1. AAMA 611 - Voluntary Standards for Anodized Architectural Aluminum Revised
   2. AAMA 2605 - Voluntary Specifications, Performance Requirements and Test Procedures for Superior Performing Organic Coatings and Aluminum Extrusions and Panels

C. American Welding Society (AWS):
   1. AWS D1.2 - Structural Welding Code - Aluminum

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
   2. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
   3. ASTM D1187 - Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal
   4. ASTM E488 - Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements

E. Building Research and Information Association (BSRIA):
   1. HEVAC Technical Specification - Laboratory Testing and Rating of Weather Louvres When Subjected to Simulated Rain

F. National Association of Architectural Metal Manufacturers (NAAMM):
   1. NAAMM's "Metal Finishes Manual for Architectural and Metal Products"

G. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):
   1. SMACNA - Architectural Sheet Metal Manual

1.3 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section, unless otherwise defined in this Section or in referenced standards.

B. Standard Free Area: Free area of a louver 48 inches wide by 48 inches high, identical to that provided.

C. Maximum Standard Airflow: Airflow at point of beginning water penetration through a louver 48 inches wide by 48 inches high, identical to that provided.

D. Drainable-Blade Louver: Louver designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and channels in jambs and mullions.

1.4 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide exterior metal louvers capable of withstand the effects of loads and stresses from wind and normal thermal movement without evidencing permanent deformation of louver components including blades, frames, and supports; noise or metal fatigue caused by louver blade rattle or flutter; or permanent damage to fasteners and anchors.

   1. Design: By professional engineer employed by louver manufacturer.
   2. Wind Load: Uniform pressures (velocity pressures) required by applicable local code acting inward or outward. Refer to Design Wind Pressure Schedule on drawings.
   3. Thermal Movements: Provide louvers that allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, and other detrimental effects:
      a. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

B. Air-Performance, Water-Penetration, and Air-Leakage Ratings: Provide louvers complying with performance requirements indicated, as demonstrated by testing
WALL LOUVERS

manufacturer's stock units 48 inches wide by 48 inches high.

1. Perform testing on unpainted, cleaned, degreased units.
2. Perform water-penetration testing on louvers without screens.
3. Test units according to AMCA 500-L.
4. Storm Resistant Louvers: Performance ratings of units shall be certified by BSRIA under HEVAC Technical Specification.

1.5 SUBMITTALS

A. Product Data: For each type of product specified.

B. Shop Drawings: For louver units and accessories. Include plans; elevations; sections; and details showing profiles, angles, and spacing of louver blades. Show unit dimensions related to wall openings and construction; free area for each size indicated; profiles of frames at jambs, heads, and sills; and anchorage details and locations.

1. For louvers indicated to comply with design loadings, include shop drawings and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Samples for Initial Selection: Manufacturer’s color charts showing the full range of colors available for units with factory-applied color finishes.

D. Samples for Verification: Of each type of metal finish required, prepared on Samples of same thickness and material indicated for final Work. Where finishes involve normal color and texture variations, include Sample sets showing the full range of variations expected.

E. Product Certificates: Signed by manufacturers of louvers certifying that the products furnished comply with requirements and are licensed to bear the AMCA seal based on tests made according to AMCA 500 and complying with AMCA’s Certified Ratings Program.

1.6 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is licensed in State of Texas and who is experienced in providing engineering services of kind indicated. Engineering services are defined as those performed for installations of louvers that are similar to those indicated for this Project in material, design, and extent.

B. Source Limitations: Obtain louvers through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

C. Welding Standards: As follows:

1. Comply with AWS D1.2.
2. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.


1.7 PROJECT CONDITIONS

A. Field Measurements: Verify louver openings by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish opening dimensions and proceed with fabricating louvers without field measurements. Coordinate construction to ensure that actual opening dimensions correspond to established dimensions.

1.8 WARRANTY

A. Finish Warranty: Provide written warranty signed by manufacturer and installer, agreeing to repair or replace work which exhibits defects in finish. "Defects" is defined to include, but is not limited to, peeling, chipping, chalking, fading, abnormal aging or deterioration, and failure to perform as required.

1. Warranty Period for Fluoropolymer Finish: 10 years from date of Final Acceptance for color and film integrity.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Following manufacturers listed are “acceptable” only if manufacturer can evidence product compliance with requirements of Contract Documents.

1. Airline Products Co.
2. Airolite Co.
3. American Warming and Ventilating, Inc.
5. Construction Specialties, Inc.
7. Industrial Louvers, Inc.
8. Nystrom Building Products
9. Ruskin Company Tomkins PLC.
10. Or approved equal.

2.2 MATERIALS

A. Aluminum Extrusions: ASTM B221, alloy 6063-T5 or T-52.
B. Aluminum Sheet: ASTM B209, alloy 3003 or 5005, 0.032 inch minimum thickness with temper as required for forming, or as otherwise recommended by metal producer for required flashings.
C. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
   1. Use types and sizes to suit unit installation conditions.
   2. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
D. Postinstalled Fasteners: Torque-controlled expansion anchors, made from stainless-steel components, with capability to sustain, without failure, a load equal to 4 times the loads imposed, for concrete, or 6 times the load imposed, for masonry, as determined by testing per ASTM E488, conducted by a qualified independent testing agency.
E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187.

2.3 FABRICATION, GENERAL

A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
   1. Continuous Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates and without interrupting blade-spacing pattern.
B. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining materials’ tolerances, and perimeter sealant joints.
   1. Frame Type: Channel type, unless otherwise indicated.
D. Include supports, anchorages, and accessories required for complete assembly.
E. Provide vertical Mullions of type and at spacings indicated, but not more than recommended by manufacturer, or 72 inches o.c., whichever is less.
   1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
   2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.
   3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
   4. Exterior Corners: Prefabricated corner units with concealed close-fitting splices or welded blades and with semirecessed mullions at corners.
F. Provide sill extensions and loose sills made of same material as louvers where required for drainage to exterior and to prevent water penetrating to interior.
G. Join frame members to one another and to fixed louver blades with manufacturer’s standard fillet welds or threaded fasteners concealed from view, unless size of louver assembly makes bolted connections between frame members necessary.

2.4 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Standard Horizontal Louvers: Nondrainable fixed-blade louvers with extruded-aluminum frames and blades.
   1. Louver Depth: 4 inches or 6 inches as indicated.
   2. Frame Thickness: As required by the engineered design, but not less than 0.080 inch.
   3. Blade Thickness: As required by the engineered design, but not less than 0.080 inch.
4. Blade Angle and Spacing: 45 degrees and 4 inches o.c. for 4 inches deep louver.

5. Blade Angle and Spacing: 45 degrees and 6 inches o.c. for 6 inches deep louver.

6. Free Area: Not less than 8.0 sq. ft. for 48-inch wide by 48-inch high louver.

7. Point of Beginning Water Penetration: Not less than 790 fpm.

8. Air Performance: Not more than 0.12-inch wg static pressure drop at 790 fpm free-area velocity.

9. AMCA Seal: Mark units with AMCA Certified Ratings Seal.


B. Continuous, Horizontal, Drainable-Blade Louvers: Fabricated with close-fitting, field-made splice joints in blades designed to permit expansion and contraction without deforming blades or framework and with mullions recessed from front edges of blades so blades have continuous appearance.

1. Louver Depth: 6 inches unless otherwise indicated.

2. Frame Thickness: As required by the engineered design, but not less than 0.080 inch.

3. Blade Thickness: As required by the engineered design, but not less than 0.080 inch.

4. Blade Profile: Continuous Dual Drain.

5. Mullion Profile: Semi Recessed.

6. Blade Angle and Spacing: 45 degrees and 6 inches o.c. for 6 inches deep louver.

7. Free Area: Not less than 7.8 sq. ft. for 48 inch wide by 48 inch high louver.

8. Point of Beginning Water Penetration: Not less than 850-fpm.

9. Air Performance: Not more than 0.10 inch wg static pressure drop at 850 fpm free-area velocity.


2.5 LOUVER SCREENS

A. General: Provide each exterior louver with louver screens complying with the following requirements:

1. Screen Location: Interior face, unless otherwise indicated.

2. Screening Type: Bird screening, unless otherwise indicated.

B. Secure screens to louver frames with stainless-steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.

C. Louver Screen Frames: Fabricate screen frames with mitered corners to louver sizes indicated and to comply with the following requirements:

1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.

2. Finish: Same finish as louver frames to which louver screens are attached.

3. Bird Screen Type: Non-rewirable, U-shaped frames for permanently securing screen mesh.

D. Louver Screening for Aluminum Louvers:

1. Bird Screening: Aluminum, 1/2 inch square mesh, 0.063 inch wire.
2.6 FINISHES, GENERAL

A. Comply with NAAMM’s "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Finish louvers after assembly.

2.7 ALUMINUM FINISHES

A. Finish designations prefixed by AA comply with system established by the Aluminum Association for designating aluminum finishes.

B. Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

C. High-Performance Organic Coating Finish: AA-C12C42R1x (Chemical Finish: cleaned with inhibited chemicals; Chemical Finish: acid-chromate-fluoride-phosphate conversion coating; Organic Coating: as specified below). Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Fluoropolymer Two-Coat Coating System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent polyvinylidene fluoride resin by weight; complying with AAMA 2605.


3.3 INSTALLATION

A. Locate and place louver units level, plumb, and at indicated alignment with adjacent work. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection. Form closely fitted joints with exposed connections accurately located and secured. Provide perimeter reveals and openings of uniform width for sealants and joint fillers.

B. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

C. Protect metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

D. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses, where weathertight louver joints are required. Comply with Section 07900, "Seals and Sealants" for sealants applied during louver installation.

3.4 CLEANING, AND PROTECTING

A. Clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

B. Protect louvers from damage during construction. Use temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at the time of Substantial Completion.

C. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Contracting Officer, remove damaged units and replace with new units.

1. Clean and touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

3.5 LOUVER SCHEDULE

A. Standard Horizontal Louver: Typical exterior protected locations - Lower level of aerial and cut stations.

B. Drainable Blade Louvers: Typical exterior semi-protected locations - Above elevators doors at upper level of aerial and cut stations.

C. Storm Resistant Louvers: Typical exterior non-protected locations - Locations not listed above.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for wall louvers per location indicated wherein no measurement will be made.

END OF SECTION 10210
SECTION 10430
SPECIALTY SIGNS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing specialty signs. The extent and location of "specialty signs" work is indicated on the drawings, and includes:

1. Site Identification Signs (sign Types 1.X)
2. Platform Sign Bands (Sign Types 4.X)
3. Kiosks (Sign Types 6.X)

1.2 REFERENCED STANDARDS

A. American Institute of Steel Construction, Inc. (AISC):
   1. "Specifications for Design, Fabrication, and Erection of Structural Steel for Buildings"

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel
   2. AWS D1.2 - Structural Welding Code Aluminum

C. DART Sign Standards Manual.

1.3 SUBMITTALS

A. Manufacturer's Data: Submit manufacturer's technical data and installation instructions for each type of sign required.

B. Samples: Submit samples of the color and finish of exposed materials and accessories required for specialty signs prior to proceeding with prototype signs. The Contracting Officer's review of samples will be for color and texture only. Compliance with other requirements is the exclusive responsibility of the Contractor.

C. Submit samples for approval of the following materials and colors:

   1. DART Yellow background on 0.125 inch extruded aluminum plate (minimum 24 inch x 24 inch), with typical DART logo screen-printed in white and DART Blue, in baked enamel.
   2. White background on 0.125 inch extruded aluminum plate (minimum 24 inch x 24 inch), with typical DART Blue screen-printed lettering, in baked enamel.
   3. White background baked enamel finish, on 0.125 inch extruded aluminum plate (minimum 24 inch x 24 inch), with typical DART Blue vinyl cut-out lettering.
   4. Bright Blue background on cast aluminum plate (minimum 12 inch x 12 inch) with typical raised characters or symbol and grade 2 Braille.

D. Shop Drawings: Submit shop drawings of sign components, fittings, parts, wiring, and installation procedures showing layout, jointing, and complete anchoring and supporting systems for the various applications, and mounting details. Drawings shall clearly show provisions for performance functions described herein. Provide details and sections at full size. Differences from the Contract Drawings shall be clearly identified and brought to the Contracting Officer's attention in writing.

E. Sign Face Patterns: Submit, in duplicate, accurate full-size sign face patterns of each sign, accurately showing the relationship of parts to each other, including the sign border, and a description of the method of executing the work. Obtain the Contracting Officer's approval of patterns before proceeding with the work part of the assembly. Submit, where required, in duplicate, accurate full-size translations of Grade 2 Braille sign messages.

F. Prototypes: Manufacturer to fabricate and submit for approval, one completed sign of each type specified in the construction documents before proceeding with subsequent signs. When approved, the prototype sign will be counted as a completed unit.

G. Certifications: Submit certificates indicating that materials and products used on the Project meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. The Contractor shall be an established firm which is regularly engaged in the fabrication of sign systems. The Contractor shall also submit a list of sizable installations provided over a period of at least three years, or the Contracting Officer shall be sufficiently convinced by observation and other substantiating data that fabrication and installation of a lesser period of time will prove adequate.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver specialty signs in cartons or crates to provide protection during transit and storage to the Worksite.
B. Inspect specialty signs upon delivery for damage. Repair minor damage provided that the finish items are equal in all respects to new work; otherwise, remove and replace damaged items as indicated. If damaged, polycarbonate panels shall not be repaired but shall be replaced.

c. Insofar as practicable, fabricate, assemble, and fit the work in the shop with the various parts or assemblies ready for erection at the site.

d. Trial fit work that cannot be shipped to site, shop assembled, to assure a proper and expeditious field assembly.

e. Accurately machine, file, fit, and rigidly frame together sign joints, corners, miters, etc., at joint and contact points. Form materials to shapes with straight lines, sharp angles and smooth curves, and hairline joints. Fit operable parts to stationary components with only enough clearance for proper operation. Final product to resemble custom metal casework in quality and tolerances. On plastic materials upon which graphics will be fixed or surfaced, make joints “seamless” from a viewing distance of 5 feet.

f. Machine and fit removable and operable members and devices carefully for smooth, easy operation.

g. Secure members, components, and elements by mechanical fasteners of proper size and spacing as detailed or otherwise required to rigidly hold members in place without distortion or deflection. Utilize concealed mechanical fasteners unless otherwise allowed or indicated to be exposed.

h. Exposed fasteners are to be of tamper proof type, painted to match adjacent material.

i. Perform welding of the correct type to minimize permanent distortions of flat surfaces. Utilize welding rods of the same alloy as the substrate panel. Remove welding flux, oxides, and discolorations by pickling or grinding, to match the finish of the adjacent areas. Comply with AWS D1.1/D1.1M for structural steel and AWS D1.2 for aluminum. Make welds full penetration type unless noted to be spot welds.


k. Provide cutouts, fittings, and anchorages required for coordination of assembly and installation with other work.

C. Store specialty signs under cover. Place units on at least 4 inch sills on floors in a manner that will prevent damage and rusting. Avoid the use of non-vented plastic or canvas shelters which could create a humidity chamber, or contact with soil or exposure to the elements.

D. Specialty signs shall be delivered to the Worksite in original unopened packages, clearly labeled with manufacturer’s name, brand, specification identification data, and identification as shown on approved shop drawings or submittals.

E. Packaging shall be made with labels fixed identifying clearly the type and quantity of the specialty signs, and the station where these signs will be installed.

PART 2 - PRODUCTS

2.1 ALL SIGNS

A. Lettering: Lettering shall be computer generated/cut. Hand-rendered or hand-cut lettering is not acceptable.

B. Where noted, utilize camera-ready art provided by the Contracting Officer.

C. Structural Frame: The framework of signs shall have sufficient strength and rigidity to support the weight and horizontal loads (wind loads) of the entire sign box assembly, from mounting points located as indicated in the mounting detail drawings, without noticeable deformation due to deflection or warping of any part of the assembly. Separate aluminum from steel with suitable bituminous coating.

D. Sign Cabinets, Cladding, and Trim:

1. Aluminum: 0.125 inch extruded aluminum with channel framework. Pieces shall be true, square, and free from warping, bending, blemishes, and scratches.

2. Fabrication:
   a. Develop details for fabrication engineering on shop drawings.
   b. Fabricate signs to comply with requirements indicated for materials, thickness, finishes, colors, designs, shapes, sizes, and details of construction as shown in the Contract documents.
SPECIALTY SIGNS

1. Punch or drill for temporary field connections and attachment of work by other trades. Pre-drill for attachments in steel sign faces and trim panels before porcelainizing.

m. Touch-up fabrication abrasions prior to shipment.

3. Accessibility: Provide for easy access by Authority's maintenance crews to interior of the sign box for changing lamps and ballasts. Provide for easy removal and easy, accurate reinstallation of the sign face by maintenance crews.

4. Expansion/Contraction: Provide for expansion and contraction of the sign face, without bowing, warping, or exposure of light leaks, to a range of ambient temperatures from plus 100 degrees F to 0 degrees F for exterior signs and from 85 degrees F to 55 degrees F for interior signs, taking into account the added temperature of the ballast and lamps.

5. Heat Dissipation: Provide means to adequately and safely dissipate heat from the ballast, ensuring that light leaks, moisture, or dust penetration do not result.

6. Moisture and Water Dissipation: Provide means to adequately and safely dissipate moisture and water from the signs.

7. Interior Painted Illuminated Signs: Paint interior surfaces and parts (except the inside of raceways) with two coats of matte white, noncombustible paint compatible with the receiving surface.

E. Sign Faces:

1. Steel Faces: Steel sign faces shall be 16 gauge, porcelain enamel grade. Exposed edges shall be true and smooth, shall have sharp interior corners, and shall be colored identical to the face. Back steel faces with 1/2 inch thick exterior gypsum sheeting, followed with an additional 22 gauge sheet steel backing. Attach backing with suitable adhesive and/or welded studs.

2. Aluminum Faces: Aluminum sign faces shall be 0.125 inch extruded aluminum plate. Exposed edges shall be true and smooth, shall have sharp interior corners, and shall be colored identical to the face. Back faces with ½ inch thick exterior gypsum sheeting, followed with an additional 0.0625 inch sheet backing. Attach backing with suitable adhesive and/or welded studs.

3. Polycarbonate:

   a. 1/8 inch thick translucent polycarbonate plastic sheeting, G.E. "Lexan", or approved equal. The following is a standard Lexan color and shall be strictly adhered to in hue, shade, and tone. Backup or body sheet; Green #2108.

   b. Polycarbonate for faces and backup sheets must not discolor with age or under conditions of normal light, cold, heat, and moisture of exterior weather.

   c. Exposed edges or cut-outs shall be true and smooth and have sharp interior corners.

   d. Attachment of polycarbonate backup or body sheet to porcelain enamel shall be done with approximately 1/8 inch diameter studs welded to interior surface of sign face.

4. Vinyl Film Graphics:

   a. Vinyl film graphics and/or backgrounds shall be placed on sign faces as noted in the Contract Drawings. Vinyl to be applied only by mechanics skilled and experienced in vinyl application.

   b. Shop conditions of the Contractor shall be clean, free of air dust and of proper temperature.

   c. Applied vinyl film shall be free of air bubbles, dirt and dust bubbles. Lines shall be accurately and sharply cut by computerized cutting equipment, tightly seamed, and applied per manufacturer's specifications.

   d. Vinyl film shall be 3M, in the following materials and colors for vinyl sheeting and copy: Refer to DART Sign Standards Manual.

5. Joints:

   a. Joints are permitted only where shown on the Contract Drawings. Vertical and horizontal joints in the sign faces shall be true, tight, and unnoticeable with respect to shadows, dark strips, light strips, gaps, light leaks, or mismatched coloration.
b. Make provision to ensure that joints will remain true and tight under conditions of expansion and contraction of the faces, and under conditions of reinstallation of lamps and ballasts by maintenance crews.

6. Removability: Sign faces shall be removable and replaceable, without damage to the faces or the sign box assembly.

7. Illumination: Space lamps and arrange so that the entire sign face has uniform light intensity. Fluorescent lamps to be placed at no more than 12 inches on centers.

8. Antistatic Treatment: Treat polycarbonate surfaces with an antistatic solution following installation.

9. Manufacturer's Identification, Date, Sign Number: Illuminated signs shall have a label on the underside corner showing the manufacturer's name, date of manufacture, and numbers of the sign as shown on the drawings (sign number and elevation number), in 1/4 inch letters. The label shall be of clear material or of a matching dark blue color, with black letters.

10. Interchangeability: Sign faces of same sign types must be fabricated with identically matching mountings and mounting holes to ensure interchangeability.

11. Baked Enamel Colors: Baked enamel sign panels and graphics are to be gloss finish, and shall match the following colors: Refer to DART Sign Standards Manual.

12. Screen Printing: Signs designated in the DART Sign Standards Manual to have screen-printed legends shall be screen printed using materials and processes that are compatible with baked enamel finishes and processes. Colors shall match the above referenced Pantone colors. Screen-printing shall be performed in accordance with manufacturers instructions.

13. Grade 2 Braille: Where required, translations of sign messages to grade 2 Braille shall be provided by the Contractor.

2.2 ROOM NUMBER / ROOM IDENTIFICATION SIGNS

A. General: Provide combination room number/room identification signs as indicated on the schedules and/or Drawings.

B. Material: Sign type shall be white copy and background color on matte acrylic facing panel and aluminum frame.

C. Typeface: Helvetica Medium, all caps. Tactile text complying with applicable accessibility standards shall be provided at each location.

D. Composition:

1. A standard format shall be followed on all signs. The exact room numbers, titles and locations will be supplied to the Contractor in sufficient time to allow for fabrication and installation prior to completion.

2. Allow for fifty letters maximum for each sign. Letters shall be heights indicated with a minimum of 1/2 inch space at top, bottom and ends.

3. Locate graphics on sign as indicated on the drawings.

4. Provide one sign to read “Men” with graphic and tactile symbols at each Men’s restroom outer door.

5. Provide one sign to read “Women” with graphic and tactile symbols at each Women’s restroom outer door.

6. Provide one sign to read “Restroom” with graphic and tactile symbols at each Unisex’s restroom outer door.

7. Provide one handicap accessibility sign with graphic and tactile symbols at each restroom outer door. Symbols may be incorporated with room identification sign.

8. Door signs will be placed on the public side of the door and wall to latch side of door except where noted otherwise.

9. Signs shall have edges properly finished and with letters and numbers evenly and accurately cut. Spacing of letters and numbers shall be optically correct.

E. Sizes: As indicated on the drawings.

F. Attachment: Mounting to surfaces shall be done by pressure sensitive frame double-faced tape. Signs shall be delivered to the project site with the tape in place and trimmed on each sign, but with the protective paper not removed. Paper shall be removed just prior to installation of signs.

2.3 PAINTING

A. General: Refer to drawings for specific color locations.
B. Sign Painting:
   1. The painting of signs shall be performed only by mechanics skilled in painting and experienced in producing quality work. Lines shall be sharply cut.
   2. The shop conditions of the Contractor shall be clean, free of air dust, and of proper temperature.
   3. Apply shop painting by spraying except where inaccessible surfaces require brushing. Protect adjoining or adjacent surfaces against any discoloration.
   4. Painted faces shall be baked porcelain enamel finish unless otherwise noted, and be accomplished in compliance with the Porcelain Enamel Institute requirements.
   5. Paint sign brackets and exposed hardware (where required) to match adjacent surfaces.

C. Bituminous Coating: Heavy based asphaltic type. Apply to contact surfaces between aluminum and concrete and between aluminum and other dissimilar metals.

2.4 ELECTRICAL WORK

A. Electrical Work:
   1. Materials and equipment shall be new and UL approved for the purpose used. Accomplish work in accordance with applicable electrical construction codes and electrical safety codes.
   2. Obtain permits and pay fees required by governmental agencies having jurisdiction over the work. Arrange for inspections required during installation. Upon completion of the work, furnish satisfactory evidence that work has been installed in accordance with codes.
   3. Do cutting and patching required for installation of the work. Perform cutting and patching carefully to prevent damage to the structure and work of other trades. Cutting and patching shall be done by mechanics skilled in the trade affected and subject to approval of the Contracting Officer.
   4. Promptly remove and dispose of waste material and rubbish from the site. At completion of the work, clean lighting fixtures and signs and check for proper operation.
   5. Materials and workmanship shall be guaranteed for a period of one year after acceptance. Repair or replace failures or defects in materials or workmanship during this period without delay, at no expense to the Authority, provided that in the judgment of the Contracting Officer, such failures are not the result of misuse or abuse.

B. Raceways and Wiring:
   1. Install wiring in metallic raceways. Conceal raceways in finished areas. Exposed conduit is not permitted. In moist or damp areas, conduit shall be rigid galvanized steel; in dry areas, use electrical metallic tubing, galvanized or sheradized. E.M.T. fittings shall be compression type, similar to Appleton 96T050.
   2. Where crossing expansion joints or areas of movement of structure, install expansion joints O-Z type AX or AX8. Where approved by the Contracting Officer, flexible steel conduit may be used, either galvanized steel or watertight, depending upon environment. Connectors shall be of the type to provide secure connection for continuity of the raceway system.
   3. Outlet boxes or box extensions shall be galvanized or sheradized, processed steel not less than 1-1/2 inches deep and 4 inches square or octagonal.
   4. Wire shall be of copper conductors with type THHN/THWN or XHHW insulation. Minimum wire size shall be No. 12 A.W.G.
   5. Make splices or taps with 3M Brand "Scotch-Lok" connectors or equal with insulating caps. Color-coding of wires shall follow standardized building color-coding system.
   6. Plates, where required, shall be stainless steel in finished areas and galvanized steel in unfinished areas except for sign-mounted switch plates as noted below.
   7. When voltage and circuit designations are not shown on the drawings, verify these voltages and connection points before proceeding with the manufacture of the electrical portions of the signs and lighting.

C. Ballast:
   1. Ballasts shall be rated 120 or 277, as shown, CBM-certified by ETL, shall be high-power factor, and shall operate with a case temperature not to exceed 90 degrees C in the installed location. Ballasts shall be specifically qualified for sign usage, manufactured by Advance, Magnetic, Valmont, or approved equal.
   2. Fixtures located in areas subject to outside temperatures shall have low-temperature ballasts.
D. Sign Wiring: Conform to Article 600 of the N.E. Code. Label the stubbed-up conduit with the appropriate load.

E. Fluorescent Lamps: Lamps shall be standard T-12, rapid-start, high-output, 60 Hz units unless otherwise shown. "Watt Miser" type lamps are not acceptable. The color of fluorescent lamps shall be cool white for signs and lighting fixtures. Lamps shall be General Electric, Sylvania, Westinghouse, or equal.

F. Incandescent Lamps: 69 watt, type A21 clear traffic signal lamps (8000 hour rating) shall be used for flashing lamp applications indicated.

G. Fixtures: Fixtures and installation shall be Underwriters Laboratories - and Texas Electrical Code-approved.

H. Individual Sign Switch: Provide an "on - off" sign illumination switch, Bryant No. 7201 or approved equal, where noted on the drawings or schedule.

I. Switchable Signs: Signs incorporating switchable messages shall have appropriate internal baffles to prevent light from leaking from one sign message onto another. Cabinets shall be sealed to prevent light leaks to the sign exterior.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. Specialty signs described in this section will be paid for on a lump sum basis per location indicated wherein no measurement will be made.

END OF SECTION 10430
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the furnishing and installation of permanent specialty post and pole mounted signs, including Traffic Control Signs (Sign Types 3.X), and Bus Stop Signs (Sign Types 7.X), placed within the Light Rail Transit (LRT) Station areas as shown on the drawings.

B. Refer to Section 02845 “Traffic Control Signs” for requirements for regulatory and warning signs to be placed within City or State street right-of-way.

C. This section also specifies the furnishing and installation of posts for Pathfinder Signs (Sign Types 2.X), but does not include sign panels for this sign type.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel
   2. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   3. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

B. DART Sign Standards Manual.

1.3 SUBMITTALS
A. Manufacturer’s Data: Submit the manufacturer’s technical data and installation instructions for each type of sign required.

B. Samples: Submit full-size samples of complete sign panels of each sign type to be manufactured. The Contracting Officer’s review of samples will be for color, material, and compliance with the DART Signage Standards Manual. Compliance with other requirements is the exclusive responsibility of the Contractor.

C. Shop Drawings: Submit to the Contracting Officer shop drawings of sign components, fittings, parts, and installation procedures showing layout, jointing, and complete anchoring and supporting systems for the various applications and installation details. Drawings shall clearly show provisions for performance functions described herein. Provide details and sections at full size. Differences from the Contract Drawings shall be clearly identified and brought to the Contracting Officer’s attention in writing.

D. Submit copies of manufacturer’s product warranties for aluminum signs, vinyl film sheeting, screen printing inks and related materials.

E. Submit qualifications of sign manufacturer.

1.4 QUALITY ASSURANCE
A. The sign manufacturer shall be an established firm which is regularly engaged in the fabrication of specialty post and pole mounted signs. The Contractor shall submit a list of sizable fabrication projects completed over a period of at least three years, or the Contracting Officer shall be sufficiently convinced by observation and other substantiating data that experience over a lesser period of time will prove adequate.

1.5 JOB CONDITIONS
A. Location of Underground Facilities and Structures:
   1. Prior to excavating for sign post foundations, Contractor shall verify locations of underground facilities and structures. Locations shown for utility facilities are taken from the various utility records and are approximate.
   2. Verify locations of existing utilities in accordance with Section 02760, “Maintenance, Support and Restoration of Existing Utility Facilities”.

1.6 WARRANTY
A. Upon completion of sign installation, provide a 10 year warranty for the sign substrate and sign face against chipping, delaminating, and fading. Also, provide a warranty against retroreflectivity loss of not more than 50 percent for the reflective film over a 7 year period.

B. Refer to the General Provisions, Warranty of Construction, for additional warranty requirements applicable to the work of this section.

PART 2 - PRODUCTS

2.1 SIGNS
A. Sign Panels:
   1. Sign panels shall be fabricated from 0.125” thick aluminum and shall have retroreflective sheeting on face side. Pieces shall be true, square, and free from warping, bending, blemishes and scratches. Exposed edges shall be true and smooth. Panel fabrication
including cutting, punching, and drilling of holes shall be completed prior to final surface preparation and application of retroreflective sheeting.

2. Reflectivity: Copy and graphics shall be screen-printed over 3M Scotchlite Reflective Sheeting Diamond Grade VIP (Visual Impact Performance).

3. Sign faces shall be capable of withstanding the following tests:
   a. Sign face shall not be permanently defaced by steam, acids, aromatics, scratching, inks, or paints.
   b. Sign face shall be readily wiped clean with paint remover or solvents without affecting the appearance or legibility of the sign finish or graphics.
   c. Sign face shall retain legibility and finished appearance when sprayed with a 10 percent solution of hydrochloric, nitric, or sulfuric acid for one-half hour.
   d. Sign face shall retain legibility and finished appearance when scrubbed by a brush of medium hardness using common commercial cleaning compounds such as ammonia, laundry soaps, detergents, or petroleum base solvents.

4. Fabrication: Fabricate components in a uniform manner in compliance with the following requirements:
   a. Joints and seams are not acceptable. Pieces shall be true, square, and free from warping, bending, blemishes, and scratches. Edges shall not be crazed or cracked, and the edge finish shall be smooth, clean, and neat.
   b. The finished sign shall be absolutely flat.

5. Removability: Sign faces shall be removable and replaceable, without damage to the faces or the sign supports.

6. Manufacturer’s Identification, Date, Sign Number: Signs shall have a label on the support post, placed between the sign face brackets showing the manufacturer’s name, date of manufacture and number of the sign as shown on the Contract Drawings (sign number and elevation number), all in 1/4 inch letters. The label shall be of clear material, or of a matching gray color with black letters. The label shall not exceed 2 inches in width or height.

7. Interchangeability: Sign faces of like dimensions shall be fabricated with identical matching mountings and mounting holes to ensure interchangeability and ease of replacement.

B. Sign Graphics: Sign graphics shall be screen printed, utilizing camera-ready art provided by the Contracting Officer. Neither hand rendered nor hand-cut legends will be accepted.

1. SCOTCHLITE Sheeting Series 3990/SCOTCHLITE Ink Series 880:
   3M Products/Literature Bulletins
   Base/Application Film: 3990
   SCOTCHLITE Reflective Sheeting Series 3990
   Screen Printing Ink: SCOTCHLITE Ink Series 880
   Thinner: 821
   Overprint Clear: SCOTCHLITE
   Overprint Clear 880
   Thinner: 821
   Related Literature:
   Scoring/Cutting 4.1
   Surface Preparation 5.1
   Application Procedures 5.5
   Removal Procedures 6.5

2. Manufacturing: Manufactured using materials and procedures described in the appropriate Product Instruction Bulletins referred to above.

3. Graphics Installation: Surface preparation and application of marking must use the material, methods and tools described in the appropriate Product and Instruction Bulletins referred to above.

4. Screen-printing shall be performed in a "first class" manner, with edges of graphics sharp and accurate, and with adequate ink opacity and color consistency to avoid any changes in colors or graphics, including where graphic elements overlap.


C. Support Posts:

1. Support posts shall be 3-inch square steel tubes, as specified in the Contract Drawings, galvanized ASTM A500. Post shall be
designed to bend on impact at a height six inches above finished grade.

2. Support post for Pathfinder Signs: Breakaway as specified in with Section 02845, “Traffic Control Sign”.

D. Sign Face Brackets: Where signs are to be mounted to new poles, the mounting brackets shall be steel angle, galvanized ASTM A36/A36M.

E. Flared Leg Bracket (for Existing Poles): Where signs are to be mounted to existing poles, a flared leg bracket, #M2G-FUB as manufactured by Hawkins Traffic Safety Supply, Berkeley, CA; or approved equal shall be used. The signs shall be attached to the bracket with vandal-resistant screws. Stainless steel straps with tightening clips shall hold the brackets to the post.

2.2 PAINTING

A. Where specialty post and pole mounted signs are installed on LRT platforms, paint posts and brackets gray (Benjamin Moore #1600), gloss finish, in accordance with Section 09970, “Coatings for Steel”.

2.3 CONCRETE

A. Concrete: Mix S-7, as specified in Section 03305, “Portland Cement Concrete”.

B. Concrete Reinforcement: In accordance with Section 03200, “Concrete Reinforcement”.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the substrates and conditions under which the specialty post and pole mounted signs are to be installed.

B. Verify location of underground utilities prior to installing posts.

3.2 INSTALLATION

A. Excavate for concrete foundations in accordance with Section 02220, “Grading, Excavating, and Backfilling”. Install concrete foundations in accordance with Section 03300, “Cast-in-Place Concrete”.

B. Install sign posts plumb.

C. Set posts at locations and to elevations shown.

D. Install posts for Pathfinder Signs in accordance with Section 02845, “Traffic Control Signs”.

E. Install sign units and components at the locations shown or scheduled, securely mounted.

F. Install level, plumb, and at the proper height. Coordinate with work of other sections for installation of sign units to finish surfaces. Repair or replace damaged units as directed by the Contracting Officer.

3.3 TEMPORARY COVERS

A. Signs which are installed prior to their assigned function being open to public use shall be covered by the Contractor to conceal the face from view.

B. Coverings shall be dark gray or black plastic material acceptable to the Contracting Officer, neatly affixed to the sign face with matching or concealed fasteners. Clean the signs when coverings are removed.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Specialty post and pole mounted signs described in this section will be paid for on a lump sum basis per location indicated wherein no measurement will be made.

B. Pathfinder Signs (Sign Types 2.X) shall have all components installed as shown on the drawings, with exception of sign panels. Sign panels will be furnished and installed by others.

END OF SECTION 10441
SECTION 10522
FIRE EXTINGUISHERS AND CABINETS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the furnishing and installing of fire extinguishers and cabinets as specified herein and supporting devices as shown.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
   2. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
   3. ASTM C1048 - Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass
B. National Fire Protection Association (NFPA)
   1. NFPA 10 - Standard for Portable Fire Extinguishers

1.3 SUBMITTALS
A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for fire-protection specialties.
   1. Fire Extinguishers: Include rating and classification.
   2. Cabinets: Include roughing-in dimensions, details showing mounting methods, relationships of box and trim to surrounding construction, door hardware, cabinet type, trim style, and panel style.

1.4 QUALITY ASSURANCE
A. Source Limitations: Obtain fire extinguishers and cabinets through one source from a single manufacturer.
B. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Standard for Portable Fire Extinguishers".
C. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Following manufacturers listed are "acceptable" only if manufacturer can evidence product compliance with requirements of Contract Documents.
   1. J.L. Industries, Inc.
   2. Larsen's Manufacturing Co.
   3. Potter-Roemer, Div. of Smith Industries Inc.
   4. Or approved equal.

2.2 MATERIALS
A. Cold-Rolled Steel Sheet: Carbon steel, complying with ASTM A1008/A1008M, commercial quality, stretcher leveled, temper rolled.
B. Stainless Steel Sheet: ASTM A666, Type 302 or Type 304 alloy.

2.3 PORTABLE FIRE EXTINGUISHERS
A. General: Provide fire extinguishers of type, size, and capacity for each cabinet and other locations indicated.
B. Multipurpose Dry Chemical Type: UL-rated 4-A:60-B:C, 10-lb nominal capacity, in enameled steel container.
C. Clean-Agent Type: UL-rated 2A:10B:C, 15-1/2 lb. nominal capacity of a proprietary blend of HCFC-123 and inert material, in enameled-steel container with pressure-indicating gage.
D. Carbon-Dioxide Type: UL-rated 10-B:C, 15-lb nominal capacity, in enameled high pressure aluminum container.

2.4 FIRE-PROTECTION CABINETS
A. Cabinet Construction: Provide manufacturer's standard box (tub), with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated. Weld joints and grind smooth. Miter and weld perimeter door frames.
B. Cabinet:
3. Cabinet Type: Suitable for 10 lb. Fire extinguisher.
4. Cabinet Mounting: Recessed in walls of sufficient depth to suit style of trim indicated.
5. Cabinet Trim Style: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.
   a. Exposed Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).
      1) Rolled-Edge Trim: 2-1/2 inch backbend depth.
6. Cabinet Trim Material: Manufacturer's standard, same metal and finish as door.
8. Door Glazing: Tempered float glass, ASTM C1048, Kind FT, Condition A, Type I, Quality q3, Class 1 (clear).
9. Door Style: Manufacturer's standard vertical duo panel design.
10. Door Construction: Fabricate doors according to manufacturer's standards, of materials indicated, and coordinated with cabinet types and trim styles selected. Provide minimum 1/2 inch thick door frames, fabricated with tubular stiles and rails, and hollow-metal design.
11. Door Hardware: Provide manufacturer's standard door-operating hardware of property type for cabinet type, trim style, and door material and style indicated. Provide either lever handle with cam-action latch, or exposed or concealed door pull and friction latch. Provide concealed or continuous-type hinge permitting door to open 180 degrees. Hardware shall comply with applicable accessibility standards.

2.5 ACCESSORIES

A. Mounting Brackets: Manufacturer's standard steel, designed to secure extinguisher, of sizes required for types and capacities of extinguishers indicated, with plated or baked-enamel finish. Provide brackets for extinguishers not located in cabinets.

B. Identification: Provide lettering to comply with authorities having jurisdiction for letter style, color, size, spacing, and location.
   1. Bracket-Mounted Extinguishers: Identify with the words "FIRE EXTINGUISHER" in red letter decals applied to wall surface.
   2. Fire Extinguisher Cabinet: Identify with the words "FIRE EXTINGUISHER" in black die cut vinyl letters applied to door.

2.6 FINISHES

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
D. Interior of Cabinet Finish: Provide manufacturer's standard baked-enamel paint.
E. Door and Exterior of Cabinet Finish: Provide stainless steel finish.
F. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils.
G. Stainless Steel Finish: Remove or blend tool and die marks and stretch lines into finish. Grind and polish surfaces to produce uniform, directionally textured polished finish indicated, free of cross scratches. Run grain with long dimension of each piece. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
   1. Bright, Directional Polish: No. 4 finish.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive fire extinguishers, cabinets and associated work and conditions under which work will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer. Starting work within a particular area will be construed as applicator's acceptance of surface conditions.

3.2 INSTALLATION

A. Install products in accordance with the requirements of NFPA-10.

B. Mount extinguishers at a height of 48 inches to the top above finished floor.

C. Set fire extinguisher cabinets true and level at a height of 54 inches to the top above finish floor.

3.3 ADJUSTING, CLEANING, AND PROTECTION

A. Adjust cabinet doors that do not swing or operate freely.

B. Refinish or replace cabinets and doors damaged during installation.

C. Provide final protection and maintain conditions that ensure that cabinets and doors are without damage or deterioration at the time of Substantial Completion.

3.4 CHARGING

A. Just prior to final acceptance by the Authority, notify the local fire department and charge and tag all extinguishers, showing date tagged and expiration date.

3.5 FIRE EXTINGUISHER SCHEDULE

A. FE-1: Dry Chemical extinguisher mounted on surface of wall with mounting bracket.

B. FE-2: Dry Chemical extinguisher installed in a single type cabinet.

C. FE-3: Clean-Agent extinguisher mounted on surface of wall with mounting bracket.

D. FE-4: Carbon-Dioxide extinguisher mounted on surface of wall with mounting bracket.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Fire Extinguishers and Cabinets described in this section will be paid for on a lump sum basis where in no measurement will be made.

END OF SECTION 10522
SECTION 10525
FIRE DEPARTMENT KEY KEEPER

PART 1 - GENERAL

1.1 DESCRIPTION
A. Work required for this section includes fire department key keeper and supplementary items necessary for their proper installation.
B. Connection to tamper switch is specified in Section 16721, “Fire Alarm and Detection Systems”.

1.2 QUALITY ASSURANCE
A. Local Authority Approval: Obtain approval of local fire department for keyway access and exact location of key keeper box. Coordinate contact with AHJ through Contracting Officer.
B. Key keepers are required at locations shown on Contract Drawings.

1.3 SUBMITTALS
A. Product Data: Manufacturer’s product data, marked specifically to indicate compliance with these specifications.
B. Samples: 3 inch square samples of finishes. For selection of finish colors.

PART 2 - PRODUCTS

2.1 KEY KEEPER
A. Basis-of-Design Product: Knox Co. “Knox Box” Recessed Mounted with Lift-Off Door, Alarm Tamper Switch option (UL Listed) and Recessed Mounting Kit (RMK).
B. Finish: Manufacturer’s standard weather resistant polyester powder coat.
   1. Color: As selected from manufacturer’s standard colors. Color for each location will be selected separately.
C. Types:
   1. Type A: 4400 Series with RMK (Part No. 4440).
      a. Size: 9-1/2 inches wide, 9-1/2 inches high, 5 inches deep
   2. Type B: 3200 Series with RMK (Part No. 3240).
      a. Size: 7 inches wide, 7 inches high, 3-1/4 inches deep

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install in accordance with manufacturer’s latest published requirements.
B. Coordinate installation of tamper switch through Contracting Officer.
C. Coordinate closure or securing of box through Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The work described in this section will be paid for on a lump sum basis for fire department key keepers per location indicated wherein no measurement will be made.

END OF SECTION 10525
SECTION 10800
TOILET ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY
A. Work required for this section includes toilet accessories and supplementary items necessary to complete their installation.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   2. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
   3. ASTM C1036 - Standard Specification for Flat Glass
B. Federal Specifications (FS):
C. International Code Council (ICC):
   1. ICC/ANSI A117.1 - Accessible and Usable Buildings and Facilities

1.3 SUBMITTALS
A. Product Data: Include construction details, material descriptions and thicknesses, dimensions, profiles, fastening and mounting methods, specified options, and finishes for each type of accessory specified.
B. Setting Drawings: For cutouts required in other work; include templates, substrate preparation instructions, and directions for preparing cutouts and installing anchoring devices.
C. Maintenance Data: For accessories to include in maintenance manuals specified in Division 1. Provide lists of replacement parts and service recommendations.

1.4 QUALITY ASSURANCE
A. Source Limitations: Provide products of same manufacturer for each type of accessory unit and for units exposed to view in same areas.

1.5 COORDINATION
A. Coordinate accessory locations with other work to prevent interference with clearances required for access by disabled persons, proper installation, adjustment, operation, cleaning, and servicing of accessories.
B. Deliver inserts and anchoring devices set into wall construction as required to prevent delaying the Work.

1.6 WARRANTY
A. Mirror Warranty: Manufacturer's written warranty, executed by mirror manufacturer agreeing to replace mirrors that develop visible silver spoilage defects within minimum warranty period indicated.
   1. Minimum Warranty Period: 15 years from date of Final Acceptance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Following manufacturers listed are "acceptable" only if manufacturer can evidence product compliance with requirements of Contract Documents.
   2. American Specialties, Inc.
   5. General Accessory Manufacturing Co.
   6. Or approved equal.

2.2 MATERIALS
A. Stainless Steel: ASTM A666, Type 304, with No. 4 finish (satin), in 0.0312-inch minimum nominal thickness, unless otherwise indicated.
B. Mirror Glass: ASTM C1036, Type I, Class 1, Quality Q2, nominal 6.0 mm thick, with silvering,


D. Fasteners: Screws, bolts, and other devices of same material as accessory unit, tamper and theft resistant when exposed, and of galvanized steel when concealed.

2.3 FABRICATION

A. General: Unless otherwise indicated, fabricate units of all-welded construction, without mitered corners. Fabricate frames drawn and leveled, one-piece seamless construction. Hang doors and access panels with full-length, stainless-steel hinge. Provide anchorage that is fully concealed when unit is closed.

B. Names or labels are not permitted on exposed faces of accessories. On interior surface not exposed to view or on back surface of each accessory, provide printed, waterproof label or stamped nameplate indicating manufacturer's name and product model number.

C. Framed Glass-Mirror Units: Fabricate frames for glass-mirror units to accommodate glass edge protection material. Provide mirror backing and support system that permits rigid, tamper-resistant glass installation and prevents moisture accumulation.
   1. Provide galvanized steel backing sheet, not less than 0.034 inch and full mirror size, with nonabsorptive filler material. Corrugated cardboard is not an acceptable filler material.
   2. Provide mirror-unit mounting system that permits rigid, tamper- and theft-resistant installation.
   3. Heavy-duty wall brackets of galvanized steel, equipped with concealed locking devices requiring a special tool to remove.

D. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Contracting Officer.

2.4 TOILET TISSUE DISPENSERS

A. Jumbo Roll Tissue Dispenser - MARK TA-1: Fabricate of stainless steel, size to accommodate two 10 inch diameter toilet tissue rolls.

2.5 GRAB BARS

A. Provide Stainless Steel grab bars with wall thickness not less than 0.05 inch and 1-1/2 inch outside diameter.
   1. Mounting: Concealed, manufacturer's standard flanges with snap flange cover.
   2. Clearance: 1-1/2 inch clearance between wall surface and inside face of bar.
   3. Anchorage: Concealed steel plate for steel stud walls to support 300 lbs.
   4. Basis-of-Design Product:
      a. MARK TA-5: Bobrick B-6806 x 36.
      b. MARK TA-6: Bobrick B-6806 x 42.

2.6 SANITARY NAPKIN VENDORS

A. Surface Mounted MARK - TA-9: Fabricate cabinet of stainless steel, not less than 0.0312 inch thick, all-welded construction. Provide door of stainless steel, minimum 0.05 inch thick, equipped with tumblers lockset. Provide identification reading "Napkins" and "Tampons" at coin slots; brand name advertising is not allowed.
   1. Capacity: Not less than 30 napkins and 27 tampons.
   2. Operation: Twenty-five-cent coin operation, with locked coin box keyed separately from door and other accessory units. Operation shall comply with both ICC/ANSI A117.1 and State of Texas Program for the Elimination of Architectural Barriers provisions and ADAAG.

2.7 SANITARY NAPKIN DISPOSAL UNITS

A. Surface-Mounted - MARK TA-8: Fabricate of stainless steel with seamless exposed walls, self-closing panel and reusable receptacle. Provide flush door with continuous piano hinge and tumblers lock.

2.8 SOAP DISPENSERS

A. Surface Mounted - MARK TA-4: Fabricate of stainless steel, sized for 40-oz. minimum capacity. Provide stainless steel piston, springs, and internal parts designed to dispense liquid soap in measured quantity by pump action. Provide cover of
TOILET ACCESSORIES

stainless steel, with unbreakable window-type refill indicator.


2.9 MOP AND BROOM HOLDER

A. Holder without Utility Shelf - MARK TA-10: 0.05-inch Type 304, stainless steel hat channel with spring-loaded, rubber, cam-type mop/broom holders. Provide unit 24 inches long and complete with three holders.


2.10 MIRROR UNITS

A. Stainless Steel Framed Mirror Without Shelf - MARK TA-3: Fabricate frame with angle shapes not less than 0.05 inch with square comers mitered, welded, and ground smooth. Galvanized steel back panel with hanging brackets for attachment to steel wall hanger assembly.


2.11 MISCELLANEOUS ACCESSORIES

A. Robe Hook - MARK TA-7: Heavy duty, one-piece brass casting with satin nickel-plated finish.

1. Basis-of-Design Product: Bobrick B-211.

B. Warm-Air Hand Dryer MARK - TA-2: Surface-mounted, warm-air hand dryer with no-touch operation controlled by electronic sensor and with manufacturers' standard white-painted cover.


PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Secure mirrors to walls in concealed, tamper-resistant manner with special hangers, toggle bolts, or screws. Set units level, plumb, and square at locations indicated, according to manufacturer's written instructions for substrate indicated.

C. Install grab bars to withstand a downward load of at least 250 lbf when tested according to method in ASTM F446.

3.2 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written recommendations.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for toilet accessories per location indicated wherein no measurement will be made.

END OF SECTION 10800
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies products and installation procedures for furnishing complete cathodic protection and stray current corrosion control systems for buried, pressurized ferrous piping systems and test facilities for PVC piping installations and steel encasement pipe.

B. Steel waterline piping shall be coated as described in these Specifications. Two options are shown on the utility drawings for anode installations for ductile iron pipe (DIP) depending on whether the piping is coated or uncoated. The piping is considered to be uncoated and additional anodes are required if the DIP is installed without applying the recommended coating systems described herein. The option for uncoated pipe is included in the event that the DIP suppliers refuse to allow aftermarket coatings on the piping supplied. Under no circumstances will the use of the polyethylene encasement be allowed on cathodically protected piping.

1.2 REFERENCED STANDARDS

A. American Water Works Association (AWWA):
   1. AWWA C209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
   2. AWWA C214 – Tape Coating Systems for the Exterior Steel Water Pipelines
   3. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. Through 12 in. (100 mm Through 300 mm), for Water Distribution

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A536 – Standard Specification for Ductile Iron Casting
   2. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   5. ASTM D570 - Standard Test Method for Water Absorption of Plastics
   8. ASTM D693 - Standard Specification for Crushed Aggregate for Macadam Pavements
   11. ASTM D1000 – Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

C. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

D. National Association of Corrosion Engineers (NACE)
   1. SSPC-SP 2 – Hand Tool Cleaning
   2. SSPC-SP 3 – Power Tool Cleaning
   3. SSPC-SP 7/NACE No. 4 – Brush-Off Blast Cleaning

1.3 SUBMITTALS

A. Shop Drawings:
   1. Indicate the exact locations of test facilities, bonding cables, and installation details.
   2. Include manufacturer’s literature and data for each proposed product, including installation procedures.
   3. Contractor shall provide photos showing the actual connection at the piping or encasements along with final installed locations that are marked or identified from a minimum of two dimensions added to the as-built drawings to all test stations to be located.
1.4 QUALITY ASSURANCE

A. Manufacturer: Select a firm regularly engaged in the manufacture of corrosion control products, cathodic protection, and stray current control systems of the type specified herein.

B. Products and Equipment: Incorporate corrosion control products, cathodic protection, and stray current control systems into the work that duplicate products and equipment that have been in satisfactory use for a minimum period of five years prior to the bid opening of this project.

C. Comply with:
   1. Codes and regulations of the jurisdictional authorities
   2. NEC

1.5 PROJECT CONDITIONS

A. Environmental Conditions:
   1. Apply coatings to dry clean surfaces only, in strict accordance with the manufacturer’s recommendations.
   2. Perform exothermic welding after surfaces have been cleaned, using a power grinder, and dried.

PART 2 - PRODUCTS

2.1 ANODE MATERIALS

A. Magnesium Anode: Weight as shown; prepackaged in a permeable cloth sack containing a backfill mixture consisting of 75 percent gypsum, 20 percent bentonite, and 5 percent sodium sulfate. Provide magnesium ingot of the high-potential type with the following chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.01 (maximum)</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.5 to 0.8 (a minimum of 0.5 plus 60 percent of aluminum)</td>
</tr>
<tr>
<td>Copper</td>
<td>0.02 (maximum)</td>
</tr>
<tr>
<td>Iron</td>
<td>0.03 (maximum)</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.001 (maximum)</td>
</tr>
<tr>
<td>Other Impurities</td>
<td>0.05 (maximum) each element, 0.3 (maximum) Total</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Remainder</td>
</tr>
</tbody>
</table>

B. Zinc Anode: Weight as shown, high purity zinc, ASTM B-418, Type II, prepackaged in a permeable cloth sack containing a backfill mixture consisting of 75 percent hydrated gypsum, 20 percent bentonite clay and 5 percent sodium sulfate.

   1. Lead Wire: 12 AWG single conductor, solid copper with type TW 600 volt insulation, factory-welded or soldered to the steel core, and the connection sealed with cast epoxy resin or suitable potting compound.

C. Manufacturers of anode products that comply with these requirements include the following companies:

   1. Duriron Company, Inc.
   2. Dow Chemical Company.
   3. Corrpro Companies Inc.

2.2 DIELECTRIC INSULATORS

A. Plastic Casing Insulator: High density, injection molded polyethylene, sized to provide permanent insulation between pipe casing and carrier pipe, with the following additional requirements:

   2. Tensile strength (ASTM D638): 3,100 psi to 5,500 psi.
   3. Water absorption (ASTM D570): 0.1 percent
   4. Temperature impact strength 180 degrees F Min (82 degrees C)(ASTM D256): 1.5 to 2.0 feet lb./in. notch.
   5. Bolts and Nuts: Cadmium plated steel (square nuts).

B. Insulating Flange Kit: Supplied in complete sets from a single manufacturer; securely packaged and clearly labeled as to size, ANSI rating, style, and material; and with the following provisions:

   1. Gasket: Full faced, neoprene coated phenolic; size, temperature, and pressure rating suitable for the application, with the following additional minimum requirements:

      a. Thickness: 1/8 inch minimum
      b. Water Absorption: 1.6 percent maximum
      c. Tensile Strength (with grain): 13,000 psi minimum
2. Sleeves: NEMA Grade LE laminated phenolic; size, temperature, and pressure rating suitable for the application; and with the following additional requirements:
   a. Thickness: 1/32 inch minimum
   b. Dielectric Strength (volts per mil): 400 minimum
   c. Water Absorption: 2 percent maximum
   d. Length: Shall extend through both flanges and insulating washers

3. Insulating Washers: Glass mat polyester laminated phenolic; size, temperature, and pressure rating suitable for the application; and with the following additional requirements:
   a. Thickness: 1/8 inch minimum
   b. Dielectric Strength (volts per mil): 400 minimum
   c. Compressive Strength (flatwise): 26,000 psi minimum
   d. Water Absorption: 2 percent maximum

4. Steel Washers: 1/8 inch thick, SAE zinc plated, two per stud.

C. Insulating Couplings: Pre-assembled steel, compression gasket type; factory coated with 12 mils minimum thermosetting epoxy-polyamide; size, temperature and pressure rating suitable for the application; and with the following additional requirements:
   1. Insulating gasket to extend entirely under the follower rings.
   2. Armored gasket to bond between metal parts and protected piping.
   3. Middle insulator ring to extend over the pipe ends.

D. Insulating Unions: Air refined malleable iron; complete with brass bearing ring and molded nylon insulated material; size, temperature, and pressure rating suitable for the application, with the following additional requirements:
7. Or approved equal.

I. Pipeline Casing Insulators:

1. Band: 14 Ga. (0.074 inch) steel, hot rolled and pickled. Two piece through 36 inch carrier pipe size. Width of band as recommended by manufacturer as determined by carrier pipe size. PVC Liner shall have the following properties:

- Thickness minimum: 0.09 inch
- Hardness: Durometer “A” 85-90
- Dielectric Strength (1/8” thick): Surge Test 60,000 V, Step-by-Step Test 58,000 V
- Test Water Maximum Absorption: 1 percent

2. Studs, Nuts, and Washers: Stainless steel or cadmium plated; number, size, and length as required by manufacturer.

3. Runners: 2 inch wide glass reinforced plastic (G_2), height as required to center the carrier pipe within the casing pipe, and to provide permanent 1 inch minimum clearance between casing, and carrier pipe couplings and hubs, and with the following additional requirements:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ASTM</th>
<th>Requirement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>D638</td>
<td>17,600 psi</td>
<td></td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D790</td>
<td>25,300 psi</td>
<td></td>
</tr>
<tr>
<td>Compression Strength (10% Deformation)</td>
<td>D695</td>
<td>18,000 psi</td>
<td></td>
</tr>
<tr>
<td>Deflection Temp. (at 264 psi)</td>
<td>D648</td>
<td>405 °F</td>
<td></td>
</tr>
</tbody>
</table>


J. PVC Insulating Insert: 18 inch, plain end length of PVC in accordance with AWWA C900.

2.3 PIPE COATINGS

A. Wax-Tape Coating System:

1. Primer: Petrolatum primer containing moisture-displacing corrosion inhibiting compounds.


4. Protective Outer Wrap: Plasticized PVC sheeting coated on one side with a pressure sensitive rubber resin adhesive.

B. Butyl Adhesive Tape Coating System:

1. Primer: Liquid adhesive system with butyl based elastomers blended with polymeric resins, dissolved in an organic solvent system, compatible with the tape coating system.

2. Filler Tape: Moldable butyl rubber compatible with primer and tape coating.

3. Tape Coating: High tack butyl rubber adhesive with polyethylene backing (35 mils total thickness) with the following additional properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>ASTM</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>D1000</td>
<td>15 lb/in</td>
</tr>
<tr>
<td>Elongation</td>
<td>D1000</td>
<td>150%</td>
</tr>
<tr>
<td>Dielectric Breakdown</td>
<td>D1000</td>
<td>650 V/mil</td>
</tr>
</tbody>
</table>

C. Coal Tar Mastic: Cold, brush applied one-part solvent drying thixotropic coal tar with chemically inert resins and fillers; supplied in one gallon containers; and with the following additional requirements.

1. Minimum of 60 percent solids by volume;

2. Film Thickness: 20 mils wet - 12 mils dry per coat

3. Products that comply with these requirements include:
   a. Bitumastic 50, as manufactured by the Kop-Coat/Carboline Company
   b. Roskote A-51, as manufactured by Royston Laboratories, Inc.
   c. Or approved equal.

D. Coal Tar Epoxy:

1. Two-component

2. Chemically cured

3. High-build (up to 40 mils per coat)
4. 100 percent solids, 0.0 lbs V.O.C.

E. Heat Shrink Sleeve: Heat shrinkable joint wrap sleeve for below grade insulating joints, crosslinked polyolefin backing and butyl alloy adhesive, with compatible filler material to fill voids and other irregularities prior to application of the sleeve, and with the following requirements:

1. Minimum Total Thickness: 50 mils
2. Tensile Strength: 85lb./in. width or 2,900 psi
3. Elongation: 300 percent
4. Nominal Application Temperature Range: Minus 30 degrees F to 122 degrees F
5. Dielectric Strength: 30,000 Volts
6. Insulation Resistance: 1,000,000 megohms
7. Water Vapor Transmission Rate: Less than 0.04g/100 in²/24 hr at 70 degrees F

2.4 TEST BOXES

A. At-Grade Test Box: A.B.S. polymer body with a heavy duty cast iron pentagon locking lid and flange, supplied with a stand-off type seven post, terminal polyester laminate block as shown, with the following additional requirements:

1. Top Logo to read “DART TEST”
2. Minimum internal body diameter: 5-inches
3. Supply each test box with a pentagon wrench opening key.
4. All test boxes, if not installed in concrete pavement or walks, shall be installed in an individually placed concrete pad a minimum of 18 inches x 18 inches x 12 inches flush with adjacent surfaces.

B. Above-Grade Test Box: Cast Aluminum Alloy, suitable for wall or post mounting, sized as shown complete with a weather tight neoprene gasket with the following additional requirements:

1. Threaded outlet(s) for conduit entry
2. Cover Logo to read “DART TEST”
3. Nominal minimum box width, length, or diameter: 4 inches for flush wall boxes; 6-inches for wall-mount boxes; 4.5 inches for post-mount boxes.
4. Nominal minimum box depth: 4 inches for wall-mount boxes; 2.5-inches for post mount boxes.

C. Roadway Test Box: Cast Ductile Iron - ASTM A536 Grade 65-45-12, rated medium duty suitable for driveways, parking lots, and sidewalks; and with the following additional requirements:

1. Cover Logo to read “DART TEST”
2. Shop coated with manufacturer's standard paint
3. Total Weight-frame and lid not to exceed 50 pounds

D. Cable:

1. Magnesium Anode Header Wire: 10 AWG stranded copper, with Type TW 600 volt insulation.
2. Extruded Magnesium Anode Wire: 4 No. 12 AWG stranded copper, with Type TW 600 volt insulation.
3. Pipe Bond Wire: 4 AWG stranded copper, with Type TW 600 volt black insulation.
4. Pipe Test Wires: 10 AWG stranded copper ASTM B8, Class B wire with Type TW 600 volt insulation.
5. Reference Electrode Wire: 10 AWG stranded copper ASTM B8, Class B wire with Type TW 600 volt insulation.
6. Reinforcing Steel Bond Wire: 1/0 AWG Class G Stranded tinned bare copper wire.
7. Reinforcing Steel and Welded Wire Fabric Test Wire: 4 AWG stranded copper, with Type HMWPE black insulation.
8. Ground Mat/Rod Wire: 1/0 AWG Class G stranded copper with Type TW 600 volt insulation.

E. Wire Connections:

1. Exothermic cartridge, type and size suitable for the metals being connected using molds, disks, and sleeves as recommended by the manufacturer.
2. At the sump pump locations, mechanical type (bolt/crimp) connections can be used.

F. Manufacturers offering electrical component products that comply with these requirements include:

1. Handley Industries, Inc.
2. Gerome Manufacturing Company
3. Cott Manufacturing Company
4. Bingham and Taylor Corporation
5. Harco Technologies Corporation
6. Stuart Steel Protection Corporation
7. Or approved equal.

**2.5 WIRE AND CABLE**

A. Anode Header Cable: 8 AWG stranded copper, with Type RHW/USE direct burial insulation.

B. Pipe Bond Wire: Stranded copper with type RHW/USE direct burial insulation. Sizing of Bond Wire shall be as follows:

<table>
<thead>
<tr>
<th>Nominal Pipe Diameter</th>
<th>Wire Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 4 inches</td>
<td>12 AWG</td>
</tr>
<tr>
<td>4 inches to 12 inches</td>
<td>6 AWG</td>
</tr>
<tr>
<td>Greater than 12 inches</td>
<td>2 AWG</td>
</tr>
</tbody>
</table>

C. Pipe Test Wires: 10 AWG stranded copper ASTM B8, Class B wire with Type TW 600 V insulation.

D. Reference Electrode Wire: 10 AWG stranded copper ASTM B8, Class B wire with type TW 600 V insulation.

E. Reinforcing Steel Bond Wire: 1/0 AWG Class G stranded copper with Type RHW/USE direct burial insulation.

F. Reinforcing Steel and Welded Wire Fabric Test Wire: 4 AWG stranded copper, with Type RHW/USE direct burial insulation.

G. Ground Mat/Rod Wire: 1/0 AWG Class G stranded bare copper in earth. 1/0 AWG Class G stranded copper with Type TW 600 V insulation from test or junction box to earth 3 feet past conduit/earth interface.

H. Exothermic Welding Process: Exothermic cartridge, type and size suitable for the metals being connected using properly sized molds, disks, and sleeves as recommended by the manufacturer’s printed materials. Exothermic weld materials and products shall be Cadweld as manufactured by Erico Products, Inc. Thermoweld, or approved equal.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

A. Anodes: Bury anodes of type, size, and number at locations shown with the following additional requirements:

1. Wet pre-packaged anodes thoroughly before backfilling hole.
2. Use fine clay or native soil, free from stones, bricks, and organic matter, for backfilling.

3. Use exothermic welding process to connect anode leads to header cable as shown and route as sown on the drawings. Terminate cables in test boxes at the locations shown on the drawings.

B. Test Stations:

1. At-Grade Test Box: Install at locations shown on the drawings. Route all wires as shown and in a manner that will not cause damage to the wire insulation. Allow enough slack to compensate for soil movements and to extend panel above grade for test access. Coil excess wire inside box. Boxes shall be placed outside of vehicular traffic lanes, and shall be accessible for performing future cathodic protection testing.

2. Wall and Post-Mount Test Boxes: Install at locations shown on the drawings. Route all wires as shown and in a manner that will not cause damage to the wire insulation. Allow enough slack to compensate for soil movements. Mount terminal board inside box in a manner that will not permit electrical contact between the test wires and box.

C. Wire and Cable: Electrically bond mechanical joints on metallic piping as shown. Provide test wires of the size and type shown from each bonded facility and terminate at locations shown on the drawings. All wire/structure connections and buried wire and cable splices shall be exothermically welded and coated. Use of compression and split bolt connectors is prohibited. Identify each wire in test boxes using nonmetallic tags or pressure sensitive labels. Ring tongue connectors shall be attached to test wires, for connection to test box terminal board, using a crimping tool specifically designed for use with type of connectors used.

D. Exothermic Welds:

1. Molds, weld metal, and associated accessories shall be sized and designed for making electrical connections for copper-to-copper, copper-to-steel, and copper-to-ductile iron as required.

2. Perform exothermic welding after surfaces have been cleaned, using a power grinder, and dried.

3. Place weld cap over completed wire/pipe exothermic welds. The edges of the weld cap shall extend over the existing pipe coating as shown and totally encapsulate the weld, exposed pipe surface, and bare wire. If weld caps with coal tar mastic are used, fill weld cap with coal tar mastic and place over weld, exposed pipe surface, and bare wire.
4. Wire and cable splices, including anode-to-header cable connections, shall be exothermically welded. Connection shall be clean and dry prior to wrapping. Completed weld shall be initially wrapped with 3 layers of butyl rubber splicing tape, followed by two layers of vinyl plastic tape, using 50 percent overlap during application.

E. Insulating Fittings:

1. Insulating Flange: Provide appropriate sized flange-to-flange joint and install insulating gasket, sleeves, and washers in accordance with the manufacturer’s written instructions, using all thread studs. Entire flange, exposed nuts, studs, and washers shall be coated with petrolatum coating system or heat shrink sleeve as described in Subsections 3.1.G.2 and 3.1.G.3.

2. Insulating Coupling: Install at locations shown with insulating adapter gasket located away from cathodically protected piping. Install bond wires as shown to electrically connect coupling to cathodically protected piping. Coat all exothermic welds, bare steel, and threaded rods with 24 mils DFT coal tar mastic as described in Subsection 3.1.G.5.

F. Steel Pipe Coating System: Cathodically protected steel pipe used for waterlines shall be tape-coated in accordance with AWWA C214 and AWA C209.

G. Ductile Iron Pipe (DIP) Coating Systems: Five pipe coating options may be considered for cathodically protected DIP as described below. Polyethylene encasement shall not be used on cathodically protected DIP.

1. Butyl Adhesive Tape Coating System: May be used for straight piping, fittings, and field joints. Do not use on insulating fittings. Apply in strict accordance with coating manufacturer’s published application instructions with the following minimum requirements.

a. Surface Preparation: Pipe surfaces for straight piping and fittings shall be cleaned by blasting with sand, grit, or shot to achieve a surface preparation equal to that specified in SSPC-SP 7, Brush-Off Blast Cleaning. Field joints shall be free of mud, wax, tar, oil, grease, or any other material prior to preparing the surface in accordance with SSPC-SP 3, Power Tool Cleaning. Use a suitable solvent to remove oil and grease prior to blasting or power tool cleaning. Kerosene shall not be used.

b. Primer: Apply suitable primer to prepared pipe surfaces in accordance with the coating manufacturer’s published application instructions. Encase retainer glands, set screws, bolts, and other surface irregularities by filling voids with butyl rubber filler tape prior to application of wrapping tape.

c. Tape Application: Apply under hand tension or using a hand-wrapping machine in a spiral configuration. Apply tape with a 55 percent overlap to provide two layers with a total final thickness of 70 mils.

2. Wax-Tape Coating System: May be used for buried insulating fittings, straight piping, fittings, and field joints. Apply in strict accordance with the following minimum requirements:

a. Surface Preparation: Prepare surfaces by removing all loose scale, rust, or other foreign matter in accordance with SSPC-SP 2, Hand Tool Cleaning, or SSPC-SP 3, Power Tool Cleaning.

b. Primer: Apply a thin uniform coat of petrolatum primer to entire surface with gloved hand, brush, or rag. Encase retainer glands, set screws, bolts, and other surface irregularities by filling voids with petrolatum molding mastic prior to application of wax tape.

c. Tape Application: Tape shall be spirally wrapped using a minimum 1 inch overlap. While wrapping, press air pockets out and smooth all lap seams.

d. Outer Wrap Application: Tape shall be spirally wrapped using a minimum 1 inch overlap. Apply sufficient tension to provide continuous adhesion of the tape.
e. Coatings shall be tested with an appropriate Holiday Detector. Coating faults shall be repaired and retested prior to backfilling.

f. Insulating Material (1/8 inch thick rubber or polyethylene) shall be installed between coated pipe and solid support (wood blocking, etc.) or between coated pipe and concrete thrust blocks. Rebar shall not be in direct metallic contact with the pipe. Coating piping shall be backfilled with clean, rock free soil to avoid coating damage.

3. Heat Shrink Sleeves: May be used for buried insulating fittings and field joints. Apply in strict accordance with coating manufacturer's published application instructions with the following minimum requirements:

a. If the heat shrink sleeve is a one-piece tubular type, it should be placed over the pipe prior to assembly of flange. If the sleeve is not tubular and has a connecting seam, then the flange can be coated at any time.

b. Clean the uncoated metal surface with a hand or power wire brush to remove dirt, rust, and foreign materials. The portion of adjacent pipe coating that will be coated by the sleeve must also be cleaned.

c. Preheat the joint until hand warm, exercising extreme care not to damage insulating components.

d. Install mastic filler or sealant material (that is recommended by the sleeve manufacturer) in irregular areas of the flange where voids may occur under the shrink sleeve to result in gradual, sloping surfaces, without sharp corners from the external edges of the flange faces to the line pipe.

e. Remove the sleeve's inner protective release paper, if one exists, and center the sleeve over the preheated joint, allowing a minimum of 3 inches overlap on the existing coating.

f. Use an appropriate torch, heat the sleeve as indicated by the manufacturer's instructions. These instructions may vary upon product type. Some manufacturers instruct that the heating should begin in the center of the sleeve, working to the ends, while others suggest working from one end to the other.

4. Coal Tar Epoxy: May be used for straight piping, fittings, and field joints. Do not use on insulating fittings. Apply in strict accordance with coating manufacturer's published application instructions with the following minimum requirements.

a. Environmental Requirements: Air and surface temperature limits provided by the manufacturer shall be strictly adhered to during surface preparation and application and curing of coatings. Surfaces to be coated shall be protected from dust and airborne contaminants during the application and curing phases.

b. Surface Preparation: Pipe surfaces for straight piping and fittings shall be cleaned by blasting with sand, grit, or shot to achieve a surface preparation equal to that specified in SSPC-SP 7, Brush-Off Blast Cleaning. Field joints shall be free of mud, wax, tar, oil, grease, or any other material prior to preparing the surface in accordance with SSPC-SP 3, Power Tool Cleaning. Use a suitable solvent to remove oil and grease prior to blasting or power tool cleaning. Kerosene shall not be used.

c. Coating Application: Thoroughly mix components in strict accordance with manufacturer's written instructions. Apply in sufficient number of coats to achieve a final dry film thickness not less than 35 mils. Consult coating manufacturer's written recommendations for number of coats required, maximum thickness of coats, and allowable timeframe between subsequent coats.

d. Coatings shall be tested with an appropriate Holiday Detector. Coating faults shall be repaired and retested prior to backfilling.

e. Insulating material (1/8 inch thick rubber or polyethylene) shall be installed between coated pipe and solid support (wood blocking, etc.) or between coated pipe and concrete thrust blocks. Rebar shall not be in direct metallic contact with the pipe. Coated piping shall be backfilled with clean, rock free soil to avoid coating damage.

5. Coal Tar Mastic: May be used to coat threaded rods, exothermic welds, and other pipe appurtenances that cannot utilize
aforementioned tape wrapping systems. Do not use on insulating flanges.

a. Surface Preparation: Prepare surfaces by removing all loose scale, rust, or other foreign matter in accordance with SSPC-SP 2, Hand Tool Cleaning. Use a suitable solvent to remove oil and grease prior to hand tool cleaning. Kerosene shall not be used.

b. Apply two 12 mil coats using a brush or gloved hand to achieve a final dry film thickness (DFT) of 24 mils. Allow sufficient curing time between coats as documented in the coating manufacturer's published application instructions.

c. Coatings shall be tested with an appropriate holiday detector. Coating faults shall be repaired and retested prior to backfilling.

6. Handling Coated Pipe in Field or Trench:

a. Pipe shall be stored along trench side, suitable supported off the ground to avoid damage to the coating.

b. Pipe shall be hoisted from the trench side by means of wide, non-metallic canvas or leather belt slings. Chains, cables, tongs, or other equipment likely to cause damage to the coating, shall not be permitted, nor shall dragging or skidding of the pipe. Inspection of the coating on the underside of the pipe is recommended while the pipe section is suspended from the sling. Damage shall be repaired before the pipe is lowered into the trench.

c. The pipe ditch shall be smooth and offer maximum uniform support to the pipe. It shall be free of debris, stones, and clods. Ditch bottom cuts through rock formations shall be panned for adequate pipe protection, and the ditch sides shall be avoided in lowering-in operations to minimize coating damage. Consideration shall be given to extra ditch width in rock areas.

d. During construction of the pipeline, use every precaution to prevent damage to the protective coating on the pipe. No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. Workmen will be permitted to walk upon the coating only when necessary, in which case they shall wear shoes with rubber or composition soles and heels. This rule shall apply to surfaces, whether bare, primed or coated. Any damage to the pipe or protective coating, from any cause, during the installation of the pipeline and before final acceptance, shall be repaired as required by the Contracting Officer at no additional cost.

H. Pipeline Casing Insulators: Install in accordance with the manufacturer's published instructions, and with the following requirements:

1. Space one insulator one foot in from each casing end, and every 10 feet (maximum) thereafter.

2. Additionally, place an insulator one foot from each side of each mechanical joint within the casing.

3. Carrier pipe coating shall be tested as required to the satisfaction of the Authority Corrosion Engineer prior to installation inside the casing pipe. Damage to the pipe coating during the installation process shall be repaired to the satisfaction of the Authority Corrosion Engineer.

I. Casing End Seals: Install in accordance with the manufacturer's published instructions. Slide end seals over the carrier pipe at the casing entrance during carrier pipe installation. Remove dirt and debris from the carrier pipe and casing surfaces prior to positioning the seal and tightening the stainless steel bands.

J. Dielectric Modular Penetration Seals: Provide modular mechanical type wall seals, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall sleeve. Assemble the links loosely with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tighten the bolts so that the rubber sealing elements expand and provide watertight seal between the pipe and wall opening. Construct the seal so as to provide electrical insulation between pipe and wall. Caulking, other types of mastic sealant, or lead oakum joints are not acceptable.

K. DIP fittings installed with non-metallic water supply systems shall be protected in accordance with the following:

1. Isolated, individual DIP fittings installed with PVC water distribution mains shall be installed with polyethylene wrap.

2. If the total continuous length of a DIP pipe and fittings assembly installed with a PVC water distribution main exceeds 20 lineal feet, then the following cathodic protection
measures are required for the DIP assembly:

a. Metallic elements associated with the fitting assembly shall be coated with a coating system as described in Subsection 2.3

b. Metallic pipe joints in the assembly shall be bonded.

c. One 50 pound high potential magnesium anode shall be exothermically welded to the assembly. One additional 50 pound anode shall be exothermically welded to the assembly for each additional twenty lineal feet of DIP piping associated with the assembly.

3.2 QUALITY CONTROL

A. Do not cover anodes, header cables, test wires, bonding wires, and other buried and embedded components of corrosion control systems without inspection of the Authority Corrosion Engineer and approval of the Contracting Officer.

B. Test coatings with coating integrity test equipment (holiday detector) and thickness gauges prior to installation of piping in the trench, using instructions of the test equipment manufacturer. The Authority Corrosion Engineer will witness these tests. Repair coating deficiencies to the satisfaction of the Authority Corrosion Engineer.

C. The Authority Corrosion Engineer will test the corrosion control systems. Tests to include, but not limited to, electrical continuity of bonded structures, including pipes and accessories, wires, splices, test cables; coating and dielectric effectiveness; and anode installations. Repair or replace deficiencies and damaged components to the satisfaction of the Authority Corrosion Engineer.

D. Contractor shall notify the Contracting Officer for scheduling Corrosion Control Quality Inspection of the installation by Authority Corrosion Engineer. Final Corrosion Control Acceptance Tests will be conducted by the Authority Corrosion Engineer. The Contractor shall complete advanced testing and furnish copies of their test data to the Authority’s Corrosion Engineer prior to the final acceptance testing.

PART 4 - MEASUREMENT

4.1 GENERAL

A. Corrosion control will be paid for on a lump sum basis wherein no measurement will be made.

END OF SECTION 13100
PART 1 - GENERAL
1.1 DESCRIPTION
A. Work specified in this Section describes tests to be made on corrosion control measures installed with transit facilities and utilities. The work includes testing of sacrificial anode cathodic protection systems, electrical continuity of piping and reinforcing steel, electrical effectiveness of insulating devices and the effectiveness of protective coatings, and others as defined herein and approved by the Authority Corrosion Engineer.
B. Electrical tests of impressed current cathodic protection system components is not included as part of this work and is covered as part of the section where such related work is to be performed by the Contractor.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM B1 - Standard Specification for Hard-Drawn Copper Wire
2. ASTM B258 - Standard Specification for Standard Nominal Diameters and Cross-Sectional Areas of AWG Sizes of Solid Round Wires Used as Electrical Conductors

1.3 QUALITY ASSURANCE
A. The number of readings taken to determine an electrical constant or property will be sufficient to assure that random factors due to human error in reading the instruments and transient disturbances in the electrical network have negligible influence on the final results. The adequacy of the data will be established by the tester. The data will be examined to see that removal of either the highest or lowest value will not alter the arithmetic average of the group by more than five percent. If the average is altered by more than five percent, one more set of data will be taken and the results combined with the first set. If the average of the combined data is still altered by more than five percent, by removal of the highest or lowest value, an unstable condition might exist, the contractor will perform additional inspections and tests to determine solutions to the problem, and provide report describing the issue(s) and resolution(s). Report will contain final test report that shows and proves issues are resolved.

PART 2 - PRODUCTS
2.1 VOLTMMETERS
A. Analog dc Voltmeter: Multi-scale (1mV to 10V, or 2mV to 20V), center zero or 10 percent upscale, accurate to within 0.5 percent of full scale.
B. Electronic dc Voltmeter (Digital Readout): Multi-scale (20mV to 20V), accurate to within 1 percent of reading plus or minus 1 digit, minimum input resistance of 10 megohms for ranges above 20mV.

2.2 AMMETERS
A. Analog dc Ammeter: Multi-scale (1mA to 10A, or 2mA to 20A), center zero or 10 percent upscale, accurate to within 0.5 percent of full scale.
B. Electronic dc Ammeter (Digital Readout): Multi-scale (20mA to 20A), accurate to within 1 percent of reading plus or minus digit.

2.3 VOLTAGE RECORDERS
A. Strip Chart Voltage Recorder: Multi-scale, ac/battery powered, with 2.5 megohm input resistance (minimum), 0.5 second response time (full scale (maximum)) and adjustable chart speed control.
B. Digital Voltage Recorder: Multi-scale, ac/battery powered, data logger with 10 megohm input resistance (minimum).

2.4 COATING TEST EQUIPMENT
A. Low Voltage, Wet Sponge Holiday Detector: Portable, battery operated, self-contained unit, with terminal connections for ground wire to the structure, and open cell sponge electrode. Voltage rating shall be between 5 and 90 VDC, providing an audible signal for locating coating faults.
B. High Voltage Holiday Detector: Portable, battery operated, self contained unit, with terminal connections for ground wire to the structure, and exploring electrode with audible signal for locating coating faults. Electrode shall be of the type capable of maintaining continuous contact with the surface being inspected. Voltage rating shall be selectable between 900 volts and 35,000 volts to conform to coating manufacturer's test voltage recommendations.
C. Coating Thickness Gauge: Hand held, battery operated, nondestructive instrument capable of determining non-magnetic coating thickness from 1 to 80 mils on horizontal, vertical, and inverted surfaces.

2.5 MISCELLANEOUS
A. DC Power Source: 12 volt, sealed, rechargeable battery with a minimum 6.5-ampere/hour capacity. For tests requiring additional current magnitudes, use two or more batteries in series, a DC generator, or portable test rectifier.
B. Test Wires: Insulated, single conductor stranded copper test leads of various sizes and lengths, and with appropriate connectors to suite test conditions. At least two hand reels with approximately 500 feet of insulated, stranded copper wire (16 AWG minimum).

C. Cu-CuSO\(_4\) Reference Electrode: 1.25 inches diameter, 6 inches long with solid copper rod contacting a saturated solution of copper sulfate, with porous plug allowing electrical contact with the soil.

PART 3 - EXECUTION

3.1 CORROSION CONTROL MEASURES ON REINFORCING STEEL

A. This section is applicable only for structures utilizing electrically continuous rebar for corrosion control. The purpose of these tests is to determine the longitudinal resistance of welded reinforcing steel in poured concrete aerial structure decks, tunnel inverts, columns, bents and pile shafts. Tests will be made on the following measures:

1. Physical Inspection:
   a. Subsequent to weldment and after weld has cooled, each weld will be tested by striking the connection with a two pound hammer. If the connection separates, the connection shall be rewelded by the Contractor. The Authority Corrosion Engineer will then retest the connection.
   b. Prior to pouring of concrete, visually inspect all welds.

2. Test Station Wire Effectiveness (To be conducted after concrete is poured):
   a. The Contractor shall establish a current (I) and voltage (E) circuit between the structure test wires as shown in Figure 2 (available from the Contracting Officer). With the current circuit closed, the meter ranges will be reduced until the lowest readable scales are reached. The current "on" values for each circuit will be read and recorded.
   b. The current (I) circuit will be opened, and the "off" values for the voltage (E) and current (I) circuits will be immediately read and recorded. This will be repeated a minimum of three times for accuracy.
   c. The change in current, \( \Delta I \), and the change in voltage, \( \Delta E \), for each reading (\( \Delta I = I_{on} - I_{off} \) etc.) will be calculated.
   d. The resistance of the wires will be calculated by dividing the summation of the change on voltage, \( \Sigma \Delta E \), by the summation of the change in current, \( \Sigma \Delta I \).

\[
R_{\text{TEST WIRES}} = \frac{\Sigma \Delta E}{\Sigma \Delta I} = \text{ohms}
\]

e. The theoretical resistance of the test wires will be calculated.

\[
R_{\text{THEOR}} = \left( 2 \times L_{\text{WIRE}} \times R_{\text{WIRE}} \right) + \left( L_{\text{REBAR}} \times R_{\text{REBAR}} \right)
\]

where:

\[
L_{\text{WIRE}} = \text{Length of one test wire from the voltage connection to the rebar (feet) (assumes both wires are equal in length)}.
\]

\[
L_{\text{REBAR}} = \text{Length of rebar between test wires (feet)}.
\]

\[
R_{\text{WIRE}} = \text{Longitudinal resistance of the test wire (ohm/1000 feet) from Table II}.
\]

\[
R_{\text{REBAR}} = \text{Longitudinal resistance of rebar (ohm/1000 feet) from Table I}.
\]

f. Acceptance Criterion: Test wires shall be considered as acceptable provided they meet the following criterion:

\[
R_{\text{TEST WIRES}} < 1.20 \times R_{\text{THEOR}}
\]

g. Failure to meet this criterion will be reported to the Contracting Officer. Corrective action shall be taken, at the Contractor's expense, to remedy the unacceptable condition. Subsequent to corrective action(s), the tests shall be repeated.

3. Reinforcing Steel Electrical Continuity (To be conducted after concrete is poured):

a. The Authority Corrosion Engineer will obtain electrical access to the reinforcing steel through the test stations located on the aerial structure at hinges or on the columns. A current (I) and voltage circuit (E) will be established as shown on Figure 3 (available from the Contracting Officer). With the current "on", the meter ranges will be reduced until the lowest readable scales are reached.
b. The Authority Engineer will read and record "on" values for voltage (E) and current (I). The current (I) circuit will be opened and the "off" values for voltage (E) and current (I) will be immediately recorded. This will be repeated a minimum of three times for accuracy.

c. The change in current, \( \Delta I \), and the change in voltage, \( \Delta E \), will be calculated for each reading (\( \Delta I = I_{on} - I_{off} \) etc.).

d. The longitudinal resistance of the welded reinforcing steel will be calculated by dividing the summation of change in voltage, \( \Sigma \Delta E \), by the summation of change in current, \( \Sigma \Delta I \).

\[
R_{REBAR} = \frac{\Sigma \Delta E}{\Sigma \Delta I} \text{ ohms}
\]

e. Acceptance Criterion: Electrical continuity of reinforcing steel shall be considered as acceptable provided the following criterion is met:

\[
R_{REBAR} \leq 1.20 R_{THEORETICAL}
\]

where:

\[
R_{REBAR} = \text{Measured longitudinal resistance}
\]

\[
R_{THEORETICAL} = \frac{(L_{REBAR} \times R_{REBAR})}{n} \text{ ohms}
\]

\[
L_{REBAR} = \text{Length of welded longitudinal reinforcing steel bars between test facilities (feet)}
\]

\[
R_{REBAR} = \text{Longitudinal resistance of reinforcing steel (ohm/1000 feet) from Table I.}
\]

\[
n = \text{Number of welded longitudinal steel bars connected together at ends of Test Section by collector bars.}
\]

3.2 CORROSION CONTROL MEASURES ON WELDED WIRE FABRIC

A. This section is applicable when welded wire fabric is required. The purpose of this test is to assure the electrical continuity of the welded wire fabric (WWF) that is installed under track on the aerial structures. This test should be conducted prior to installation of the track. Subsequent to installation of the butyl membrane material, the protective covering, the WWF, and test wire connections to the WWF, a visual inspection should be made of the welded wire fabric. Longitudinal continuity of the WWF should be visually verified across longitudinal lap splices in the WWF. The point of connection of each test wire to the WWF should be visually verified. No additional testing is required subsequent to installation of the track.

3.3 The CORROSION CONTROL MEASURES ON PIPING SYSTEMS

A. Electrical tests specified herein shall be performed by the contractor on those piping systems for which electrical continuity and/or cathodic protection has been provided. Tests will be made on the following measures:

1. Physical Inspection: Prior to backfilling and during installation of the piping system, the following items will be tested or inspected.

   a. Each thermite weld will be tested by striking the weld with a two pound sledge hammer, while pulling firmly on the test or bond wire at a forty-five degree angle. Defective welds shall be repaired or replaced at Contractor's expense.

   b. The exposed areas of pipe, weldment and copper wire at exothermic welds will be inspected to assure that bare metal areas are adequately coated.

   c. Pipe coatings will be visually inspected to assure that the coating is free of defects and damage. Subsequent to visual inspection, electrical tests, using a high or low voltage pulse-type detector will be conducted prior to backfilling as specified elsewhere.

   d. Insulating devices shall be visually inspected to assure material specifications are satisfied. A visual inspection of the assembled and installed devices shall be conducted to assure that the components of the insulating device suffered no damage prior to or during installation.
CORROSION CONTROL ACCEPTANCE TESTS

1. Test Station Wire Effectiveness:
   a. The contractor will measure the electrical resistance of test wires at each test station facility in accordance with 3.1 A2 and Figure 2 (available from the Contracting Officer).
   b. Theoretical resistance of the test wires will be calculated.

\[
R_{THEOR} = \frac{2 \times L_{WIRE} \times R_{WIRE}}{L_{STRUCT} \times R_{STRUCT}}
\]

where:

- \(L_{WIRE}\) = Length of one test wire from the structure to the voltage connection assuming both wires are equal in length (feet).
- \(R_{WIRE}\) = Longitudinal resistance of the test wire (ohm/1000 feet), from Table II.
- \(L_{STRUCT}\) = Length of structure between test wires (feet)
- \(R_{STRUCT}\) = Longitudinal resistance of structure (ohm/1000 feet.), from Table III.

   c. Acceptance Criterion: Test wires shall be considered as acceptable provided they meet the following criterion. Failure to meet this criterion will be reported to the Contracting Officer. Corrective action shall be taken at the Contractor's expense.

\[
R_{TEST\ WIREs} < 1.20 R_{THEOR}
\]

b. The current "on" values for voltage and current will be read and recorded. The current circuit will be opened and the "off" values for voltage and current will be immediately read and recorded. A minimum of three readings will be obtained to assure accuracy.

c. The change in voltage, \(\Delta E\), and the change in current, \(\Delta I\), will be calculated for each reading (\(\Delta I = I_{on} - I_{off}\) etc.).

d. The longitudinal resistance of the pipe between the two test facilities will be calculated by dividing the summation of the change in voltage, \(\Sigma \Delta E\), by the summation of the change in current, \(\Sigma \Delta I\).

\[
R_{PIPE} = \frac{\Sigma \Delta E}{\Sigma \Delta I} = \text{ohms}
\]

e. The theoretical resistance of the pipe between the two test facilities will be calculated, using as-built diagrams to determine the number of pipe joints and fittings.

\[
R_{THEOR} = (L \times R_{P}) + (n \times R_{B}) = \text{ohms}
\]

where:

- \(R_{THEOR}\) = Resistance of pipe between test stations
- \(L\) = Length of pipe between test facilities (feet)
- \(R_{P}\) = Longitudinal resistance of pipe (ohm/1000 feet), from Table III
- \(n\) = Number of bond wire pairs between test facilities (based on the number of pipe joints, including fittings)
- \(R_{B}\) = 0.0001922 ohm for one bond pair (two 18-inch long No. 4 wires). \(R_{B}\) will vary, depending upon the length and size of the bond wire and should be calculated if lengths other than 18-inches are used.

\[
R_{B} = \frac{R_{W} \times L_{W}}{n} = \text{ohms}
\]

3. Pipe Continuity
   a. The contractor shall obtain access to the pipe through the test station facilities. Using individual structure test wires in each facility, a current circuit (I) and a voltage circuit (E) will be established as shown on Figure 4 (available from the Contracting Officer). With the current circuit closed, the meter ranges will be

   reduced until the lowest readable scales are reached.
where:

\[ R_W = \text{Longitudinal resistance of bond wire (ohm/1000 feet), from Table II} \]

\[ L_W = \text{Length of bond wire (feet)} \]

\[ n = \text{Number of bond wires} \]

f. **Acceptance Criterion:** The resistance of the pipe section shall be considered as acceptable, indicating effective pipe joint bonding, provided the following criterion is met:

\[ R_{\text{PIPE}} \leq 1.10 R_{\text{THEOR}} \]

g. If the acceptance criterion is not met, the Contracting Officer will be notified and the test procedure will be repeated for a smaller distance, preferably half, within the original section tested. Keeping point A (See Figure 4, available from the Contracting Officer) at the same location and a point C will be selected halfway between points A and B. The above procedures, a to f, will be repeated for the section of pipe between points A and C and B and C.

h. The above procedure will be continued on the pipe section, AC or BC, that does not meet the acceptance criterion. The procedure shall be used by again splitting the defective (i.e. high resistance) section in half and repeating the resistance measurements. A point will be reached when the pipe section being tested includes only a single pipe joint. This pipe joint shall be excavated and the bond wires repaired and/or replaced, as required, at Contractor's expense.

i. Subsequent to repair of the defective bond wires, as located above, the original pipe section (A to B) shall be retested to determine if it meets the acceptance criterion.

4. **Electrical Insulating Devices:**

a. These tests will be made on those devices installed to provide electrical separation between two or more structures for corrosion control purposes. These devices will normally include insulating flange assemblies or couplings, casing sleeve insulators, and non-metallic pipe inserts. These tests must be made on the insulating device prior to backfilling.

b. All insulating devices, other than PVC inserts, will be tested with one side of the device suspended in air, and/or free of earth contact or other connections that will establish a contact to earth.

c. The contractor shall connect an ohmmeter across the insulating device with the positive connection on one side of the device and the negative connection on the other, as shown on Figure 5 (available from the Contracting Officer). The resistance, \( R_J \), will be measured and recorded.

d. The contractor shall connect an ohmmeter between the section of pipe suspended in air, and a low resistance earth contact, i.e. ground rod. The resistance between pipe and earth, \( R_E \), will be measured and recorded.

e. **Acceptance Criteria (Insulating Flanges/Couplings):** The following two criteria must be satisfied for the acceptance of the insulating flange assembly or coupling:

\[ R_E \geq R_J \]

\[ R_J \geq 1 \times 10^6 \text{ ohms} \]

f. If the above acceptance criteria are not satisfied, the insulating device shall be considered ineffective and the Contracting Officer will be notified. Corrective action shall be made at the Contractor's expense.

g. Casing/wall seal insulators will be tested with the side of the carrier pipe inside the casing suspended in air and/or having no earth contact.

h. The contractor shall connect an ohmmeter between the casing or wall sleeve and the section of carrier pipe passing through the casing or wall sleeve, as shown on Figure 6 (available from the Contracting Officer). The resistance between the casing/wall sleeve and pipe, \( R_{CP} \), will be measured and recorded.
i. Acceptance Criteria: Two criteria must be satisfied for the acceptance of the electrical isolation of the carrier pipe from the casing/wall sleeve.

\[ R_J \geq 1 \times 10^6 \text{ ohms} \]

\[ R_{CP} \geq 1 \times 10^6 \text{ ohms} \]

j. If only the first part of the above criteria is satisfied, an electrical path exists between the carrier pipe and casing/wall sleeve. A physical inspection of the casing, the casing seals, and the pipe shall be conducted to determine the cause of the electrical path and the corrective measures required.

5. Magnesium Anode Installation:

a. Instruments will be set up as shown on Figure 7 (available from the Contracting Officer). The current circuit (I) will be located on the outside of the test wire for the magnesium anodes and to either of the test wires from the structure. The copper-copper sulfate reference cell will be positioned one foot from the test station on the side of the test station opposite the magnesium anode(s). The location of the half-cell will be documented.

b. The current (I) circuit will be closed and the meter ranges of both the current and voltage circuits will be reduced until the lowest readable scales are reached. The current “on” values for voltage and current will be read and recorded.

c. The current (I) circuit will be opened and the “off” values for voltage and current will be immediately read and recorded. This will be repeated a minimum of three times for accuracy.

d. The change in current, \( \Delta I \), and the change in voltage, \( \Delta E \), will be calculated for each reading (\( \Delta I = I_{on} - I_{off} \) etc.).

e. Resistance-to-earth of the magnesium anode installation will be calculated by dividing the summation of change in voltage, \( \Sigma \Delta E \), by the summation of the change in current, \( \Sigma \Delta I \).

\[ R_{MAG} = \frac{\Sigma \Delta E}{\Sigma \Delta I} = \text{ohms} \]

f. The theoretical resistance of the magnesium anode installation will be calculated.

\[ R_{TM} = \frac{1}{N} x R_m \times \rho_{soil} \]

where:

\[ R_{TM} = \text{Theoretical resistance-to-earth of magnesium anodes under test} \]

\[ N = \text{Number of magnesium anodes under test} \]

\[ R_m = \text{Resistance of single magnesium anode in 1,000 ohm-cm soil (ohms)} \]

\[ R_m = 4.5 \text{ ohms for 48 lb. anode} \]

\[ \rho_{soil} = \text{Soil resistivity in 1,000 ohm-cm increments} \]

g. Acceptance Criterion: The resistance-to-earth of the magnesium anode installation shall be considered as acceptable provided the following criterion is met:

\[ R_{MAG} \leq 1.5 \times R_{TM} \]

h. If the acceptance criterion is not met, the Contracting Officer will be notified and, with his approval, the following may be required.

1) The resistivity of the soil around each anode shall be measured. This shall be obtained using a single probe soil resistivity measuring device with related instrumentation. The data shall be obtained at a minimum depth of 6 inches below the bottom of the pipe trench and as close as possible to the location(s) of the anode(s). This data shall be used to recalculate the theoretical magnesium anode resistance. At the discretion of the Contracting Officer, additional action may or may not be deemed necessary.

2) If additional action is deemed necessary, the Contractor, at his expense, shall excavate one of the magnesium anodes for physical examination. The examination shall include evaluation of the soil
environment around the anode and the electrical splice of the anode wire to the anode collector wire. At the discretion of the Contracting Officer, additional anodes may be excavated if conditions observed at the first anode indicate material or installation problems.

6. Protective Pipe Coating Evaluation:

a. A current \( I_A \) and a voltage measuring circuit \( E_A \) will be established between the pipe test wires and the anode bus wire as shown on Figure 8 (available from the Contracting Officer). Voltage connection to the anode bus wire will be a minimum of 6-inches below the current connection.

b. The current circuit will be closed and the meter ranges of both circuits will be reduced until the lowest readable scales are reached. The "on" values for voltage and current will be read and recorded.

c. The current circuit, \( I_A \), will be opened and the "off" values for voltage and current will be immediately read and recorded. A minimum of three readings will be obtained to assure accuracy.

d. The change in voltage, \( \Delta E_A \) and the change in current, \( \Delta I_A \), will be calculated for each reading \( \Delta I = I_{on} - I_{off} \) etc.

e. The resistance between the anodes and the pipe will be calculated by dividing the summation of change in voltage, \( \Sigma \Delta E_A \), by the summation of change in current, \( \Sigma \Delta I_A \).

\[
R_{A-A} = \frac{\Sigma \Delta E_A}{\Sigma \Delta I_A} = \text{ohms}
\]

f. Maintaining the current circuit between the anodes and pipe, a voltage measuring circuit, \( V_{gA} \), will be established between the pipe and a copper-copper sulfate reference cell positioned in earth above the pipe.

g. The current circuit, \( I_A \), will be closed and the meter ranges of both circuits will be reduced until the lowest readable scales are reached. The "on" values for the current, \( I_A \) and voltage, \( V_{gA} \) circuits will be read and recorded.

h. The current circuit, \( I_A \), will be opened and the "off" values for current and voltage will be immediately read and recorded. A minimum of three readings will be obtained to assure accuracy.

i. The change \( \Delta V_{gB} \) and the change in current, \( \Delta I_A \), will be calculated for each reading \( \Delta I_A = I_{on} - I_{off} \) etc.

j. The volt per ampere earth coupling between the pipe and the reference cell will be calculated by dividing the summation of the change in voltage, \( \Sigma \Delta V_{gB} \) by the summation of the change in current, \( \Sigma \Delta I_A \).

\[
RV_{gB-A} = \frac{\Sigma \Delta V_{gB}}{\Sigma \Delta I_A} = \text{volts/ampere}
\]

k. Maintaining the current circuit, \( I_A \), a voltage measuring circuit, \( V_{gC} \), will be established between the magnesium anodes and the reference cell and the change in potential and change in current will be measured as described in 6g through 6j above.

l. The volt per ampere earth coupling of the anodes will be calculated.

\[
RV_{gC-A} = \frac{\Sigma \Delta V_{gC}}{\Sigma \Delta I_A} = \text{volts/ampere}
\]

m. The summation of the absolute values of \( RV_{gC-A} \) and \( RV_{gB-A} \) shall be within plus or minus ten percent of the resistance between the anodes and the pipe, \( R_{AA} \). If this criterion is not satisfied, indicating an unstable condition or a failure to follow these procedures, the measurements will be repeated. If the unstable situation still exists, the Contracting Officer will be notified.

n. Maintaining the current circuit, \( I_A \), a pipe to reference cell voltage circuit will be established at test facilities along the pipe, keeping on the front side of any insulating devices as shown on Figure 9 (available from the Contracting Officer). A volt per ampere earth coupling will be obtained as specified above at each test facility; identifying each as follows:

\[
RV_{gD-A} = \frac{\Sigma \Delta V_{gD}}{\Sigma \Delta I_A} = \text{volts/ampere}
\]

\[
RV_{gE-A} = \frac{\Sigma \Delta V_{gE}}{\Sigma \Delta I_A} = \text{volts/ampere}
\]
o. The Authority Corrosion Engineer will average the pipe-to-soil volt per ampere couplings to determine the average pipe-to-soil resistance.

p. A coating resistance will be calculated by using the following equation:

\[ CR = R_{PS} \times \pi \times OD \times L = \text{ohm-sq. feet} \]

where:

\[ R_{PS} = \text{Average pipe-to-soil resistance} \]
\[ OD = \text{Outside diameter of pipe (feet)} \]
\[ L = \text{Length of pipe section (feet)} \]

q. Acceptance Criterion: The pipe coating shall be considered as acceptable provided the following criterion is met:

\[ CR > 10,000 \text{ ohm-sq. feet} \]

r. Failure to satisfy this requirement will be reported to the Contracting Officer and will require a cell-to-cell coating fault survey.

d. Beginning with the highest scales on the voltmeter and ammeter, the current circuit will be closed and meter ranges will be reduced until the lowest readable scales are reached. The current will be limited to a maximum of 10 amperes to prevent damage to the coating or other facilities.

e. The "on" values for voltage and current will be read and recorded. The current circuit will be opened and the "off" values for voltage and current will be immediately read and recorded. The incremental change in current, \( \Delta I \), and potential, \( \Delta E_x \), \( (\Delta E_x = E_{on} - E_{off} \text{ etc.) will be determined} \)

f. Maintaining the current circuit as shown, the reference cells will be moved, each three feet toward the other end of the pipe. The positive reference cell will always be closest to the end of the pipe where current is impressed. Step e above will be repeated. The cells will then be moved another three feet and step e will be repeated once more. This procedure is to be performed over the entire length of pipe.

g. Figure 11 (available from the Contracting Officer) shows an example of typical data for a portion of a cell-to-cell survey. The incremental voltage changes, \( \Delta E_x \), will be summed, starting with the first reading. The resulting summations will be plotted versus distance on rectangular coordinate graph paper. Figure 12 (available from the Contracting Officer) shows a sample plot. Areas of coating defects are indicated by peaks in the resulting plot. It should be noted that if there is a significant variation in test current, then it may be necessary to divide each incremental voltage change, \( \Delta E_x \), by the magnitude of test current, \( \Delta I \), and then obtain the summation of the quotients and plot the quotient summations versus distance.

h. The shape and relative magnitude of the resulting graph will indicate the general condition of the coating system. A graph with many peaks of relatively equal magnitude indicates a general overall coating problem. A
graph with a few large peak effects indicates isolated problem areas. As a general guideline, the relative sizes of the defects can be interpreted from the magnitude of the peaks. Large peak values correlate to large areas of coating faults as compared to lower peak values.

i. The graphical results of the survey will be submitted to the Contracting Officer. Several areas along the main will be selected to be excavated and examined to determine the condition of coating. The entire main at the coating fault locations must be excavated to ensure that all defects are uncovered. Obvious coating defects shall be repaired. Prior to repair of visually obvious coating defects, the entire area shall be inspected using the proper type holiday detector.

j. Subsequent to repair of coating defects, and after the coating has dried, the exposed pipe area will be retested using the coating holiday detector.

k. The Contractor shall backfill the excavation(s) so that the Authority Corrosion Engineer can repeat the electrical resistance test as described in 3.3 6 above at select locations to determine if the resistance level of the main has shown an appreciable increase subsequent to repair of located coating faults.

l. If the calculated coating resistance is now above the acceptable level, no additional excavations are required. However, if no appreciable improvement is observed in the coating resistance, additional excavations may be required at the discretion of the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Corrosion control acceptance tests will be paid for on a lump sum basis wherein no measurement will be made.
<table>
<thead>
<tr>
<th>Rebar Size</th>
<th>Diameter (in.)</th>
<th>Cross Sectional Area (sq. in.)</th>
<th>DC Resistance* (ohm/1000 feet)</th>
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<td>6.78 x 10^{-3}</td>
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<td>4.71 x 10^{-3}</td>
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*Based on Steel Resistivity (q_{STL}) of 9.7 x 10^{-6} ohm-sq. in./feet
## TABLE 13101 - II

**COPPER WIRE DATA**

<table>
<thead>
<tr>
<th>Cable AWG</th>
<th>Kcmil</th>
<th>No. of Strands per Cable (1)</th>
<th>Diameter (2) (inches)</th>
<th>D.C. Resistance (3) at 20 degrees C (68 degrees F) (Ohms/1,000 feet)</th>
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<td>Cable AWG</td>
<td>Kcmil</td>
<td>No. of Strands per Cable (1)</td>
<td>Diameter (2) (inches)</td>
<td>D.C. Resistance (3) at 20 degrees C (68 degrees F) (Ohms/1,000 feet)</td>
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(1) Resistance specified for stranded cables determined as follows:

3 strands - R = 1.01 R solid (equivalent AWG)

7 & greater - R = 1.02 R solid (equivalent AWG)

(2) Solid cable diameters based on ASTM B258; stranded cable diameters may vary slightly without affecting resistances specified.

(3) Based on \( q_{cu} = 10.486 \text{ ohm-circular mil/foot} \) corrected for 98.9% IACS conductivity

(Ref. ASTM B1).
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<th>Nominal Size (inches)</th>
<th>Class</th>
<th>Out Dia. (inches)</th>
<th>In Dia. (inches)</th>
<th>Area of Pipe Wall</th>
<th>Resistance (ohm/1000 feet)</th>
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### CORROSION CONTROL ACCEPTANCE TESTS

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*Based on Resistivity of Ductile Iron Pipe = $310 \times 10^{-6}$ ohm-in$^2$/feet

END OF SECTION 13101
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work specified in this section describes testing necessary to follow measuring resistance to earth of running rails which are used as the conductors for returning the train operating current to the substation.

B. Procedures presented in this section are general guidelines for the measurement of track-to-earth resistance as construction progresses and may require modification to suit actual field conditions and the electrical networks established by the track work as a result of changing conditions. The Authority’s Corrosion Engineer may modify the procedures, as may be necessary, to suit actual conditions.

C. Final acceptance tests for track-to-earth resistances will be the responsibility of the Authority subsequent to the completion of the in-progress tests specified in this section.

D. Contractor shall coordinate with the Authority to obtain unrestricted access to the track work sections scheduled for Rail-to-Earth (R-T-E) resistance testing. Time required for R-T-E testing will be determined when length of track to be tested is determined, and availability of track access can be scheduled.

1. Contractor shall maintain track work sections clear of debris, prior to scheduled R-T-E resistance testing to prevent problems causing rail-to-ground shorting conditions.

2. Rail-to-earth resistance testing shall be allotted in the Contractor’s Baseline Schedule as a final scheduled requirement prior to acceptance by the Authority.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):


1.3 QUALITY ASSURANCE

A. Tests specified herein will be made by the Contractor. The number of readings taken to determine an electrical constant or property will be sufficient to assure that random factors due to human error in reading the instruments and transient disturbances in the electrical network have negligible influence on the final results. The adequacy of the data will be established by the testing procedure. The data will be examined to see that removal of either the highest or lowest value will not alter the arithmetic average of the group by more than five percent. If the average is altered by more than five percent, one more set of data will be taken and the results combined with the first set. If the average of the combined data is still altered by more than five percent, by removal of the highest or lowest value, an unstable condition might exist, and the Contractor will perform additional inspections and tests to determine solutions to the problems.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 SCHEDULING OF TESTS

A. Contractors will test individual sections of track as practical to construction sequencing as all major construction work is completed. When only minor work remains to be completed, the Contractor shall schedule this work early so that testing is not delayed. Since the purpose of the testing is to verify the electrical resistance quality of the track as the work proceeds, the Contractor will not be permitted to interfere with Authority testing to consolidate the testing effort.

B. As per DART Design Criteria Manual Volume II – Systems Design, paragraph 8.3.3.C Negative Distribution System, Rail-to-ground resistance shall be continuously monitored by the Contractor during construction to detect variations of decreases in the resistance. The testing shall be performed in accordance with a pre-approved test procedure.

3.2 VISUAL INSPECTION

A. Track work will be visually examined to ensure that there is no appreciable degree of debris, water, dirt, ballast or other conductive material in electrical contact with the track or track components, which could result in lowering of the effective track-to-earth resistance, thus producing incorrect data. It is assumed, unless shown otherwise, that the installation of the track system has been in accordance with material and construction specifications. The Contractor shall be required to clear/clean any problems observed during the visual inspection. The condition of the track section to be tested will be recorded on data sheet.

3.3 ELECTRICAL TESTS MAINLINE TRACKWORK

A. Electrical tests will be performed for all yard and mainline track work including special track work areas in accordance with ASTM G165.
3.4 ACCEPTANCE CRITERIA

A. The following are the minimum acceptable in-service track-to-earth resistances:

1. Mainline track (Concrete & Wood Tie and Ballast): 625 ohms for 1000 feet of single track (two rails) in wet condition.

2. Mainline track (Direct Fixation): 625 ohms for 1000 feet of single track (two rails) in wet condition.

3. Mainline track (Embedded): 150 ohms for 1000 feet of single track (two rails).

B. If the test results show that any section of track work fails to meet the acceptance criteria, the Contractor shall work with the Authority’s Corrosion Engineer to check all instrumentation setups; verify that the equipment is operating properly; inspect the section under test for installation deficiencies; and notify the Contracting Officer of any deficiencies that were found. The Contractor shall correct any problems detected including cleaning of the track work as may be required to assure proper data collection. Following Contractor resolution of the problems, the tests will be repeated as soon as possible and notify the Authority of the test results.

C. Corrections to track work shall be made in accordance with Section 02450, “General Track Construction”; Section 02455, “Track Appurtenances”; Section 02459, “Special Trackwork”; Section 02460, “Ballasted Track Construction”; and Section 02462, “Direct Fixation Track Construction”.

D. If the retest results fail to meet acceptance criteria, the Contractor shall notify the Authority and prepare a nonconformance in accordance with established Quality Control procedures. The adverse condition(s) causing the failure to meet the acceptance criteria shall be corrected by the Contractor. In case of a failed test, the track shall be retested.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Track-to-earth resistance test will be paid for on a lump sum basis wherein no measurement will be made.

END OF SECTION 13102
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work specified in this Section consists of providing a pre-engineered Enclosure for each new Traction Power Substation (TPSS) furnished by this Contract.

B. Design a weatherproof Substation housing in full compliance with the Contract Documents and Referenced Standards.

C. Fabricate the housing to prevent driving rain from entering the enclosures and to provide a dry and condensation-free environment for the installation of electrical equipment. These enclosures are intended for outdoor use and are primarily to provide a degree of protection against rain and sleet. They shall meet rain tests and paint qualification design tests as described in the Referenced Standards.

D. Design and install the housing on a structural steel base frame to withstand stresses caused during transportation, installation and during the maximum specified wind loadings. Provide the base frame with removable lifting lugs to enable lifting fully equipped substation sections.

E. Provide the housing with a rigid non-slip floor, ¼ inch steel plate minimum, suitable for installation of floor insulation.

F. If required by the final design, manufacture the enclosure to accommodate no more than two shipping sections, with the transformer/rectifier in one shipping module.

G. Design double wall and double roof housing to accommodate insulation material to reduce heat transfer. Select the thermal insulation level taking into account the climatic conditions encountered in the Substation location, the installed equipment and the temperature range inside the Substation. Design the insulation to enable satisfactory operation of all the Substation equipment during extreme ambient temperatures.

H. Provide a Substation enclosure with 2 outward opening entry doors for maintenance and personnel access, and as required by the final design, provide an emergency exit behind the DC Switchgear lineup. Locate the personnel doors at the opposite ends of the Substation enclosure. Key all doors alike to a keying system approved by the Authority. Provide doorstops to hold the doors in the open position.

I. Provide hinged, watertight exterior access doors behind each equipment cubicle or other equipment requiring rear access for cable makeup, routine inspection, or maintenance. Provide security head bolts to bolt doors shut. Design the door and hinges to enable the doors to be opened simultaneously.

J. As required by the final design, select aesthetically acceptable roof and wall-mounted vents and exhaust fans. Select vents and fans designed to prevent rain, snow and vermin from entering the Substation. Provide vents with replaceable filters.

K. Provide a Knox box (lock box) to store keys for emergency access; location to be confirmed by FLSC and SSCRT. Refer to Specification Section 10525, “Fire Department Key Keeper”, for details.

L. Contractor shall verify with each local Authority that the final design and Substation will comply with local Codes and Regulations.

1.2 REFERENCED STANDARDS

A. American Institute of Steel Construction (AISC)
   1. AISC  S335 - Specifications for Structural Buildings

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
   1. ASHRAE  1989 - Guideline for HVAC

D. American National Standards Institute (ANSI)
   1. ANSI  C37.20.2 - Standard for Metal-Clad Switchgear

E. ASTM International (formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM A36 - Carbon Structural Steel
   2. ASTM A242M - High-Strength Low-Alloy Structural Steel
   3. ASTM D229 - Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation
   4. ASTM A307 - Carbon Steel Bolt & Studs
   5. ASTM A325 - Structural Bolts, Heat treated
6. ASTM A653 - Steel Sheet, Zinc-Coated (Galvanized)

7. ASTM A1008 - Steel, Sheet, Cold Rolled

F. American Welding Society (AWS)

G. Institute of Electrical and Electronic Engineers (IEEE)

1. IEEE 693 - Recommended Practices for Seismic Design of Substations

H. National Fire Protection Association (NFPA)

1. NFPA 10 - Portable Fire Extinguishers
2. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
4. NFPA 220 - Standard Types of Building Construction

I. International Conference of Building Officers (ICBO)

1. IBC Uniform Building Code) as adopted by the City of Dallas

J. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

1. HVAC Duct Construction Standards

K. Underwriters Laboratories, Inc. (UL)

1. UL 752 - Bullet Resisting Equipment
2. UL 154UL - Standard for Safety Carbon-Dioxide Fire Extinguishers

L. Uniform Mechanical Code (UMC)

M. MBMA Metal Building Manufacturers Association

### 1.3 SUBMITTALS

A. Contractor shall submit descriptive literature, and fabrication drawings in sufficient detail to enable the Authority to evaluate the enclosure and the enclosure accessories to be in full compliance with the Contract Documents, submit as a minimum:

1. Manufacturer's descriptive literature, catalog data, shop drawings, fabrication drawings and other information as applicable for each installed component.

B. Layout arrangement and detailed shop drawings of the enclosure with installed accessories and Substation equipment.

1. Contractor shall submit layout details in accordance with these specifications.
2. With approval by the Authority, the Contractor may combine drawings and submittals to more clearly indicate the conformance to the Contract Documents.

C. Certificates of Compliance for specified materials.

D. Point to point wiring diagrams for all electrical and communications equipment.

E. A licensed Professional Engineer registered in Texas shall certify structural analysis calculations for roof, wind and seismic loadings.

F. Certified test results for the thermal, electrical, and acoustical insulation.

G. Fabrication and Construction drawings shall include:

1. Enclosure base anchorage locations, shipping sections, lifting and placement instructions, floor loading, uplift and horizontal wind and seismic loadings for anchorages and foundations.
2. Raceway, conduit, cable trays and ductwork arrangements including incoming and exiting conduits and raceways.
3. Enclosure grounding details including connection point to the AC earth ground mat, DC earth ground mat and Utility Ground.
4. Provide a submittal on the enclosure lighting, HVAC/ventilation, fire detection, intrusion detection, and equipment wiring.
5. Shipping section drawings with details on proper re-alignment and re-assembly instructions.

H. Contractor shall furnish other drawings, literature, catalog data that may be requested by the Authority.
I. NLT (60 days after NTP):
   1. Structural Calculations
   2. Enclosure Equipment Layout
   3. Enclosure Details
   4. Enclosure Elevations
   5. Enclosure Base Plan

J. NLT (90 days after NTP):
   1. HVAC Calculations
   2. HVAC Plan and Equipment Arrangement
   3. HVAC Power and Control Wiring
   4. Enclosure AC Power Wiring & Lighting
   5. Enclosure Grounding Drawing

K. NLT (120 days after NTP):
   1. Fire Detection and Alarms
   2. Intrusion Detection and Alarms

L. NLT 15 days after Testing: Enclosure test results

1.4 FABRICATION AND CERTIFICATION

A. Contractor shall perform the following in accordance with the Contract Documents and these Specifications.

B. Fabricate, assemble and test each Substation enclosure.

C. Provide Certification for all materials, components and assemblies used in the construction and manufacturing of the enclosure.

D. Provide Factory Fabrication Control Testing and Certification for all in-progress work performed in house and in supplier’s shops, off site facilities and other factories.

E. Provide Certification of On-Site inspection of specified work elements specified herein or in the Referenced Standards.

F. Electrical installation materials and workmanship shall be as specified in the Contract Documents.

1.5 QUALITY CONTROL

A. Contractor shall perform all work included in this Section in strict accordance with the requirements of the Contractor’s Quality Control Program as specified in these Contract Documents and as approved by the Authority.

PART 2 - PRODUCTS

2.1 GENERAL

A. Contractor shall provide products in accordance with parameters identified here.

2.2 DESIGN

A. Structural Loadings: Enclosure shall be engineered to withstand a vertical line roof loading of 35 lbs/sf, a wind pressure of 25 lbs/sf, a snow load of 25 lbs/sf, and a seismic loading for Zone 1 as defined in IBC, and the stresses caused during transportation.

B. Substation Floor: Shall be designed to support the required equipment loading without buckling, bending or sagging and shall over the life of the Enclosure, maintain a level surface.

C. Doors, Walls, and Roof Panels: Shall be reinforced by braces, stiffeners, and structural members to provide a rigid module. Deflection under the indicated loadings shall not exceed 1/8 inch per 10 feet of span.

D. Supports: Supports, fasteners, structural insulators, and anchorages shall resist seismic loadings in accordance with IBC recommendations, and shall be designed in accordance with recommendations in the referenced standards.

2.3 CONFIGURATION

A. Overall Substation enclosure exterior dimensions shall be as specified herein and as indicated on the Contract Drawings.

B. Overall dimensions of the finished enclosure shall be approximately 16 feet wide, 45 feet in length and 12 feet in height; the highest point of the substation enclosure shall not exceed 12 feet from top of foundation inclusive of all ventilation and auxiliary equipment. If roof mounted air conditioning units are required, height limitations shall be adjusted and approved by the Authority.

C. Any other dimensions must be approved by the authority and coordinated with individual site conditions.
D. Interior working spaces and clearances shall comply with the latest edition of the NEC in both size and arrangement.

2.4 ENCLOSURE

A. Enclosure type shall be an integrated weatherproof unit that will house the TPSS equipment, power assemblies and sub-assemblies.

B. Enclosure shall provide a dry, condensation-free, stable internal ambient temperature environment.

C. Enclosure shall be of Type II-N noncombustible construction and have a Group B, Division 4 occupancy classification in accordance with IBC requirements.

D. Enclosure Construction: Enclosures should be of metal suitably supported, constructed, and assembled so that the enclosure will have the strength and rigidity necessary to meet the requirements of these Specifications and the Referenced Standards.

E. Enclosure Finishes: Unless the enclosure is made of a material that will resist corrosion, both inside and outside surfaces should be finished in accordance with the Referenced Standards. The metal clad switchgear must withstand the applicable coating qualification test.

F. Enclosure Material: The thickness of the enclosure should not be less than that indicated in these specifications and the Referenced Standards. If metals other than steel are used, the thickness should be such that equivalent strength and deflection are provided.

G. Supporting structures: A supporting structure should be formed of ASTM A36 structural steel shapes and plates of sheet metal, or the equivalent, and should be rigidly fastened together and have essentially the same outside dimensions as the enclosure surfaces.

H. Supporting structures and frames:

1. With reference to these specifications, an enclosure is not considered to have a supporting frame if it is:
   a. A single sheet with single formed flanges (formed edges).
   b. A single sheet that is die formed (corrugated or ribbed).
   c. An enclosure surface loosely attached to a frame, i.e., with spring clips.

2. All supporting structures and frames enclosing conduit entrances shall be so constructed as to accommodate cable pulling equipment. Clearly label all such pulling structures for points of attachments and maximum pulling tensions.

I. Weatherproofing:

1. Provide a completely weatherproof enclosure per the referenced standards.

2. All doors, joints, walls, roof, floor, shall be rain proof under conditions of 70 miles per hour winds from any direction and as required by the Referenced Standards.

2.5 ENCLOSURE SHELL

A. Enclosure, including doors, shall be constructed of not less than No. 14 gauge sheet steel mounted on a structural steel base frame to permit jacking, rolling, and skidding.

B. Enclosure walls shall be not less than 3 inches thick including thermal insulation.

C. Removable lifting lugs shall be provided on the base to facilitate a 4 point or 6-point lift on each fully equipped substation assembly or shipping modules.

D. Structural steel, roof, and wall panels shall have a minimum allowable yield as specified in the referenced standards.

E. Grounding pads shall be provided and welded to enclosure base at each corner.

F. Doors and Removable Panels

1. Substation shall have entry doors located as indicated on the Contract documents. Entry doors shall be sized as required to permit removal of the substation equipment.

2. Each entry door shall be equipped with a 3-point crash-bar with safety latches to permit opening from within under all conditions. All entry door hinges shall be concealed from the exterior. Latches shall have tamperproof locks.

3. Door thumb latch for each access door shall have the capability of being deactivated so the door locking mechanism continuously stays locked without a key inserted.

4. Entry doors shall be keyed using a Ruswin/Corbin key-coring system,
compatible with the existing Authority substations or an Authority approved equal. A unique key shall be provided for the substation with provision for re-keying by the Authority after the unit is energized. Refer to the contract documents or the Authority for keying coring system requirements.

5. Door closers and doorstops shall be provided to hold the doors in the open and closed position. Install reinforcement for access doors and door panels at each anchorage point to prevent deformation and to prevent excess stress on the door and panel.

6. Hinged exterior access panels, with 3-point latches and padlocking lugs, shall be provided behind equipment requiring access for cable makeup or maintenance. Hinges shall be concealed from the exterior.

7. Bolted panels with tamper-resistant fasteners shall be furnished to permit removal of rectifier transformers through the side of the enclosure.

8. Removable bolted panels shall also be furnished behind the DC Feeder Breaker section for access for feeder cable installation. Contractor shall provide structure support, "pulling eyes", and other means to attach pulling dollies and equipment for cable installation at each DC Feeder section.

9. Each equipment enclosure shall display an equipment label mounted on the front of the equipment enclosure. The label shall display all basic equipment information relating to the equipment such as; KVA rating, KV, BIL, etc.

10. All enclosure entryways (not access panels) shall have stairs, handrails and platforms in accordance with requirements of OSHA and IBC.

G. Finish

1. Exterior Metal Surfaces, Excluding the Floor Bottom; steel shall be prepared for finish painting with a vinyl wash primer. Apply an electrostatic powder coat baked-on paint for each panel and over the complete enclosure per the manufacturer’s recommendations. Minimum dry film thickness shall be 3 mils. Color shall be Sierra Tan as specified on the Contract Drawings; however the Authority reserves the right to change the color on selected individual units. The finish shall have passed the Salt Spray Test per the referenced standards and shall be certified by an independent laboratory.

2. Exterior Floor Bottom and Base Framing: Steel shall be commercial blast cleaned in accordance with Steel Structures Painting Council (SSPC) Procedure SP-6 and then be prime coated with 3 mil minimum dry film thickness (DFT) of inorganic zinc such as Carbo Zinc II as manufactured by Carbolime Company, Valspar MZ-7 as manufactured by the Valspar Corporation or Authority approved equal. After inorganic zinc has cured as noted in manufacturer’s recommendations, apply top coat(s) of minimum 16 mil DFT of coal tar epoxy such as Carbomastic No. 14 as manufactured by Carbolime Company, Coal Tar-Epoxy No. 64-J-3 as manufactured by Valspar Corporation or an Authority approved. Materials shall be applied and cured in accordance with manufacturer’s recommendations.

3. Interior Metal Surfaces Excluding the Floor and Insulated Areas: Apply electrostatic powder coat paint, baked on per manufacturer’s recommendations. Minimum dry film thickness shall be 2 mils. Color shall be white. The finish shall have passed the Salt Spray Test per ASTM B117 certified by an independent laboratory.

4. Interior Floor Excluding Insulated Areas: Apply 1 coat of alkyd primer and at least 2 coats of alkyd resin industrial enamel for a dry film thickness of 6 mils. Color shall be medium light gray No. 49 in accordance with ANSI Z55.1.

H. Insulation

1. Electrical Insulation:
   a. Minimum dielectric strength of the insulating material for standoff insulating fasteners and flooring shall not be less than 300 volts/mil. Floor insulation thickness shall be a minimum of 1/4 of an inch.
   b. DC switchgear and rectifier sections shall be insulated from the floor in a manner that the equipment will not become grounded under extreme humidity conditions.
c. Extent of floor insulation shall be as required to maintain the integrity of the high-resistance grounding scheme to 50 megohms or greater.

d. Substation walls behind and to the sides of the DC equipment enclosure shall be insulated with flame resistant insulating material that meets Class 1 flame spread requirements of IBC.

e. Insulation system design shall protect against any accidental contact between the DC equipment enclosures and grounded metal surfaces.

2. Acoustical Insulation:

a. Maximum permitted continuous noise level produced by all equipment associated with the substation, as measured at a distance of 50 feet from any point outside of the substation shall not exceed 45 dBA when the substation is operating at its 100 percent rated kW output and all cooling systems are operating at full power.

b. Material used for substation enclosure wall, roof, and floor insulation shall have a noise reduction coefficient of at least 0.6 to meet the above specified allowable noise level.

c. Noise level for the interior of substation shall be less than 80 dBA with all equipment operating at 100 percent load and all cooling and heating systems operating at full power. Interior acoustics shall be coordinated with selection of interior equipment to achieve the desired noise reduction.

3. Thermal Insulation: In each prefabricated substation, the enclosure walls and ceiling cavities shall include insulation, with a minimum rating of:

a. Walls R-12
b. Doors R-12
c. Floor R-12
d. Ceiling R-22

2.6 HEATING AND VENTILATION

A. Enclosure shall include a heating, ventilation and air conditioning (HVAC) system to maintain the substation temperature at a level permitting the traction transformers and the rectifiers to operate at their design load cycle.

B. Provide a Substation Heating-Ventilation-and Air-Conditioning (HVAC) system to control the Substation ambient temperature using multiple HVAC units. The system shall consist of the following:

1. Multiple HVAC units, sized and quantity as required by the final design.

2. System control package with thermostat, relays and programmable logic controller for system operation. Control the units by adjustable thermostat installed in the substation aisle. Design the control circuitry to operate the units alternatively. All the units may operate simultaneously only at ambient temperature above 90 degree F.

3. Conditioned air shall be distributed throughout the building by extruded anodized grilles or register. Air conditioning system filters shall be located in return grilles.

C. Provide self-contained, attached, 240V single-phase 60HZ, HVAC units, with hermetically sealed scroll compressors. Coordinate HVAC operational voltage with the Station Service Equipment.

D. Finished color of the housing shall match the finish color of the enclosure.

E. Contractor shall furnish design calculations (ASHRAE compliant) for the required air conditioning/heating capacity. The HVAC units shall be designed to maintain the enclosure interior temperature under all operating conditions and local ambient temperature ranges.

F. Heating and air conditioning shall be thermostatically controlled and monitored. Provide a field adjustable alarm contacts interconnect to a terminal block in a PLC Interface cabinet, used for remote monitoring of the temperature and humidity extremes.

G. Contractor shall provide the number of units as required by the final design, to provide sufficient redundancy in the event of failure of one unit. In the event of failure of any one unit, the temperature extremes shall not exceed 30 percent of the normal design.
H. Provide units that have a SEER rating of 12 or higher.

I. Provide additional ceiling mounted heaters if the Contractor's calculation determines that inside temperature of the TPSS causes condensation on the structure walls and or equipment and shortens battery life under low temperature conditions.

J. Dehumidification
   1. HVAC system shall at all times maintain humidity levels a minimum of 10 percent below that of the operational ratings for the TPSS equipment and control systems.
   2. Provide dehumidifiers and controls as required by the final design to provide independent operation that will prevent mildew and condensation by controlling humidity in the enclosure.

K. Exterior Equipment Protection
   1. Outside of each wall mounted air conditioner shall be protected with a hinged, heavy gauge, hot-dipped, galvanized vandal-resistant security mesh cage, painted to match the finished enclosure. The cage shall be constructed with a slot on the frame that, when in its closed position, will not pinch the air conditioners condensation drainage tube.
   2. Cage shall be constructed of an angle iron frame and be enclosed with 1-1/2 inch x 10-gauge steel expanded metal to form a 5-sided box.
   3. Cage shall be hinged to swing horizontally open to allow for 90 degrees maintenance access. Two locking hasps shall be provided to hold the cage in the closed position. A mechanical device shall be provided for securing the cage in the 90 degrees opened position. Cage design shall allow a single maintenance technician to gain access and perform maintenance on the HVAC unit.
   4. Cage shall be attached to the exterior wall using tamper-proof screw/bolts. Provide means for disassembly for shipment.
   5. Cage shall be oversized on the hinged side to accommodate air conditioner maintenance. Paint to match enclosure.

2.7 GROUNDING

A. Ground all non-current carrying metal components of the enclosure, (with the exception of the DC ungrounded system).

B. Provide an enclosure ground connection (pad) at each corner of the Enclosure for connection to the station AC ground grid.

C. Provide an interior continuous copper ground loop ("Halo Ground Ring") for each enclosure. Install around all 4 walls, at an elevation of approximately 10 inches below the ceiling on the interior wall; solidly connect to each support channel. Provide grounding sized per the NEC, grounding conductors shall be green with 600-volt insulation. From this loop, make the following connections:
   1. Service and distribution panels.
   2. Equipment enclosures.
   3. Light fixtures.
   5. Cable trays and raceways.
   6. Connect this “Halo” at each corner to the enclosure ground pad.

2.8 ELECTRICAL WORK

A. All Electrical work, products, materials and equipment shall comply with these specifications, contract documents, and the latest edition of the NEC.

B. Lighting
   1. Interior:
      a. Provide interior lighting as specified herein and as indicated on the Contract Drawings.
      b. Minimum interior illumination level for working areas shall not be less than 50-foot candles at 30 inches above the floor.
      c. Provide additional lighting for desk areas and cabinet interior spaces.
      d. Provide interior lighting controlled by a 3-way switch located at each entry door. Illumination levels shall be in accordance with these specifications.
e. Provide self-contained, fluorescent, interior lighting to obtain the illumination levels as specified herein.

f. Provide emergency lighting that will have a minimum illumination level of 5 foot-candles 30 inches above floor level of working space.

g. Emergency lighting units can be provided as individual wall-mounted units, or by fluorescent emergency packs, which consist of an inverter/charger, batteries, and a switching unit.

2. Exterior:

a. Provide a tamper proof exterior 150W, high pressure sodium exterior floodlight for each exterior wall. Control all units by a single photocell.

b. Exterior flood/area lighting fixtures shall have a Polycarbonate type lens.

c. Provide a light refractor design for a distribution pattern for 180-degree luminaire.

d. Provide a lighting control scheme consisting of the following:
   1) Hand-Off-Auto (HOA) switch.
   2) Lighting Contactor.
   3) Photo-cell.

C. Wiring:

1. Provide all required internal wiring for all Substation equipment, station interconnections and enclosure interior and exterior electrical work.

2. Receptacles: Install standard 120 volt and 240 volt receptacle as indicated on the Contract documents for each substation.

3. Provide 120 Volt 20A exterior weatherproof outlet at each end of the enclosure.

D. Conduit and Cable Trays: Provide conduit, cable trays, supports, junction boxes, and related hardware for all control and power circuits.

2.9 FIRE AND INTRUSION DETECTION SYSTEM

A. Fire Detection and Alarming:

1. Fire detection at the TPSS shall be accomplished utilizing heat and smoke detectors to activate inputs to a local fire alarm control panel. Refer to Systems Standard Specification 16854 for additional Fire Alarm Subsystem details.

2. Local fire alarm control panel shall provide alarm indications to the Authority’s Operations Control Center (OCC) via the local RTU and via IP connectivity the OCC.

3. Local fire alarm panel shall also activate an alarm light and horn annunciators within the TPSS.

4. The following equipment shall be provided at the TPSS:
   a. Audio alarms.
   b. Visual alarms.
   c. Heat detectors.
   d. Smoke detectors.
   e. Manual fire alarm pull stations.
   f. Fire alarm control panel.
   g. System power supply.
   h. Control accessories.
   i. Backup Batteries.
   j. Magnetically operated door contact switch.
   k. Intrusion alarm control panel.
   l. A minimum of 6 spare I/O contacts.

5. TPSS fire alarm panel shall interface with an IP Communicator and an RTU. Dry alarm contacts shall be provided for TROUBLE; (problem with fire detection system), ALARM, (fire alarm zone active).
B. IP Communicator

1. Control panel shall be equipped with an IP Communicator that is UL Listed, meets the requirements of the Referenced Standards, and shall be designed for central station and remote monitoring.

2. Acceptable Communication formats include Ademco Contact-ID with 512 bit AES encryption

3. Provisions for Ethernet connectivity and programming of the IP Communicator and IP Alarm Receiver at the OCC shall be provided for by this Contract. Contractor shall coordinate with the Authority for Fire Alarm information such as IP Addresses, zone assignments, VLAN assignments and test time to program the IP Communicators.

C. Intrusion Detection

1. The door to each TPSS shall be equipped with a magnetic switch to detect when the door is opened.

2. After the door is opened, there shall be a delay (30 seconds) before an alarm is signaled. During this delay, the alarm can be deactivated from a keypad by entering a preset valid 4-digit security code.

3. If an alarm is detected by the local control panel, and not deactivated by the local keyboard the system shall send an alarm indication to the OCC via the local RTU and activate a local alarm bell.

D. Heat and Smoke Detectors

1. Detectors shall be arranged in 2 zones.

2. A fully supervised class A circuit shall be utilized for power to all sensors from the control panel power supply.

3. Activation of the alarm indication from the sensor(s) to the control panel and to the OCC shall be provided.

4. Activation of any zone shall:
   a. Activate an alarm indication to the RTU and Fire Alarm IP Communicator.
   b. Shut down the TPSS HVAC system.
   c. Operate the 86-lockout relays to shutdown all the power equipment within the TPSS.

E. Annunciator Alarm Circuits

1. Audio and visual alarm annunciators shall be arranged on separate class A circuits.

2. Indication of alarms from control panel to RTU shall utilize supervised (normally closed) circuits.

F. Control Panel

1. Functions: The fire alarm control panel shall perform the following functions:


3. Controls audio and visual alarm Annunciator activation.

4. Supervise wiring, perform self-tests (including a battery life test), and provide indication of any abnormal system events.

5. Provide summary alarm indications to the RTU and the IP Communicator.

6. Provide remote testing and monitoring of serial port.

G. Control Unit

1. Control unit shall utilize the multiple zone detection concepts to determine the fire/no fire condition.

2. Control unit logic shall be self-checking to ensure that the appropriate fire/no fire decision is made.

3. Control unit shall supervise all input and output modules to verify system integrity.

4. Control unit shall monitor input power and the status of the standby battery.

H. Input/Output Module

1. Input Circuits
   a. Manual pull stations and sensors shall be supervised for activation and power.
   b. Independent modules shall be used for separate zones.
2. Output Circuits
   a. Output circuits shall supervise 19VDC to 24VDC output to audio and visual devices.
   b. Independent modules shall be used for audio and visual devices.

I. Supplemental Relay Module
   1. Four independent single-pole, double-throw, non-supervised relays shall be provided per module.
   2. Relays shall be individually assigned.
   3. Relays shall be activated on any alarm level or trouble condition.
   4. One manual disable switch shall be associated with each relay.

J. Enclosure
   1. Fire alarm control panel shall be housed in a NEMA-3 enclosure with a locking cover.
   2. Front panel LED indications shall show the status of the following:
      a. Each zone.
      b. AC power on.
      c. Battery status.
      d. Output status.
   3. Enclosure shall be designed to be wall mounted.
   4. Enclosure shall include conduit fittings to allow all sensor, annunciator, and power wiring to enter and exit the enclosure.

K. Power
   1. Primary power shall be from the TPSS 125 VDC breaker panel.
   2. A 125 VDC to 24 VDC converter power supply shall power all sensors and output devices.

L. Alarm Units
   1. Audible Alarm Bell
      a. Alarm bells shall be fabricated from a high quality die casting with a baked red enamel finish.
      b. Power shall be 24 VDC.
      c. Typical output shall be 84 dBA at 24 VDC.
      d. Typical output shall not be less than 15 dB above ambient noise level.
      e. Alarm bells shall mount to a standard 4 inch square outlet box.
   2. Alarm Horn
      a. Alarm horns shall be fabricated from a high quality die casting with a baked red enamel finish.
      b. Power shall be at 24 VDC.
      c. Typical output shall be 97 dBA at 24 VDC.
   3. Alarm Strobe Light
      a. Each alarm strobe light shall be a high intensity flashing light, utilizing a Xenon flash tube sealed in silicone and housed in a sturdy lexan lens.
      b. The translucent lens shall be attached to a fire alarm gloss red back plate.
      c. Power shall be 24 VDC.
      d. Strobe shall flash at a rate and duty cycle compliant with ADA requirements current at time of procurement.
      e. Lens shall have “Fire” imprinted on 2 sides.
   4. Strobe Horn
      a. Strobe horn shall be a high intensity flashing (ADA Compliant) light with 97-dBA-horn output.
b. Typical output shall not be less than 15 dB above ambient noise level.

c. Strobe horn shall be housed in a fire alarm, gloss red, die-cast enclosure.

d. Light source shall be sealed in silicone and protected by a sturdy lexan lens.

e. Strobe lens shall be white translucent with the word "FIRE" imprinted upon it in red.

f. Power shall be 24 VDC.

5. Heat Detectors

a. Thermal detector.

b. Thermal detectors shall activate at 194 degrees F nominal temperature setting.

c. Detectors shall be hermetically sealed.

d. Detectors shall be shock and corrosion resistant.

e. Detectors shall automatically reset upon returning to normal temperature.

6. Smoke Detectors

a. Ionization Type.

b. Ionization type smoke detectors shall have relay contact outputs rated for 24 VDC, 1.0 amp minimum.

c. Sensitivity shall be adjustable.

d. A red alarm indication LED shall be provided on the enclosure.

e. Power shall be 18.8 VDC to 27.7 VDC with current draw as follows:

1) Normal: 40 micro amps at 24 VDC.

2) Alarm: 85 milliamps at 24 VDC.

e. Operating temperature shall be 32 degrees F to 140 degrees F.

7. Photoelectric Type Smoke Detector

a. Photoelectric type smoke detectors shall have relay contact outputs rated for 24 VDC, 1.0 amp minimum.

b. Sensitivity shall be adjustable.

c. A red alarm indication LED shall be provided on the enclosure.

d. Power shall be 17.6 to 27.7 VDC with current draw as follows:

1) Normal: 40 micro amps at 24 VDC.

2) Alarm: 85 milliamps at 24 VDC.

e. Detector shall mount on a 3 inch octagonal outlet box utilizing tamper-resistant screws.

f. Operating temperature shall be 32 degrees F to plus 140 degrees F.

8. Manual Fire Alarm Stations

a. Manual fire alarm stations shall be installed within each TPSS at each entrance door.

b. Manual stations shall be double action type, providing for 2 separate and distinct actions to activate an alarm.

c. Enclosure shall be constructed of high impact polycarbonate or metal, red enclosure with raised white lettering and a smooth high gloss finish.

d. A common key shall be provided to reset the station.

9. Intrusion Alarm Control Unit

a. Intrusion alarm control unit shall perform the following functions:

1) Monitor normally closed contacts of magnetic switch assembly.

2) Control local audio alarm annunciator activation.
3) Allow deactivation when valid 4-digit security code is entered via the control keypad within 30 seconds of opening door.

4) Allow reactivation when valid security code is entered.

5) Provide intrusion alarm indication to RTU.

6) Provide for selecting the local 4-digit security code. A key shall be required to set the code.

b. Operation

1) There shall be a 30 second nominal entry/exit period.

2) A low level alert tone shall be activated when the magnetic switch is activated.

3) If the alarm is deactivated by correct entry of a 4-digit security code within 30-second entry period, low-level alert tone shall be deactivated; otherwise, an alarm condition shall be detected.

4) Alarm detection shall cause an output to the RTU and activation of local high-level audio alarms.

5) Alarm shall be armed by correct entry of the 4-digit code. There shall then be a 30 second period for exiting without activating an alarm.

6) If an incorrect or incomplete code is entered, it shall be cleared after 3 seconds. The operator may then reenter the code.

c. Enclosure

1) Intrusion alarm control unit shall be housed in a NEMA-3 enclosure with locking cover.

2) Power shall be from the TPSS 120 VDC breaker panel.

3) Battery backup for 8 hours shall be provided.

4) Power supply shall power the intrusion alarm control unit, keypad, activation circuit, and alarm devices.

5) Provide front panel LED indication for “Power On” and “Battery Status”.

10. Fire Extinguishers

a. Enclosure shall be equipped with 2 Carbon dioxide (CO2) fire extinguishers, intended for Class B and Class C fire hazards. Fire extinguishers shall be portable; wall-mount type with UL rating 10B:C. CO2 containers shall be heavy-duty, seamless, aluminum alloy cylinders, painted red, with instruction label permanently affixed. Discharge mechanism shall have a locking pin to prevent accidental discharge.

b. Fire extinguisher shall have a flexible hose and horn for aiming at the fire. Fire extinguisher shall meet or exceed the following specifications:

1) CO2 Capacity: 15 lbs

2) Weight: 20 lbs maximum

3) Range: 50 feet

2.10 SIGNAGE

A. Identification

1. Each TPSS enclosure shall be provided with signage on each external personnel access door (2 signs) for identification.

2. Sign shall have a white, reflective background with 3 inch black lettering.

3. Sign shall display the location name as described in Contract Documents followed by the letters TPSS (e.g. Pennsylvania TPSS, or Baylor TPSS).
B. Address Sign

1. Provide 1 address sign for each TPSS location. Each sign shall contain 3 lines and shall have a white background and black letters.

2. Provide a sign the same physical size as the identification sign and install below the identification sign on 1 access door.

3. Sign shall be similar to:
   Dallas Area Rapid Transit
   XXXX Dallas Ave.
   Dallas, Texas
   TPSS XXXX

4. The Authority prior to shipment shall provide addresses.

C. Warning Signs

1. Warning signs shall be installed on the exterior entry doors, hinged access panels, and those areas where maintenance personnel will be exposed to high voltage.

2. AC Warning signs shall be made of the materials with lettering and installation as specified in the Contract documents.

D. Knox Box: Provide a sign in accordance with Specification 10525, “Fire Department Key Keeper”.

E. Substation Condensed Single Line Diagram

1. A Substation single line diagram, sized 22 inch by 34 inch in polyvinyl frame, shall be provided for each Substation.

2. The single line diagram shall be mounted in a location to aid maintenance personnel.

F. Desk

1. A metallic fold-down, wall mounted desk shall be provided for drawing review.

2. Additionally, a wall mounted drawing hanger file with a half size set of as-built shop drawings shall be provided for each Substation.

G. Storage: Provide a storage unit for storage of all spare parts; spare fuse’s, “AS-BUILT” drawings, O&M manuals and instruction books.


1. Power provisions for Ethernet switches.

2. Ethernet switches (active and cold standby).

3. TPSS VoIP Telephone and wireless headset.

4. Loud Ringing Bell compatible with VoIP phones.

2.11 FABRICATION

A. Fabricate and test each enclosure as specified herein and in the Referenced Standards.

2.12 INSTALLATION

A. Contractor shall install and wire all Substation equipment per the manufacturer specifications, as specified herein and per the Referenced Standards.

B. Equipment and components shall be mounted in accordance with the shop drawings as accepted by the Authority.

C. Provide basic electrical materials in accordance with the Contract Documents as accepted by the Authority.

D. Factory Testing and verification of each piece of equipment, assembly and sub-assembly shall comply with the provisions of the Contract Documents.

PART 3 - EXECUTION

Not Used.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Work specified in this section will not be measured separately for payment, all costs in connection with this Section will be considered incidental to the furnishing and delivery of the TPSS units.

4.2 PAYMENT

A. Payment is inclusive of all materials, labor, transportation, handling, storage, tools, computer equipment, test equipment, rental
equipment, printing services and incidentals necessary to complete the work as specified in this section, and all other related sections of the Specifications and the Drawings.

END OF SECTION – 13121
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work required for this section includes heavy duty, observation type, direct plunger hydraulic passenger elevators and supplementary items necessary to complete their installation.

B. Refer to Section 05130, “Structural Steel for Buildings” for attachment plates, angle brackets and divider beams for fastening guide-rail brackets.

C. Refer to Section 05500, “Metal Fabrications” for structural-steel shapes for subsills and pit ladders.

D. Refer to Section 08800, “Glass and Glazing” for glazing requirements.

E. Refer to Section 10430, “Specialty Signs” for “In Case of Fire Do Not Use Elevators” signs.

F. Refer to Division 16 Sections for electrical service for elevators to and including fused disconnect switches at machine room door and standby power source, transfer switch, connection from auxiliary contacts in transfer switch to controller and interface with fire alarm system.

1.2 REFERENCED STANDARDS

A. American Society of Mechanical Engineers (ASME):
   2. ASME A17.2 - Guide for Inspection of Elevators, Escalators, and Moving Walks

B. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel
   2. AWS D1.3 - Structural Welding Code - Sheet Steel

C. American National Standards Institute (ANSI)
   1. ANSI C80.1 – Electrical Rigid Steel Conduit (ERSC)
   2. ANSI/NEMA FB1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
   2. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
   3. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
   4. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

E. International Code Council (ICC):
   1. ICC/ANSI A117.1 - Accessible and Usable Buildings and Facilities

F. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code hereinafter referred to as NEC
   2. NFPA 72 – National Fire Alarm Code
   3. NFPA 130 - Fixed Guideway Transit and Passenger Rail Systems

G. Texas Accessibility Standards (TAS)
   1. Architectural Barriers Act, Article 9102

H. U.S. Architectural & Transportation Barriers Compliance Board's “Americans with Disabilities Act (ADA), Accessibility Guidelines (ADAAG)”.
   1. ADA Standards for Accessible Design, 28 CFR Part 36 Section 4.10.14

I. Underwriters Laboratories, Inc (UL)
   1. UL 486

1.3 DEFINITIONS

A. Defective Elevator Work: Operation or control system failures; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; the need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
B. Heavy Duty Elevator: An elevator designed specifically for public transportation system usage as specified by American Public Transportation Association (APTA).

C. Final Acceptance: The point at which the Authority accepts the elevator as being complete including submittal requirements and acceptance testing.

D. Interim Maintenance: Maintenance from the point of Final Completion, but prior to Revenue Service.

E. Beneficial Use: When the elevator is placed into service by the Authority, may be prior to the site being ready for public use.

F. Revenue Service: The station or facility opening date to the public.

1.4 DESIGN CRITERIA

A. Systems shall conform to the requirements of ASME A17.1 and Supplements, and ASME A17.2 and Supplements for safety devices, running clearance, testing and maintenance methods. Review Contract Documents for compatibility with respective products.

B. Elevator specifications are intended to cover complete installation of elevator and to broadly outline equipment required, but do not cover details of construction. Such details are recognized to be exclusive responsibility of the Contractor. The Authority has made selections of capacities, speeds, control systems, materials, etc., from devices made available by manufacturers.

C. Design and manufacture elevator car for rated net passenger capacity stated in Part 2 - Products exclusive of dead weight of empty car.

D. Environmental Operational Requirements: Provide elevators capable of operating with full specified performance while exposed to following climatic and environmental conditions:

1. Design exterior installations which open directly to street level, or are otherwise exposed to outdoor environment, to operate while exposed to the natural elements of weather, including sunlight, rain, slush, snow and ice; all conditions of relative humidity while exposed to salt, de-icing chemicals, airborne dust, and debris, and corrosive elements; and in a drybulb temperature range of negative 25 to 120 degrees Fahrenheit.

2. Elevator Equipment Rooms - Design machinery to operate in temperatures ranging from 35 degrees F to 104 degrees F dry bulb and all conditions of relative humidity while exposed to airborne dust.

E. Corrosion Protection: Design elevator assemblies in manner to avoid corrosion by galvanic action due to physical contact between dissimilar metals or other causes.

F. Hours of Operation: 24 hours per day, 7 days per week.

G. Allowable Tolerances for Elevator Travel - Secure guide rails plumb within overall tolerance of 1/16 inch maximum lateral movement, measured with no wind or solar load on building, and within 0.01 inch joint offset on rail surfaces. Limit short-span tolerance, continuously measured between upper and lower car guides, to 1/8 inch plumb tolerance.

H. Comply with ASME A17.1 for laboratory testing of elevator component parts, including buffers, interlocks, door contacts, connectors, fasteners and other materials and products used in elevator work. Label products and materials to indicate testing and certification by laboratory.

I. Design, fabricate and install elevator and parts, subject to repair and replacement, readily and easily removable and replaceable without requiring modification of hoist way structure, equipment room or elevator equipment.

1. Power unit, silencer, controller, electrical control panel, automatic door operator, operating fixtures, signals, limit and safety switches and other parts subject to wear - Contractor’s standard interchangeable production items.

2. Precisely identify replacement parts, whether produced in Contractor’s factories or secured from commercial factories and distributors. Make replacement parts available to the Authority without prejudice. Provide required quantities, uniform price and delivery time of replacement parts - On same basis as Contractor’s most favored maintenance consumer.

J. Bearings:

1. Machine and motor bearing housings shall be provided with a drilled, tapped and spot faced area in the vertical and axial axis to accommodate a transducer that a Fast Fourier Transform (FFT) analyzer requires. Permanently mount transducers on the drive bearings and run the wires into the controller to a panel with BNC connectors on the ends to accommodate the FFT analyzer.

   a. Motor limit:

      1) Rigid mount: 0.15 ips
      2) Flex mount: 0.2 ips
2. Bearings shall be rated for an AFBMA L10 life as specified, under a fluctuating bearing load. Bearings shall have basic dynamic load ratings.

K. Fasteners:
1. Fasteners shall be compatible with materials being fastened.
2. Fasteners shall be furnished with self locking nuts or retaining rings (spring washers, toothed disks).
3. Fasteners shall be equal to or of greater corrosion resistance than the most corrosion resistant metals being fastened.

L. Noise: Elevators shall have a maximum decibel reading of 70 with the doors closed during a run in the up direction.

M. Ride Quality: Elevators shall have a ride quality of;
1. A95 raw 35 mill-g, peak to peak in the x, y and z axis during a full load run in the up direction.
2. Vibration readings shall be verified in the field with an EVA-625 (as manufactured by PMT, Inc. or approved equal) placed in the center of the cab floor.

N. Car frame: No cantilevered car frames are permitted.

O. Seismic Zone: Design elevators to comply with seismic zone 2 requirements of ASME A17.1.

1.5 DOCUMENT VERIFICATION

A. In order to discover and resolve conflicts or lack of definition which might create problems, elevator manufacturer must review contract documents for compatibility with its product prior to bidding. Review structural, architectural, electrical, mechanical documents, and elevator specification.
1. Confirm hoist way size and rise prior to fabrication.

B. Authority will not pay for change to structural, mechanical, electrical, or other systems required to accommodate manufacturer’s equipment.

1.6 SUBMITTALS

A. Product Data: Submit manufacturer’s product data for each system proposed for use. Include the following:
1. Electrical characteristics and connection requirements.
2. Expected heat dissipation of elevator equipment in machine room BTU based on 120 round trip cycles per hour.
3. Maintenance programs: Submit detailed interim and revenue service maintenance programs, showing functions to be performed and their scheduled frequency.
4. Oil performance data sheets including operating temperatures.
5. Coordinated delivery schedule
6. Manufacturers recommended preventive maintenance plan, including interim maintenance procedures where applicable.
7. Pre-acceptance test forms.

B. Shop Drawings: Submit approval layout drawings to scale. Include the following:
1. Car, guide rails, buffers and other components in hoistway.
3. Maximum loads imposed on guide rails or racks requiring load transfer to building structure.
4. Loads on hoisting beams.
5. Clearances and travel of car runby
6. Clear inside hoistway and pit by
7. Location and sizes of access doors, hoistway entrances and frames.
8. Remote hydraulic piping layouts specific to each elevator.
9. Refuge space on top of car and pit.
11. Signal and operating fixtures, operating panels and indicators.
12. Cab design, dimensions and layout.
13. Hoistway-door and frame details.

C. Samples: For exposed finishes of cars, hoistway doors and frames, and signal equipment; 3 inch square samples of sheet materials; and 4 inch lengths of running trim members.

D. Calculations: Submit calculations of cab lighting and ventilation.

E. Keys to Doors: Furnish 3 keys for each elevator.
F. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and mechanical and electrical service, as shown and specified, are adequate and in accordance with manufacturer’s recommendations and are as required and recommended by governing regulations and agencies for elevator system being provided.

G. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

H. Field Testing:
   1. SCADA Alarm Testing: Refer to Section 16030, “Testing of Electrical Systems”.

I. Training Program: Submit training program and resume of training instructor for review.

1.7 OPERATING AND MAINTENANCE MANUALS

A. Operation and Maintenance Manuals: Provide manuals as specified in Section 01786, “Operation and Maintenance Instructions”. Manuals shall include the following:
   1. Complete table of contents.
   2. Complete instructions regarding operation and maintenance of equipment. Included will be complete illustrated, exploded views of all assemblies, and a complete, illustrated, exploded view for identifying all system parts.
   3. Complete nomenclature, lead time and location of replaceable parts, OEM and installer part numbers, current cost, and warehouse location. If product source is another vendor, contractor shall include name and address of other vendor.
   5. Descriptions of safety devices.
   6. Safety rules, tests, and procedures, including testing of all systems and subsystems.
   7. Troubleshooting techniques.
   8. Detailed lubrication and cleaning schedule indicating weekly, monthly, quarterly, semiannual, and annual lubrication; and a description of each lubrication point, lubrication type, and specification.

B. Certification:
   1. The OEM shall provide, to the Authority, certification that the owner of the elevator(s) shall be provided with copies of all documents related to maintenance, safety, operations, design changes, modifications, retrofits, etc., which relate to any part, component, equipment, system, subsystem, or material and services applicable to the elevator provided.
   2. All of the above referenced shall be provided by the installer as it pertains to the original installation through the end of the warranty period.
   3. Referenced material shall be provided within 30 days of publication or internal distribution by the OEM. The material, even if labeled PROPRIETARY, shall be delivered to the Authority without prejudice or delay and at no additional cost.

C. Electronic Material: Provide material on CD-ROM or DVD in a format approved by the Contracting Officer.

D. MSDS and product data sheets: Shall be submitted with an index listing each product, along with the application method of the product, approximate quantity of product per elevator, and the component the product is applied to or associated with. Contractor shall allow 6 weeks for review of MSDS by Contracting Officer.

1.8 QUALITY ASSURANCE

A. Manufacturer: Provide elevators manufactured by a firm with a minimum of 10 years experience in fabrication of elevators.
HYDRAULIC ELEVATORS

B. Installer: lead mechanics with a minimum of 10 years experience in installation of elevators. Documentation shall be required to document this requirement.

C. Regulatory Requirements: In addition to local governing regulations, comply with applicable provisions in ASME A17.1.

D. Accessibility Requirements: In addition to local governing regulations, comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board’s “Americans with Disabilities Act (ADA), Accessibility Guidelines (ADAAG)” and Texas Accessibility Standards (TAS) of the Architectural Barriers Act, Article 9102, Texas Civil Statutes.

E. Comply with NEC.

F. Comply with NFPA 72.

G. Comply with NFPA 130.

H. Qualifications of Welding Personnel:
   1. Employ welders whose qualification is certified in accordance with AWS D1.1/D1.1M and AWI D1.3.
   2. Inspection personnel shall be an AWS CWI.
   3. Certification shall remain in force for the duration of the welding operations under this Contract.

1.9 COORDINATION

A. Coordinate installation of sleeves, block outs, and items that are embedded in concrete or masonry for elevator equipment. Furnish templates and installation instructions and deliver to Project site in time for installation.

B. Coordinate locations and dimensions of other work relating to hydraulic elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; and electrical service, electrical outlets, lights, and switches in pits and machine rooms.
   1. Pit Drainage: Contractor shall coordinate location of sump pits, pumps, pipes and related wiring with elevator installer.
   2. Electrical: Installer shall coordinate with the contractor and appropriate trade in relation to CCTV, communications, smoke detectors, shunt trip breakers, CCTV, power and cab lighting and ventilation requirements.

1.10 WARRANTY

A. Special Manufacturer's Warranty: Written warranty, signed by manufacturer agreeing to repair, restore, or replace defective elevator work within specified warranty period.

   1. Warranty Period: 1 year from date of Revenue Service.

1.11 MAINTENANCE SERVICE

A. Interim Maintenance Service: Provide maintenance service for a period prior to Revenue Service.
   1. Include regular examination of installation; adjustment; greasing; oiling; cleaning, supplies and replacements of parts to keep the equipment in operating condition, except such parts made necessary by negligent use after acceptance by the Authority.
   2. Maintenance Program - Include following tasks:
      a. Periodic testing of completed installation to maintain elevators in completely operable condition.
      b. Running elevators for minimum 6 hours per month.
      c. Lubrication of parts as required.
      d. Repairs as needed.
      e. Adjusting and cleaning.
   3. Documentation: Submit documentation to show that Maintenance Program was done.

B. Initial Maintenance Service: Beginning at Revenue Service, provide 1 year full maintenance service by skilled employees of the elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Provide parts and supplies as used in the manufacture and installation of original equipment.
   1. Include 24-hour-per-day, 7-day-per-week emergency callback service with 1 hour or less response time.
   2. Documentation: Submit documentation to show that maintenance service was performed and detailing maintenance action taken.

C. Continuing Maintenance Proposal: Provide a continuing maintenance proposal from Installer to Authority, in the form of a 4 year maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.
HYDRAULIC ELEVATORS

1. Proposal shall be based on DART's Exhibit H - Statement of Work.

PART 2 - PRODUCTS

2.1 SUMMARY OF FEATURES

A. Elevators:
   1. Function: Passenger
   2. Type: Under-the-car single cylinder.
   4. Rated Speed: Minimum 80 fpm, maximum 100 fpm.
   6. Car Enclosures:
      b. Inside Clear Depth: 84 inches.
      c. Inside Clear Height: 96 inches.
   7. Hoistway Entrances:
      a. Width: 42 inches.
      b. Height: 84 inches.
      c. Type: Single-speed center opening.
      d. Car and Hoistway Door Operation: Power High-speed, heavy duty (Minimum opening speed 3.0 FPS)
   8. Hall Fixtures: Satin No. 4 stainless steel.

2.2 MATERIALS AND COMPONENTS

A. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Specification Section.

B. Protective Cylinder Casings: PVC pipe casings complying with ASME A17.1, of sufficient size to provide not less than 1 inch clearance from cylinder, and extending above pit floor.

C. Corrosion Protective Filler: A solventless, petroleum-based gel formulated for filling the space between hydraulic cylinders and protective casings. Filler is heavier than water, electrically nonconductive, and liquefies at approximately 150 degrees F.

1. Products: Subject to compliance with requirements, provide 1 of the following:
   a. Diversified Enterprises; No-Ox-Id R-R #6110A.
   c. Or approved equal.

D. Finish Materials: Provide the following materials and finishes for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated:
   1. Stainless Steel: ASTM A 666, Type 316, No. 4 finish unless scheduled otherwise.
   2. Aluminum: Extrusions per ASTM B 221; sheet and plate per ASTM B 209.

2.3 MACHINE ROOM COMPONENTS

A. Hydraulic system shall be of compact design suitable for operation under the required working pressure, not to exceed 400 p.s.i. measured at the pump. Pump unit shall not be mounted in the hydraulic-fluid storage tank. Pump shall be driven with a 1 piece multi-groove V-belt. The direction valve shall control flow for up and down directions hydraulically and shall include an integral check valve. A control section including control solenoids shall direct the main valve and control: up and down starting, acceleration, transition from full speed to leveling speed, up and down stops, pressure relief and manual lowering. All of these functions shall be fully adjustable for maximum smoothness and to meet contract conditions. System to be provided with a muffler and a low-pressure switch. Provide a single lever ball type shut-off valve in both the machine room and the elevator pit.
   1. Included in the reservoir shall be an oil fill strainer with air filter and a self-cleaning strainer in the suction line.
   2. Tank shall have a reserve capacity of not less than 10 gallon and sight glass with markings for minimum and maximum oil level.
      a. Mount sight glass so that it is visible and protected from accidental contact.

B. Provide 2 panel mounted run-time meters or hour meters on each elevator. Meters shall be viewable without opening panel door.
   1. One meter shall record hour unit is running in revenue service mode (not in fault mode).
2. Other meter shall only record hours the motor is running (includes viscosity control and normal revenue service operations).

2.4 CONTROLLER

A. PLC-based controller shall be provided, governing starting and stopping, as well as preventing damage to the motor from overload or excessive current. It shall automatically cut off the motor current and bring the car to rest in the event any of the safety devices are activated. Controller shall be mounted in a vented cabinet within the machine room. Controller shall utilize soft start characteristics.

1. Two Car Group: Provide “group automatic operation” as defined in ASME A17.1.

2. Provide intermittent automatic operation, once every 3 hours through the entire run of the hoistway. Cycling shall be the full 24 hours each day throughout the year.

3. Low-oil control shall turn off the elevator if a low oil condition is detected.

B. Emergency power shall be from an Uninterruptible Power System (UPS) located in the elevator equipment room.

1. Upon the failure of the normal power, the elevator shall be lowered to the lowest landing. Upon arrival at the lowest landing, the elevator doors shall open automatically and remain open until the regular door time has expired. The elevator will then become inactivated.

2. Upon restoration of normal power, the elevator shall then become activated.

C. SCADA Alarm Contacts: Provide 2 sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in each of elevator controller. The normally open contacts to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Elevator failure alarm.

D. Tank Cooler: Cooling unit Specifications:

1. Heat removal: to comply with expected heat dissipation of elevator equipment in machine room BTU based on 120 round trip cycles per hour.

2. Adjustable thermostat control

3. 10 micron filter

4. Must be capable of remote installation

E. Hydraulic piping: Piping shall use a minimum of schedule 80 pipe. No victaulic fittings are permitted. Buried piping shall be welded and left uncovered until accepted and approved by the Contracting Officer.

2.5 SAFETY DEVICES

A. Provide a pipe rupture valve on the main cylinder line in the pit.

2.6 JACK HOLE AND CASING

A. Jack hole shall be drilled by using a rotary drill. No hammer drilling or blasting shall be allowed. The hole shall be located within 1 inch of the approved shop drawing location.

B. Schedule 80 steel drill casing shall be provided. Drill casing shall be installed plumb so that the hydraulic jack can be installed perfectly plumb.

C. Prior to the installation of the drill casing, the Contractor shall submit a drawing showing the details of installation of hydraulic jack unit inside of the drill casing for approval. The drawing shall show all dimensions of the hydraulic jack, PVC liner, sand fill, drill casing, all couplings and the details for securing the PVC liner to the elevator pit.

2.7 HYDRAULIC JACK UNIT

A. It shall be of sufficient size to lift the gross load to the height specified at the rated oil pressure and speed, and be factory tested to ensure adequate strength and freedom from leakage. No brittle material, such as gray cast iron, shall be used in the jack construction. All pipe sections shall be secured to each other with threaded connections.

B. Jack shall consist of the following parts: a non telescoping plunger of heavy seamless steel tubing accurately turned and polished; a stop ring electrically welded to the plunger to positively prevent plunger leaving its cylinder; an internal babbitt-lined, guide bearing; packing or seal of suitable design and quality; a drip ring around cylinder top; a cylinder made of steel pipes and provided with a pipe connection, air bleeder valve and oil drain plugs all positioned above the pit floor. The cylinder shall be furnished at the bottom with a safety bulkhead with an orifice to limit the speed of the car’s descent to 15 feet per minute in the event that the outer case fails. Weld brackets to the cylinder for supporting the jack on pit channels. A platen plate shall be mounted with neoprene rubber sound dampeners designed to isolate the platen plate from the car frame with a safety factor of 4.

C. Jack shall be provided with a caged primary seal and secondary seal so that weep oil can be drained via tubing to the scavenger pump tank.
HYDRAULIC ELEVATORS

D. If the jack must be supplied in Sections, the Sections shall be threaded. The cylinder shall also be welded and then polished at the threaded joint. The joints shall have any pipe coatings reapplied as per manufacturer’s Specifications.

2.8 HOLE TYPE JACKS

A. The jack shall be fabricated with an integral sleeve for connection to the PVC liner. The interstitial space between the PVC liner and the jack shall be capable of being monitored by a port on the pit plate.

B. Complete outer cylinder shall be waterproofed with a factory applied extruded pipe coating to protect the casing from corrosion. Pipe coating shall consist of 10 mills of Butyl Rubber or approved equal adhesive and 40 mils of heat applied polyethylene over coating. Coated pipe shall be protected during shipment with sheet steel wrap. The jack unit shall be installed accurately centered and plumb.

C. Install the jack unit in separate PVC outer liner constructed from Schedule 80 PVC pipe. The liner shall have a dished seamless bottom, a water stop ring attached to the liner and embedded in the pit floor, and sealed joints to prevent moisture seeping into the annular space between the liner and cylinder. The top of the liner shall be attached to the integral sleeve on the hydraulic jack.

D. For the drill casing, see Structural Contract Drawings and Paragraph 2.11.

E. After centering jack unit, affix it to the pit channels. Use stainless steel shims to level the pit channels. Fill the space between the steel casing and the PVC liner with clean dry sand to maintain plumbness and support PVC liner.

2.9 HOISTWAY

A. Provide manufacturer’s standard components complying with Code, except as otherwise indicated.

B. Guide Guides Shoes - Provide adjustable, spring-loaded guides appropriate for specific applications, using minimum of 3 rollers per guide, with a minimum 6 inch nominal roller diameter.

C. Buffers - Provide buffers with necessary blocking and support under elevator car as required by ASME A17.1.

2.10 WIRING

A. Conduits:

1. Unless otherwise specified, electrical conductors in the pits and hoistways, except traveling cable connections to the car shall be provided in rigid steel conduit with steel outlet boxes, except that a small amount of flexible conduit may be used where conduit is not subject to moisture or embedded in concrete

2. Rigid steel conduit shall be full weight, threaded, hot-dip galvanized, inside enameled, conforming to ANSI C80.1.

3. Conduit fittings and bodies shall meet ANSI/NEMA FB 1; threaded type, material to match conduit.

4. Terminal boxes, pull boxes and other similar items, shall be of approved construction, thoroughly reinforced, and shall meet ANSI/NEMA FB 1.

5. Electrical boxes exceeding 150 cubic inches shall be supported independently of the conduits.

6. Raceways shall be threaded rigid steel conduit complying with ANSI/NEMA FB 1.

7. Where permitted flexible heavy-duty service cord, type SO, may be used between fixed car wiring and switches on car doors for safety edges and light ray devices for reversal devices.

8. Where permitted, flexible metal conduit shall be fabricated in continuous length from galvanized steel strip, spirally wound and formed to provide an interlocking design with a gray XLPO Thermoset Type 2 outer jacket.

9. Conduit terminating in steel cabinets, junction boxes, wireways, switch boxes, outlet boxes and similar locations shall have approved insulation bushings. If the bushings are constructed completely of insulation material, a steel locknut shall be installed under the bushing. At ends of conduits not terminating in steel cabinets or boxes, the conductors shall be protected by terminal fittings having an insulated opening for the conductors.

10. Conduits terminating in NEMA 4X boxes shall be backed up with flat rust resistant steel plates to fit the entire area where the conduit penetrated the box.

11. Conduit fittings and connections shall be compression type. The use of set screw or indentations as a means of attachment is not permitted.

12. Connect motors and other components subject to movement or vibration, to the conduit systems with flexible conduit.

13. Contractor shall furnish all materials and completely wire all parts of the electrical equipment of the elevators including...
electrical devices on hatch doors. All car wiring and conduit shall be replaced with new including car junction boxes.

14. Solid state and electrical components located on top of the car enclosure or in the hoistway shall be installed within NEMA 4X enclosures.

15. Conduits shall be brought and connected to suitable approved connection boxes at all outlets, apparatus and panels.

16. Conduit Sizing, Arrangement, And Support:
   a. Size conduit per NEC for conductor type installed or for Type THW conductors, whichever is larger; 3/4 inch minimum size for conduit.
   b. Conduits for small devices such as door switches, interlocks, etc. shall be permitted at 1/2 inch.
   c. The total overall cross sectional area of the wires contained in any conduit shall not exceed 40 percent of the internal area of the conduit.
   d. Arrange conduit to maintain headroom and present a neat appearance.
   e. Route exposed conduit parallel and perpendicular to walls and adjacent piping.
   f. Maintain minimum 6 inch clearance between conduit and piping. Maintain 12 inch clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
   g. Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using galvanized straps, lay-in adjustable hangers, clevis hangers, or bolted split stamped galvanized hangers.
   h. Group conduit in parallel runs where practical and use conduit rack constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit on racks.
   i. Do not fasten conduit with wire or perforated pipe straps. Remove all wire used for temporary conduit support during construction, before conductors are pulled.

j. No conduit shall be attached to a cable tray or installed within 6 inches of a cable tray or light fitting except for termination.

k. Approved strain boxes shall be installed for all vertical runs in accordance with Code.

17. Where conduit penetrates fire-rated walls and floors, seal opening around conduit with UL listed through penetration firestop system to maintain wall or floor rating.

18. Interlock, hall button and limit switch branch wiring shall be enclosed in flexible steel conduit with covering of liquid tight Type "EF" with connectors having nylon insulated throat.

19. Screws used for terminal connections of all wiring (machine room, hoistway and pit) shall be provided with "star washers" of proper size and type.

B. Conductors:

1. Unless otherwise specified, conductors, exclusive of traveling cables, shall be 98% conductivity copper, solid, for size 10 AWG and smaller, and stranded for size 8 AWG and larger shall be stranded or solid coated annealed copper in accordance with the NEC for Type THHW.

2. Where 16 and 18 AWG are permitted by Code, either single conductor cable in accordance with Code for Type TF, or multiple conductor cable may be used provided the insulation of single conductor cable and outer jacket of multiple conductor cable is flame retardant and moisture resistant.


4. Insulation: ANSI/NEC, type THHN/THWN, XHHW or THW.

5. The use of PVC insulation shall not be permitted.

6. Color Coding: Power conductors identified as to phase and voltage by means of color impregnated insulation, as follows:
   a. 120/208 Volts:
      1) ØA: Black
      2) ØB: Red
      3) ØC: Blue
      4) Neutral: White
HYDRAULIC ELEVATORS

5) Ground: Green

b. 277/480 Volts:

1) ØA: Brown
2) ØB: Orange
3) ØC: Yellow
4) Neutral: White
5) Ground: Green

c. For wire sizes No. 8 AWG and larger, color banding tape, minimum 2 inches wide, may be used at accessible locations in lieu of colored insulation.

7. Multiple conductor cable shall have color coding or other suitable identification for each conductor. Conductors for control boards shall be in accordance with Code.

8. No joints or splices shall be permitted in wiring except at outlets. Tap connectors may be used in wireways provided they meet UL requirements.

9. Wiring shall test free from short circuits or grounds. Insulation resistance between individual external conductors and between conductors and ground shall be not less than 1 meg-ohm.

10. Where size of conductors is not given, capacity shall be such that maximum current shall not exceed limits prescribed by Code.

11. Equipment grounding shall be furnished and installed. Ground conduits, supports, controller enclosures, motors, platform and car frames, and other non-current conducting metal enclosures for electrical equipment in accordance with Code. The ground wires shall be copper, green, insulated and sized as required.

12. Terminal connections for conductors used for external wiring between various items of elevator equipment shall be solderless pressure wire connectors in accordance with Code. Contractor may at his option make these terminal connections on No. 10 or smaller conductors with approved terminal eyelets set on the conductor with a special setting tool, or with an approved pressure type terminal block. Terminal blocks using pierce-through serrated washers are not acceptable.

13. Provide necessary conduit and wiring between remote machine room and hoistway.

C. Traveling Cables:

1. Traveling cables from junction box on car to junction box in hoistway shall consist of flexible traveling cables conforming to the requirements of Code.

2. Junction boxes in hoistway and on car shall be equipped with terminal blocks. Connections to terminal blocks shall be made with either terminal eyelet connections or pressure wire connectors of the clamp type that meet UL 486 requirements for stranded wire.

3. Terminal blocks shall have permanent indelible identifying numbers for each connection. The outer covering must remain intact between junction boxes. Abrupt bending or twisting producing distortion of cable is not permitted.

4. Cables shall be free from any possible contact with hoistway structure, car or other equipment. Furnish and install shields or pads to protect the cables.

5. Travel cables shall include, as a minimum:

a. 2 coaxial cables shielded for the CCTV system.

b. 4 cat 5 twisted shielded pairs for security and telephone systems

6. Provide 10 percent but not less than 2 spare conductors in each traveling cable.

7. Provide separate traveling cables for car lighting and fan control circuits.

8. Provide traveling cable for telephone in the elevator car. Cable shall extend from junction box in hoistway to telephone box in car.

9. Provide traveling cable for car work lights. Cable shall extend from junction box in hoistway to car junction box.

10. Car and hoistway junction boxes shall be provided for on the top of the elevator cab.

11. Cables shall include 10 percent spare wires between each controller, selector, and hoistway junction box, all spares to be properly tagged or otherwise identified with clear and indelible markings.

12. Insulated wiring, control wiring and wiring in traveling cables shall be tag coded at their
terminals in the motor room, and hoistway junction box, elevator cab junction box, and push-button stations within the cab, and shall agree with the approved wiring diagrams.

13. Traveling cable shall be wired directly from the controller to the elevator with no hoistway junction box.

14. Emergency stop switch in the car shall be connected to all alarm bells in a manner that will cause the bells to ring when the emergency stop switch is in the "On" position.

D. Motor Circuits:

1. Contacts in elevator motor circuits that are to be opened by governors or other safety devices shall be copper to carbon or other approved of the non-fusing type. Contacts on control and signal relays and switches shall be commercially pure silver. Contacts on switches breaking heavy motor circuits shall be copper to carbon or, if of metal, shall have supplementary breaking contacts and shall operate with suitable wiping action, or shall be of approved equivalent design and construction. They shall be equipped with suitable blowout coils, vanes, barriers, etc., where necessary to prevent undue arcing and heating.

2. Car and hall operating signal circuits shall not exceed 48 volts.

3. Each major component of equipment shall have the manufacturers name, type, class or catalog number on a metal plate securely attached to the item of equipment in a conspicuous location.

4. Cabinets containing motor drives, filter boxes, transformers and power reactors shall be supported on rails and isolated from the base building structure with elastomer pads having a minimum static deflection of 3/8 inch (Mason Type N, or equivalent). All connections to and from the cabinetry shall be flexible in order not to compromise the isolation system. Use non-rigid conduit for the final electrical connection, with all other conduit supports and clamps provided on a neoprene sponge insert.

5. Provide connections of fused main line disconnect switch of the lockable type for the elevators in the machine rooms.

6. Signal to the controller in the machine room to indicate special emergency condition due to lobby smoke detector activation; and smoke detectors in the elevator lobby and machine room in accordance with the ASME A17.1 code. Furnish and install means to automatically disconnect the main line power supply to the elevator prior to the application of water.

7. Car lighting and fan circuit for the elevators shall be located in circuit breaker panel in the machine rooms.

8. Permanent light fixtures with switches and duplex-grounded receptacles in the elevator machine room and elevator pit. Receptacles in the pit shall be ground fault circuit interrupter type.

2.11 EQUIPMENT: SIGNAL DEVICES AND FIXTURES

A. Car-Operating Panel: Stainless steel No. 4 vertical finish panel shall be provided with vandal resistant push buttons designed to bottom out against the panel plate and not the contacts, key switches.

B. Provide 1 car operating panel integral with a stationary return panel.

C. Braille/Arabic designations shall be flush with inconspicuous mechanical mounting.

D. Provide a service cabinet with a locked flush hinged or sliding door and integral certificate frame. Certificate Frame shall have durable Plexiglas window and be accessible from backside of locked door. Minimum window size to be approved by the Owner. Cabinet shall contain the following key type controls:

1. A light switch.
2. Two speed fan switch.
3. Inspection switch, conforming with the Code.
4. Independent service switch.
5. A duplex 120 volt, A.C. GFI convenience outlet.
7. Keying to match sample provided by Authority.

E. Engrave the car operating panels with the following:

1. No Smoking. Minimum 1 inch high lettering and graphic symbol
2. Elevator Number over operating buttons. Minimum 1/4 inch high lettering.
F. Car Position Indicator: A vandal resistant car position indicator shall be provided integral with the car operating panel.

G. Communication Device: Provide hands free communication device recessed in operating panel in each elevator cab as specified in Section 16851, “Telephone Subsystem – Communications System”, for PEC devices with following additional requirements:

   1. No blue light beacon is required.

   2. Telephone assembly shall be flush mounted into a recessed area in the elevator control panel, with brushed stainless faceplate finish or a finish to match the elevator panel. Alternatively, the unit may be mounted without faceplate behind an existing control panel that is integral to the elevator cab assembly, so long as the speaker and microphone cutouts match, the elevator control panel labeling satisfies ADA standards, and specified features and functions of the telephone are made available. Mounting height shall be in accordance with ADA Standards for Accessible Design, 28 CFR Part 36, Section 4.10.14.

   3. A readily identifiable location marker plate indicating station name, address, and telephone location (ie. south elevator) shall be installed on or adjacent to the faceplate of each telephone.

   4. Operating instructions shall be incorporated with or adjacent to the telephone and shall conform to ASME A17.1a-2002 Section 2.27.7.3.

H. Car Lantern and Chime: A stainless steel vandal resistant directional lantern visible from the corridor shall be provided in the car entrance. When the car stops and the doors are opening, the lantern shall indicate the direction in which the car is to travel and an adjustable electronic chime will sound.

I. Hall Fixtures: Hall fixtures shall be provided with necessary stainless steel vandal resistant push buttons and key switches for elevator operation. Raised markings shall be provided for each push-button

J. Landing Passing Signal: An adjustable electronic chime bell shall sound in the car to tell a passenger that the car is either stopping at or passing a floor served by the elevator.

2.12 DOOR OPERATOR EQUIPMENT

A. Provide a GAL MOVFR-HSL or equal door operator with encoderless VVVF drive and the following features:

   1. 1/2 hp motor and heavy duty sprocket, chain, belt, and sheaves.


   3. Hand-held keypad programming.

   4. Adjustments can be stored in the keypad and downloaded to another operator.

   5. Adjustable door obstruction reversal.

   6. Optical cams with LED indicators.

   7. Test switches for open, close, nudging and speed zone set up.

   8. Universal inputs for open, close, and nudging.

   9. Reversing switch to back up the door reversal device.

B. Provide a non contact door reversal device with light immunity: The Door Reopening Device shall cause both the car and hoistway doors to reverse, should they detect an obstruction in the elevator entrance and shall be Tri-Tronics, “W” Series Door Edge, or approved equal. The device electrical wiring shall be supplied with quick disconnects terminals to facilitate replacement. The infrared curtain detector shall include the following:

   1. Protective infrared detector field extending from 1-1/2 inches above the car sill to a height of 68 inches.

   2. Fail-safe control system to prevent the doors from closing in case of power loss to the detector.

   3. One-piece full door height protective lens cover designed to be completely waterproof and to withstand impact, abrasion and vandalism.

2.13 CAR FRAME

A. Car Frame: A suitable car frame shall be provided with adequate bracing to support the platform and car enclosure. The buffer striking plate on the underside of the car-frame platform assembly must fully compress the spring buffer mounted in the pit before the plunger reaches its lower limit of travel. Provide welded or bolted ASTM A123/A123M galvanized or stainless steel channel uprights affixed to crosshead and plank channels with welded or bolted bracing members and gusset plates which will remove strain from car enclosure.

B. Platform, Heavy Loading Type: The car platform shall be arranged to accommodate 1-piece loads weighing up to 25 percent of the rated load, such as wheeled food carts, hand trucks, etc. The platform shall be stainless steel.
2.14 CAR ENCLOSURES

A. General: Provide car enclosures with glazing, suspended ceiling, trim, accessories, access doors, doors, power door operators, sills (thresholds), lighting, emergency lighting and ventilation.

1. Fabricate car with recesses and cutouts for signal equipment.

2. Fabricate car door frame integrally with front wall of car.


B. The clear height under the ceiling canopy shall be a minimum of 8 foot. Ceiling canopies shall be stainless steel not less than 0.109 inch nominal thickness.

C. Ventilation: Provide 2-speed heavy duty blower. Finish and material of fan enclosure and blade shall match the finish and material of the ceiling having a NEMA 4X rating. Exhaust blowers shall be designed with a hood. Air handling capacity of blower shall be 1 air change per minute based on net inside car volume. Provide auxiliary power source capable of providing minimum air handling capacity for continuous period of at least 1 hour on each elevator car.

D. Finishes:

1. Front Walls: Satin No. 4 stainless steel with integral car door frames.

2. Car Fixtures: Satin No. 4 stainless steel.


4. Reveals: Satin No. 4 stainless steel.

5. Door Faces (Interior): Satin No. 4 stainless steel.

6. Door Sills: Stainless steel, with grooved surface, 1/4 inch thick.

7. Ceiling: Satin No. 4 stainless steel.

8. Handrails: 1-1/2 inches outside diameter satin No. 4 stainless steel, at side and rear walls. Wall connectors shall have security type fastenings and shall be the same material and finish as the handrail. Handrail height shall confirm with Code requirements.

9. Floor recessed and prepared to receive a heavy gauge stainless steel with Diamond Plate as a finished floor. Provide cementitious backer units applied over 5/8-inch underlayment grade, exterior plywood, screwed to car platform.

2.15 HOISTWAY ENTRANCES

A. Door Frames: Entrance frames shall be of bolted construction for complete 1-piece unit assembly. Frames shall be securely fastened to fixing angles mounted in the hoistway and shall be of 2 mm stainless steel. Provide an additional stainless steel sill angle support. The sill shall be stainless steel.

B. Doors: Entrance doors shall be of hollow metal construction with vertical internal channel reinforcements. Panels front and rear, framing, operating levers, and integral hardware shall be stainless steel; panel shall be 2mm and have a No. 4 finish.

C. Entrance Finish: Finish shall be stainless steel No.4 finish.

D. Sight Guards: Stainless steel

E. Provide a sill mounted closer at landings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Verify critical dimensions including accessibility for maintenance, and examine supporting structure and other conditions under which elevator work is to be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Comply with referenced standard and manufacturer’s instructions and recommendations for work required during installation.

B. Excavation for Jack: Drill excavation in each elevator pit to accommodate installation of protective casings and cylinders.

1. Provide waterproof well casings as necessary to retain walls of well hole.

2. Remove and dispose of drilling spoils.

C. Install cylinders in protective casings within well hole or casing. Before installing protective casing, remove water and debris from well hole or casing and provide permanent waterproof seal at bottom of well casing. Fill void space between protective casing and cylinder with corrosion-protective filler.

1. Align cylinders and fill space between well casing and protective casing with fine sand unless otherwise required by authorities having jurisdiction.
D. Install cylinders plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between protective casing and pit floor with 4 inches of nonshrink, nonmetallic grout.

E. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.

F. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.

G. Install piping above the floor, where possible. Where not possible, install underground piping in Schedule 40 PVC pipe casing assembled with solvent-cement fittings.

H. Lubricate operating parts of systems as recommended by manufacturer.

I. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with cars. Delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.

J. Leveling Tolerance: 1/2 inch, up or down, regardless of load and direction of travel.

K. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.

L. Program elevators to set at lower level.

3.3 FIELD QUALITY CONTROL

A. General:

1. Notify the Contracting Officer 7 days prior to each scheduled test. Contractor shall perform testing in the presence of Contracting Officer’s representative.

2. Notify the appropriate local authorities having jurisdiction a minimum of 7 days in advance of final acceptance tests.

3. Provide instruments, materials, and labor required for tests specified herein.

4. Pre-test devices within his control and provide documentation to prove compliance prior to jurisdictional inspection.

B. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.

C. Test Period: The elevator shall be subjected to a test for a period of 1 hour continuous run, with full specified load in the car. During the test run, the car shall be stopped at all floors in both directions of travel for a standing period of 10 seconds per floor.

D. Speed Load Tests: The actual speed of the elevator car shall be determined in both directions of travel with full contract load and with no load in the elevator car. Speed shall be determined by a tachometer. The actual measured speed of elevator car with full load shall be within 10 percent of rated speed. The maximum difference in actual measured speeds obtained under the various conditions outlined between the “UP” and the “DOWN” directions shall be checked.

E. Post Acceptance Inspection: After the elevator is accepted by the local jurisdiction, a second inspection will be conducted (without weights) to determine specification compliance above and beyond the code requirements of the acceptance inspection.

F. Test interface with fire alarm system with COR and Fire Marshal’s representative present. Test Phase 2 recall functions and communications.

G. Reinspection: If any equipment is found to be damaged or defective, or if the performance of the elevator does not conform with the requirements of the contract specifications or the Safety Code, no approval or acceptance of elevators shall be issued until all defects have been corrected. When the repairs and adjustments have been completed and the discrepancies corrected, the Owner shall be notified and the elevator will be reinspected. Rejected elevators shall not be used until they have been reinspected and approved.

1. Reinspection Penalty: In addition to any additional fees imposed by the local jurisdictional authority for repeated inspections. Liquidated damages of $1,000 per reinspection will be imposed if any punch list items are not completed within 1 follow up inspection.

3.4 FINAL ADJUSTMENTS

A. Align guide rails vertically within tolerance of 1/16 inch in 100 feet. Secure joints without gaps and file irregularities to smooth surface.

B. Balance cars to equalize pressure of roller guide on rails.

C. Lubricate equipment in accordance with manufacturer’s instructions.
D. Adjust motors, brakes, controllers, leveling switches, door switches, stopping switches, door operators, door gap, interlocks and safety devices, to achieve required performance levels.

E. Fabricate and assemble various parts in shop insofar as practicable to minimize field assembly. Parts which cannot be shop assembled and require close field fit - Trial assemble in shop and mark for field erection.

3.5 DEMONSTRATION

A. Provide 40 hours of local training for Authority’s personnel in proper use, operations, and daily maintenance of elevators. Review emergency provisions, including emergency access and procedures to be followed at time of operational failure and other building emergencies. Train Authority’s personnel in procedures to follow in identifying sources of operational failures or malfunctions. Provide manuals for material covered in the training program. Confer with Authority on requirements for a complete elevator maintenance program.

1. Provide a 60 minute (minimum) DVD describing and demonstrating daily maintenance, emergency procedures and troubleshoot techniques for electrical and mechanical failures and malfunctions.

B. Make a final check of each elevator operation with Authority’s personnel present and before date of Substantial Completion. Determine that operation systems and devices are functioning properly. Re-check non-compliant items.

3.6 PROTECTION

A. Temporary Use: Do not use elevators for construction purposes unless cars are provided with temporary enclosures, either within finished cars or in place of finished cars, to protect finishes from damage.

1. Provide full maintenance service by skilled, competent employees of elevator Installer for elevators used for construction purposes. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity. Use same parts and supplies as used in the manufacture and installation of original equipment.

2. Provide protective coverings, barriers, devices, signs, and other procedures to protect elevators. If, despite such protection, elevators become damaged, engage elevator Installer to restore damaged work so that no evidence remains of correction work. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work described in this section will be paid for on a lump sum basis for hydraulic elevators per location (station) indicated wherein no measurement will be made.

B. The Interim Maintenance Service will be measured by and paid for at the unit price for “Interim Maintenance Service” per month per location (station).

C. The Initial Maintenance Service will be measured by and paid for at the unit price for “Initial Maintenance Service” per month per location (station) for one year.

END OF SECTION 14240
PART 1 - GENERAL

1.1 DESCRIPTION

A. The work described in this section generally refers to pertinent sections under Division 15, "MECHANICAL".

B. This Division specifies work required to provide complete heating, ventilating, air conditioning systems, compressed air systems, complete systems for potable water, drainage systems for sanitary waste disposal and storm drainage, sump pumps, and standpipe and sprinkler systems for fire suppression, as indicated and specified. In addition, this Division specifies the complete installation of systems as specified herein and as shown, and the provision of special devices, fittings, fabrications, cutting and patching, and items incidental required to fit the respective systems into the construction.

C. The Drawings are diagrammatic and not intended for use in determining the exact locations of the components of the mechanical systems, except where specifically dimensioned, nor do the Drawings indicate fittings, devices, and accessories required for the complete installation. Refer to the Drawings of all trades of this Contract, and the drawings of other contracts as referenced in Section 01010, "Summary of the Work" to determine the location of equipment to be furnished by this Contract, and by other Contracts as referenced.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
2. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
3. ASTM F436 - Standard Specification for Hardened Steel Washers
4. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

1.3 DEFINITIONS

A. Where the word "concealed" is used in connection with insulating, painting, piping, ducts and the like, the word is understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. "Exposed" is understood to mean open to view.

1.4 SUBMITTALS

A. See submittal of details of testing and startup procedures in Paragraph 1.14B/1/b.

1.5 QUALITY ASSURANCE

A. Comply with the requirements of Section 01430, "Contractor's Quality Assurance" and Section 01450, "Quality Control".

B. Perform work in accordance with the most recent edition of the following codes:

1. State and city building, plumbing, mechanical and energy codes.
5. Authorities having jurisdiction.

1.6 EXISTING UTILITIES AND TEMPORARY SERVICES FOR CONSTRUCTION

A. Verify the location and capacity of existing utility services pertaining to work of Division 15, "MECHANICAL".

B. Temporary Services for Construction: Provide temporary services for those existing or new systems specified within this Division in accordance with the provisions of these Specifications.

1.7 EXCAVATION AND BACKFILLING

A. Perform excavation and backfilling necessary, including compaction as specified, for the installation of Division 15 work.

B. Perform excavation and backfilling associated with the work of Division 15 in accordance with the provisions of Division 2 including trench safety requirements.

1.8 PROJECT CONDITIONS

A. Examine the areas and conditions under which work of this Section will be performed.

B. Where ducts, pipes other mechanical items are shown in conflict with locations of structural members and other equipment, include labor and materials required for extensions, offsets, and supports to clear the encroachment.
C. Although such work is not specifically indicated, furnish and install supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure and complete installation.

D. Verify dimensions and distances. No additional compensation will be allowed because of differences between work shown on the Drawings and actual dimensions and distances at the jobsite.

1.9 PREPARATION AND COORDINATION WITH OTHER TRADES

A. Perform coordination work associated with work of Division 15, "MECHANICAL":

1. Coordinate as necessary with other trades to assure proper and adequate interface with the Work.

2. Coordinate accepted equipment changes from those scheduled or specified with other trades affected. Additional compensation to other trades for equipment changes are the responsibility of the contractor making the change.

B. The Mechanical Drawings are diagrammatic, but are required to be followed as closely as actual construction and work of other trades will permit. Duct and piping arrangement have been designed for maximum economy consistent with good practice and other considerations. Install the systems arranged as shown on the drawings, except as otherwise approved in advance by the Contracting Officer.

C. Where items such as diffusers, thermostats, switches, and control panels are not specifically located on the Drawings, locate as determined in the field by the Contracting Officer. When such items are installed without such specific direction, relocate as directed by the Contracting Officer and at no additional cost to the Authority.

1.10 CUTTING AND PATCHING

A. Cutting and patching associated with the work of Division 15, "MECHANICAL" shall be in accordance with Section 01731, "Cutting and Patching" and other pertinent provisions of these Specifications.

1.11 PROJECT RECORD DOCUMENTS

A. Provide project record documents associated with the work of Division 15 in accordance with Section 01785, "Project Record Documents".

B. Provide final record documents per Section 01785, "Project Record Documents".

1.12 OPERATION AND MAINTENANCE DATA AND TRAINING

A. Operation and Maintenance Manuals: Provide manuals as specified in Section 01786, "Operation and Maintenance Instructions".

B. Operation and Maintenance Training: Provide training as specified in Section 01786, "Operation and Maintenance Instructions".

1.13 EQUIPMENT FOUNDATIONS

A. Provide equipment foundations and concrete bases for floor-mounted mechanical equipment associated with the work of Division 15, "MECHANICAL" in accordance with the provisions of Division 3, "CONCRETE":

1. Reinforcing: As specified in Section 03200, "Concrete Reinforcement".

2. Concrete: Mix S-7, as specified in Section 03305, "Portland Cement Concrete".

3. Anchor bolts (Bolts, nuts, and washers):

   a. Anchor Bolts: ASTM F1554, Grade 55, unless noted otherwise on drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers.

   b. Galvanized per ASTM A153/A153M

   c. Bolts hooked, unless otherwise shown or recommended by manufacturer of structure being anchored.

   d. Two nuts and 1 washer for each anchor bolt for plumbing pole or leveling structure.

4. Bases shall be 4 inches high above finished floors or grades (unless otherwise noted) and shall protrude 2 inches beyond sides of equipment.

5. Provide chamfer of 1/2 inch on edges. Obtain dimensions for bases by certified and approved shop drawings, or by measuring the equipment to be installed.

6. Provide method of anchoring bases to concrete floor construction as shown on approved shop drawings. Anchor pads to prevent lateral movement under conditions of vibration.

7. Set anchor bolts to template as required in accordance with details provided by the equipment manufacturer.
8. Remove and reset any anchor bolt that is set out of plumb, or has been displaced after installation.

1.14 PAINTING

A. Equipment shall be delivered to the Worksite with specified factory finish. Should the finish be damaged in transit or during the installation, it shall be finished to present a neat workmanlike appearance to the satisfaction of the Contracting Officer.

1.15 TESTING AND INSPECTION

A. General: Provide complete startup, testing, and operator training services to ensure operability of equipment supplied.

B. Field Tests and Adjustments.

1. General:

a. Mechanical and electrical equipment including the interfaces with the supervisory and control system and communication system and alarm and operating modes for each such piece of equipment shall be tested by the Contractor to the satisfaction of the Contracting Officer before any facility is put into operation. Tests shall be as specified in these specifications and shall be made to determine whether the equipment has been properly assembled, aligned and connected. Changes, adjustments or replacements required to make the equipment operate as specified shall be carried out by the Contractor as part of the work. At least 15 days prior to tests, submit SCADA control points list.

1) Normal SCADA Alarm Contacts: Two sets of Form C normally open and normally closed dry contacts. See individual sections for exact requirements.

b. At least 30 days before the time allowed in his construction schedule for commencing testing and startup procedures, the Contractor shall identify if any additional support will be required from other contractors of the Authority and/or the Authority: and shall submit his request to the Contracting Officer together with, in duplicate, details of the procedure he proposes to adopt for testing and startup mechanical and electrical equipment, except when such procedures have been covered in the specifications. These procedures are to be submitted for review and acceptance.

c. Contractor's testing and startup procedures shall include detailed descriptions of pre-operational electrical, mechanical and instrumentation testing work. Each control device, item of mechanical, electrical and instrumentation equipment, and control circuits shall be considered in the testing procedures, which shall be designed, in a stepwise, logical sequence to ensure that equipment has been properly serviced, aligned, connected, calibrated and adjusted prior to operation. Contractor is advised that failure to observe these precautions may place the acceptability of the subject equipment in question; and he may be required by the Contracting Officer to demonstrate that the equipment has not been damaged; or replace it if unable to do so. Testing procedures shall be designed to duplicate as nearly as possible conditions of operations including emergency situations, and shall be carefully selected to ensure that the equipment is not damaged. Once the testing procedures have been accepted by the Contracting Officer the Contractor shall produce checkout, alignment and adjustment, and calibration sign off forms for each item of equipment, which shall be used in the field by the Contractor and Contracting Officer jointly, to ensure that each item of electrical, mechanical, and instrumentation equipment has been properly installed and tested. Cooperate with project-wide systems contractors startup and testing to be conducted concurrently where applicable.

2. Equipment Testing:

a. Before startup, the Contractor shall properly service equipment and other items which normally require service in accordance with the maintenance instructions. Contractor shall be responsible for operation and maintenance of equipment throughout the entire equipment "break-in" period.

b. Contractor shall be responsible for the startup, adjustment, preliminary maintenance and checkout of equipment and instrumentation. Systems shall be carefully checked for conformance with the design criteria.
c. If any equipment or system does not operate properly, the Contractor shall immediately replace or repair components until it operates properly.

d. When the equipment startup is complete, the Contractor shall submit a test report, including checklists, original copies of observation records with observers initials and log sheets, to the Contracting Officer.

3. Contractor shall provide support as required during the "systems startup"

C. Systems Startup:

1. Contractor shall be responsible for a 30 day startup period, during which time electrical and mechanical equipment, fixtures and associated devices shall be energized and operated under local and automatic controls. Contractor shall be present during the startup period with adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise. The startup time shall be renewed after repair made during the startup period.

2. When a piece of mechanical or electrical equipment fails to perform in accordance with specifications, an adjustment shall be made to the item by an experienced authorized representative of the manufacturer.

3. If adjustments fail to correct the operation of a piece of equipment or fixture, remove the equipment or fixture from the Project Site and replace it with a workable replacement that will meet the specification requirements.

1.16 WARRANTY

A. Unless otherwise noted, the Contractor shall guarantee mechanical equipment and workmanship for a period of 1 year in accordance with the warranty clause of the GENERAL PROVISIONS after date of final completion and replace or repair any faulty equipment or installation at no cost to the Authority for such service during this period, in accordance with requirements of the GENERAL PROVISIONS.

B. This guarantee shall not void specific guarantees issued by manufacturers for greater periods of time. Nor shall it void any rights guaranteed to the Authority by law.

C. Warranties shall be in writing in a form satisfactory to the Authority, and shall be delivered to the Authority before the final acceptance of the work in accordance with Division 1, "GENERAL REQUIREMENTS".
PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with requirements for installation, field testing and balancing as specified in the material and system installation paragraphs of this division.

B. Work in Place: Inspect the work in place and verify ability to make connections to the work in place or being installed under other current contracts. Work in place generally consists of: support inserts embedded in the construction, piping embedded in the construction and below the base slab, penetrations through floors, walls, roof, or other structural elements, and cast-in-place concrete duct systems and shafts.

C. Connections to Existing Facilities: Make connections to existing facilities in accordance with details as shown or as approved by the Contracting Officer. Where material specified under this Contract differs from material in place, provide adapters, dielectric fittings, or special connectors as required. Use the requirements of applicable codes and recommendations of material manufacturers as a basis for determining exact type of adapters and fittings to be provided under this Contract.

D. Connections to Work by Others: Connect new work provided under this Contract to work installed under other contracts, or required for equipment furnished by other contractors. Make required connections of this Contract to work by others in a proper and workmanlike manner. Refer to the drawings and specifications for other Contracts as referenced, in the WORK BY OTHERS Article of Section 01010, "Summary of the Work" of the General Requirements and to utilities drawings for services to this Worksite, to determine the number and types of connections required.

E. Alterations to Existing Facilities: If it is determined that, in order to make proper connections to existing duct and piping systems existing facilities must be altered, make such alterations in accordance with Section 01731, "Cutting and Patching", or a manner as directed by the Contracting Officer, using materials identical to and compatible with existing materials and as approved.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The work specified under the individual sections under Division 15, "MECHANICAL", will be paid under the Contract lump sum price for Mechanical Work wherein no measurement will be made.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies requirements for electric motors, motor starters, control devices, disconnect switches and supporting devices for motorized equipment, furnished under Division 15, "MECHANICAL".

B. Work Allocation:

1. Except as specified herein, provide motors, motor starters, control devices, thermostats, control relays, pilot lights, control panels and similar equipment specified under other Sections of Division 15, "MECHANICAL". Motor control centers and associated motor starters shall be furnished, installed, and wired under Division 16, "ELECTRICAL".

2. Wiring: Division 16, "ELECTRICAL", to furnish and install power wiring including connections to the line side terminals of the motor starter.

1.2 SUBMITTALS

A. Product Data: Complete catalog information.

B. Shop Drawings: Material and equipment.

C. List of Work Items: As specified in Paragraph 2.1.A of this section.

D. Motor Characteristic Curves.

E. Submit the following for all motors:

1. Manufacturer's name.

2. Voltage/Frequency.

3. Horsepower/Service factor.

4. Frame number.

5. NEMA design letter.

6. Power factor at full load.

7. Enclosure type.

8. Insulation class.


10. No load current.

11. Full load input in kilowatts.

12. Full load speed.

13. Locked rotor current.

14. Locked rotor input in kilowatts.

15. Bearing type, temperature limit and rated life.

16. Motor winding heaters wattage and voltage, provided if recommended by manufacturer.

17. Efficiency at full load.

18. Built-in-thermal protection (type and material) where provided.

1.3 QUALITY ASSURANCE

A. The applicable Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. Provide the Contracting Officer with manufacturer's certification that materials meet or exceed minimum requirements to comply with NEC, NFPA, NEMA, and all other applicable standards.

B. Manufacturer's Qualifications:

1. Select manufacturing firms regularly engaged in the manufacture of heavy-duty, industrial grade equipment of the type specified.

2. The equipment incorporated into the work shall essentially duplicate equipment that has been in satisfactory use for a period of five years, prior to the Bid Opening of this Project.

C. Source Quality Control:

1. Performance Certification: Certify that the equipment meets the performance specified.

2. Factory Testing: Test motors in accordance with the procedures specified in IEEE Publication 112A. Test two speed motors on each winding connection. Test reversible motors in both forward and reverse directions of rotation. Test motors to determine efficiency, power factor, rated load, slip and vibration.
PART 2 - PRODUCTS

2.1 GENERAL

A. Starters and disconnect switches, (except those starters and disconnect switches furnished as integral parts of mechanical equipment,) will be provided under Division 16, "ELECTRICAL".

B. Deliver starters, (other than those mounted in equipment) specified in the work of this division to Project Site, for installation under Division 16, "ELECTRICAL".

C. Provide each motor starter with approved nameplate to indicate equipment being controlled in accordance with Section 15055, "Identification of Equipment and Piping".

D. Furnish and install control wiring in conduits, minimum conductor size 16 AWG or as indicated; two conductor, balanced pair and in accordance with Division 16, "ELECTRICAL". Provide twisted and shielded conductors where indicated.

E. Provide SCADA alarm contacts, typically, two sets of Form C normally open and normally closed dry contacts. See individual sections for exact requirements.

2.2 MOTORS

A. Provide motors of sufficient size for the duty to be performed and not exceeding the full-load rating when the driven equipment is operating at specified capacity under the most severe conditions likely to be encountered. Provide motors suitable to operate the rated load when the ambient temperature is 115 deg. F. When electrically driven equipment to be furnished under Division 15, "MECHANICAL", differs from that shown on the Drawings, submit shop drawings for approval by the Contracting Officer prior to installation, in accordance with the General Requirements, with necessary adjustments to the wiring and conduit systems, disconnect devices, and circuit protection devices, required to accommodate the equipment actually installed.

B. Application:

1. Motors:
   a. Select motors with torque characteristics which will satisfactorily accelerate the driven equipment, within the starting time as specified.
   b. Select motors such that the operation at maximum load will not require the motor to operate at greater than its full load rating.

2. Drives:
   a. Provide belt guards for all belt drives in accordance with OSHA requirements.
   b. Install drives with single or multiple belts as required to properly transmit load. Provide multibelts that are matched sets.
   c. Select drive sheaves to allow an adjustment of plus or minus 20 percent from driven speed to meet the designed capacity.

C. Voltage: Unless indicated otherwise, use motors designed for continuous duty at the following voltages:
   1. 120 volts, single-phase, 60 hertz (Hz) - for motors 1/2 (HP) horsepower and smaller.
   2. 480 volt, three-phase, 60 Hz - for motors larger than 1/2 HP.
   3. Suitable for operation at variations of frequency and voltage of plus or minus 10 percent of nameplate rating without damage.

D. Motor Enclosures:
   1. Unless otherwise shown, Provide enclosures for motors located indoors of drip-proof type with drain plugs or other openings for condensate drainage.
   2. Provide weatherproof enclosures, or covers, for motors located outdoors
   3. For enclosures for motors installed in hazardous areas provide from NEMA group and class approved for the type of hazard in which they are located.

E. Bearings: Provide motors with sealed bearings unless otherwise shown. Provide bearing life as specified in other sections of this Division.

F. Accessories:
   1. Provide V-belts of heavy duty, heat, and static dissipating and oil resistant type.
   2. Fabricate sheaves of machine cast iron or steel with zero clearance tapered key
attachment to shaft. Provide drive sheave of the adjustable type.

3. Construct belt guards of minimum 16-gauge steel which completely enclose all moving parts (sheaves, shafts, belts, etc.). Provide face of guard of solid sheet steel or expanded steel mesh. Construct guard to permit easy access to moving parts and openings for shaft speed measurements without removing the guard. Construct guards in accordance with OSHA requirements.

2.3 MOTOR STARTERS

A. Refer to Section 16915, "Motor Control Centers and Starters" for requirements for electric motor starters serving Division 15, "MECHANICAL" equipment.

2.4 VARIABLE FREQUENCY DRIVES/ SPEED CONTROLLERS

A. The adjustable frequency controller shall convert 460 volts 5 percent 3-phase, 60 hertz utility power to adjustable voltage (0-460 volts) and frequency (0-60 Hz) 3-phase, AC power for stepless motor speed control with a capability of 10:1 speed range. General options and modifications shall mount within an enclosure.

B. The adjustable frequency controller shall be a voltage source or current source. Drives shall be supplied by one manufacturer. Note: Pulse-width modulated designs are not acceptable.

C. The controller(s) shall be suitable for use with new standard NEMA B squirrel-cage induction motor(s) with a 1.15 sf or with existing standard NEMA B squirrel-cage induction motor(s).

D. The controller shall have a continuous output current rating of 100 percent. Output current capability shall be 1.1 times the connected motor full load current rating. Average efficiency at one-fourth load shall be not less than 84 percent.

E. The VFD controller shall have the following basic features:

1. The converter section of the VFD will be a full wave, 3-phase converter to change the AC input power to DC power.

2. The inverter section will convert the DC output to adjustable frequency power to the motor. The VFD shall not induce excessive power losses in the motor and shall not feed electrical noise back into the electrical system of the building.


5. Door-mounted ammeter and speed meter.

6. Independent adjustable linear acceleration and deceleration rates.

7. Minimum 10:1 (6-60 Hz) controlled speed range capability.

8. Auxiliary contact for remote indication of controller fault condition.

9. VFD components shall be factory mounted and wired on a dead front, grounded, wall mounted, NEMA 1 enclosure.

10. The VFD shall provide automatic restart after a trip condition resulting from overcurrent, overvoltage, undervoltage, overtemperature or power outage. Two unsuccessful restart attempts will result in drive shutdown and require manual reset. The automatic restart feature will be capable of being defeated if VFD trip is desired upon first occurrence of a fault condition.

11. Duct static pressure to electrical transducer shall be provided. The pressure to electrical transducer will interface with controller internal speed reference voltage proportionally with change in pressure signal.

12. An EMS interface port shall be provided to allow future remote control.

F. The VFD Controller shall have the following protective features:

1. Single phase fault or 3-phase short circuit on VFD output terminals without damage to any power component.

2. Static instantaneous overcurrent and overvoltage trip.

3. Static overspeed (overfrequency) protection.

4. Line or fuse loss and undervoltage protection.

5. Power unit overtemperature protection.

G. The VFD shall operate as follows:

1. Selector Switch in the Off Position: The VFD run circuit will be open and the system will not operate.

2. Selector Switch in the Manual Position: The speed of the motor will be controlled by the manual speed potentiometer.

3. Selector Switch in the Auto Position: Operation will be from the input signal with motor speed being linearly proportional between minimum and maximum speeds selected.

H. The variable frequency drive manufacturer shall be able to provide as a minimum the following services:

1. Factory coordinated start-up service.

2. Training of user personnel in basic troubleshooting.

3. Training shall be on site and shall be a minimum of four hours duration and shall be performed in addition to start-up of system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Motors and Controls:

1. Install, align, and couple motors supplied as separate items under this Section.

2. Recheck alignment of all motors after installation of all connections and drives and after operation for a minimum of 48 hours.

3. Wire controls as specified under applicable mechanical and electrical sections of this Specification to provide proper operation of the connected equipment.

3.2 TESTING-STARTUP

A. Following procedures in accordance with Section 16030, "Testing of Electrical Systems", perform field tests on starters and disconnects provided as part of Division 15, "MECHANICAL" work and submit test report for approval.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".

END OF SECTION 15040
SECTION 15055
IDENTIFICATION OF EQUIPMENT AND PIPING

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing nameplates, signs and tags on mechanical equipment, piping, and apparatus, and supporting devices.

1.2 SUBMITTALS
A. Certification.
B. Samples: Labels and tags in each size.
C. Documentation: Charts for valves; include valve identification number, location, and purpose.

1.3 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specifications, sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials met or exceed minimum requirements to comply with AISI, NEMA, and other applicable standards.

PART 2 - PRODUCTS

2.1 NAMEPLATES
A. Furnish nameplates fabricated either from laminated plastic, or 18-gauge, stainless steel.

2.2 TAGS
A. Fabricated from 18-gauge stainless steel or 18 gauge brass.

2.3 IDENTIFICATION PLATES
A. Furnish bronze plates for equipment identification with numbers.

2.4 IDENTIFICATION LABELS FOR PIPING
A. Furnish permanent type labels; painted color bands with stenciled letters, or prefabricated pressure-adhesive cloth tape color labels with color lettering, manufactured for piping identification.

B. Provide labels with painted color bands with stenciled letters.
   1. Provide stenciled letters and flow arrows in the sizes as indicated in Table 15055 - 1. Dimensions are in inches.

PART 3 - EXECUTION

3.1 IDENTIFICATION
A. Equipment and Apparatus:
   1. Label equipment and apparatus with one inch high white letters engraved on 1-1/2 inch high black laminated plastic or manufacturers standard nameplates securely fastened to metal panels, showing function and unit number of item.
   2. Use 1/2 inch high white letters engraved on 1 inch high, black, laminated plastic nameplates identifying manufacturer and function of equipment to identify devices including controls and switches. Provide same type nameplates on front cover for each pilot light and for mode of operation selector switches. Label positions of mode selector switches AUTOMATIC/OFF/MANUAL.
   3. Provide nameplates for components located in control cabinets to show symbol used on schematic diagram to represent component. Label control cabinet terminals using same symbols and identification corresponding to that shown on schematic diagram.

B. Piping:
   1. General:
      a. Identify exposed piping systems by means of colored, stenciled, or prefabricated legends with flow arrows. Apply after painting and cleaning of piping and insulation is completed.
      b. Apply legend and flow arrow at valve locations; at points where piping enters or leaves wall, partition, bulkhead, cluster or piping, or similar obstruction; and at approximately 20 foot intervals on pipe runs.
      c. Make no changes in location and spacing without prior approval of the Contracting Officer.
d. Wherever two or more pipes run parallel, apply printed legend and other markings in close proximity, in either vertical or horizontal linearity, as appropriate.

e. Locate identifications so as to be conspicuous and legible at all times.

2. Stencil legends and bands on piping showing service and direction of flow as specified in Section 01086, "Color Codes and Color Standards".

3. Painting and Color coding of exposed piping and termination of piping is specified in Section 01086, "Color Codes and Color Standards" and Section 09920, "Interior Painting".

C. Valves:

1. Identify valves with 1-1/2 inch diameter, 18 gauge, AISI, stainless steel tags.

2. Designate appropriate service on each tag with 1/4 inch stamped black-filled letters and valve number with 1/2 inch stamped black-filled numbers.

D. Orifice Flange and Venturi Tube:

1. Identify each orifice or venturi tube with integral tab or stainless steel tag.

2. Stamp on tag differential multiplier, orifice bore, rate of flow, and equipment served.

3.2 INSTALLATION

A. Cement nameplates with epoxy type adhesive on equipment and apparatus.

B. Install labels to adhere tightly and neatly to pipe. Remove completely and reapply any labels that do not adhere, using manufacturer’s recommended adhesive.

C. Affix labels to surface of control and switch boxes by means of sheet metal rivets. Cement labels to surface with permanent adhesive when rivets cannot be used.

D. Fasten tags securely to valves, orifice flange, venturi tube with brass jack chain, so as to permit easy reading.

E. Mount valve charts in aluminum frames with clear Lucite front cover in locations as directed.

F. Fire Protection and Suppression System:

1. Stencil legends on piping as shown to identify service and direction of flow.

2. Stencil vent shaft and fan shaft identification as shown on piping adjacent to angle hose valves in tunnels.

3. Stamp information on identification plates as shown and fasten to sleeve on Siamese fire department connections for tunnel systems as shown.

3.3 FIELD PAINTING

A. Piping systems shall be color coded as per Section 01086, “Color Codes and Color Standards”.

B. Field painting of piping systems shall be per Section 09920, “Interior Painting" for interior locations and Section 09970, “Coatings for Steel” for exterior locations.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

<table>
<thead>
<tr>
<th>Minimum Outside Diameter of Pipe or Covering</th>
<th>Width of Stencil Band</th>
<th>Size of Stencil Letter</th>
<th>Length of Flow Arrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 to 1-1/4</td>
<td>8</td>
<td>1/2</td>
<td>2-1/2</td>
</tr>
<tr>
<td>1-1/2 and 2</td>
<td>8</td>
<td>3/4</td>
<td>2-1/2</td>
</tr>
<tr>
<td>2-1/2 to 6</td>
<td>12</td>
<td>1-1/4</td>
<td>4</td>
</tr>
<tr>
<td>8 to 10</td>
<td>24</td>
<td>2-1/2</td>
<td>5</td>
</tr>
<tr>
<td>over 10</td>
<td>32</td>
<td>3-1/2</td>
<td>6</td>
</tr>
</tbody>
</table>

END OF SECTION 15055
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the furnishing and installing of piping, fittings, valves, drains, piping specialties for sanitary drain, waste, vent piping, storm, subsoil, underdrain, domestic hot and cold piping, equipment drains, natural gas piping, heating, chilled, condenser piping, steam piping, refrigerant piping, and supporting devices.

1.2 REFERENCED STANDARDS

A. American Society of Mechanical Engineers (ASME):

1. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
2. ASME B31.5 - Refrigeration Piping and Heat Transfer Components

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings
3. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
5. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications
6. ASTM D2513 - Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
7. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications

C. Plumbing & Drainage Institute (PDI):

1. PDI/PLUMB WH 201 - Water Hammer Arrester Standard

1.3 SUBMITTALS

A. Shop Drawings: Shop drawings to include, but not be limited to indicate the following: Pipes and piping layout, locations and types of pipe hangers and supports, valves, clean-out deck plates and wall plates, escutcheons, gauges, expansion joints, guides and anchors, air eliminators, pipe sleeves, and drains.

B. Product Data: Include complete manufacturer's literature for material and equipment including manufacturer's recommendations for use and installation.

C. Certification.

1.4 QUALITY ASSURANCE

A. The following applicable Codes, Regulations, Reference Standards, and Specification sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested provide the contracting officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with ASME, ASTM, AISI, and other applicable standards.

B. Qualify and certify welders employed in the Work in accordance with the standards of the American Welding Society or, if applicable, to be NCPWS qualified welders under rules established in the Welding Qualifications of the ASME Boiler and Pressure Vessel Code.

C. Test and sterilize piping as specified in Section 15990, "Testing and Balancing".

PART 2 - PRODUCTS

2.1 PIPE AND PIPE FITTINGS

A. General:


B. Sanitary Drain, Waste, and Vent Piping:

1. Piping underground shall be service weight hub and spigot cast iron pipe and shall extend to above the floor. Joints shall be positive double seal elastomeric compression joints.

2. Piping above grade, 1-1/2 inches or smaller and vent piping, may be threaded galvanized schedule 40 steel or DWV copper. 2 inch and larger pipe shall be service weight cast iron hub and spigot or hubless.
3. Fittings shall be galvanized cast iron drainage fittings for threaded piping, cast iron soil fittings for hub and spigot piping, and hubless piping, DWV copper for DWV copper piping.

C. Storm, Subsoil and Underdrain Drainage Piping:

1. Piping below grade - Service weight hub and spigot cast iron soil pipe and fittings with elastomeric joints as specified above.

2. Piping above grade - Service weight hub and spigot or hubless cast iron pipe and fitting.

3. Subsoil piping shall be corrugated polyethylene perforated tubing with snap-on fittings or perforated schedule 40 PVC sewer pipe with solvent weld fittings.

4. Track drainage piping shall be schedule 40 PVC sewer pipe.

D. Domestic Hot and Cold Water Piping:

1. Piping below grade, 2-1/2 inches and smaller, shall be Type K copper with wrought copper fittings; piping 3 inches and larger shall be cast iron AWWA class 150 water main with mechanical joint fittings.

2. Piping above grade shall be Type L copper with wrought copper fittings; piping 3 inches and larger may be schedule 40 galvanized pipe with threaded or grooved couplings and fittings. No sharp edged orifice type reducers shall be used in grooved pipe systems.

3. Provide lead-free solder for soldered joints.

E. Equipment Drains and Relief Valve Piping:

1. Drain piping from air dryers, automatic air vents, pump bases, air handling units, etc., shall be Type L hard drawn copper, not less than 3/4 inch diameter or the connection size, whichever is larger. Condensate drains shall be trapped. Extend equipment drain piping to a suitable drain.

2. Relief valve piping shall be Type L hard drawn copper or Schedule 40 steel, not less than valve outlet size. Extend discharge piping to a hub drain or floor receptor as required by local codes.

F. Natural Gas Piping:

1. Piping below grade - Schedule 40 black steel pipe conforming to ASTM A53 with factory fabricated steel fittings, threaded or welded. Buried piping shall be protected against corrosion by a factory applied wrapping, following the recommendations of the local gas company. Field-fabricated joints shall be similarly protected. Non-ferrous pipe with tracer wire may be used if approved by local governing authorities.

2. Underground gas distribution piping may be polyethylene plastic gas pipe SDR 11 conforming to ASTM D2513 only when approved for use with 5 psi medium pressure distribution by both the Gas Utility Company and local building officials, and shall be listed by IAPMO.

   a. Plastic pipe shall be buried in its entirety and shall not run under or within any structure and be furnished with a copper trace wire.

   b. Connection of such plastic pipe to metallic pipe shall be by means of an approved compression coupling with insert.

   c. Joints in such plastic pipe of 1-1/2 inches and smaller shall be made by a approved coupling socket weld fitting or compression fitting, if approved by local code; 2 inches and larger may be joined as described above or by heat fusion method, but such work shall be in accordance with the manufacturer's recommendations.

   d. Meter and regulator risers shall be made with pre-bent factory coated steel piping joined as described in (b) above. Such steel piping shall be a 3 foot steel riser and approximately 1 foot long horizontal steel section with compression coupling to attach to the polyethylene pipe.

   e. Where plastic pipe joins to building, exposed pipe shall be steel. Exposed metal on compression couplings shall be wrapped and sealed to prevent corrosion.

   f. Pipe shall be permanently marked at maximum 2 foot intervals with the following minimum information:

      1) Manufacturer's name and the word "Natural Gas".

      2) Material designation.

      3) SDR 11.

      4) IAPMO listing.
3. Piping above grade - Schedule 40 black steel pipe conforming to ASTM A53 with threaded black malleable iron fittings. Piping 2-1/2 inches and larger shall be welded. Welded fittings shall be factory fabricated schedule 40 black steel.

G. Heating, Chilled and Condenser Water Piping:
1. Piping above grade - Scheduled 40 black steel pipe, threaded, welded or with grooved fittings, 150 pound flanges, or 150 pound malleable iron screwed fittings; or Type L hard drawn copper with wrought copper fittings.
2. Steel Piping 2-1/2 inches and below shall be threaded, piping 3 inches and above shall be flanged, welded or grooved. No sharp edged orifice type reducers shall be used in grooved pipe systems.
3. Piping below grade: AWWA Class 150 cast iron mechanical joint pipe and fittings.

H. Low Pressure Steam Piping:
1. Piping above grade - Schedule 40 black steel pipe, welded, 150 pound flanges, or 150 pound malleable iron screwed fittings.
2. Piping 2-1/2 inches and below shall be threaded, piping 3 inches and above shall be welded.

I. Condensate Piping: Schedule 80 seamless black piping.

J. Refrigerant Piping: Seamless ACR copper tubing, Type L, hard drawn with wrought or bronze solder joint fittings.

2.2 VALVES, COCKS, AND SPECIALTIES
A. Materials: Bronze or cast iron per local codes with screwed or flanged ends for steel pipe and solder ends for copper pipe.

B. Gate Valves: Rated for 200 psig WOG:
1. 2-1/2 inches and below - Threaded for steel pipe, and solder for copper pipe.
2. 3 inches and above - Flanged.

C. Ball Valves: Rated for 200 psig WOG. 2-1/2 inches and below, - Threaded.

D. Check Valves (Domestic Water System):
1. Swing check valve with bronze or composition disc rated for 200 psig WOG.
2. 2-1/2 inches and below - Threaded.

3. 3 inches and above - Flanged.

E. Water Balancing Cocks: Provide cocks with memory stop.

F. Backflow Preventer:
1. Double check valve assembly consisting of two independently operating, spring loaded check valves, two gate valves, and four test cocks for field testing.
2. Provide reduced pressured type as indicated on Contract Drawings.

G. Water Hammer Arrestor: Provide arrestors sized in accordance with PDI/PLUMB WH 201.

H. Butterfly Valves: Butterfly valves may be used in lieu of gate valves on chilled water and hot water heating lines rated to 150 psig.

I. Backwater Valves: Bronze swing check assembly, offset type, with sheargate and removable handle.

J. Refrigerant Valves:
1. Globe and Angle Valves: Forged brass or bronze alloy with packed stem and seal cap.
2. Check Valves: Spring-loaded, forged brass or bronze alloy body with solder connections.
3. Relief Valves: Forged brass bodies with nonferrous corrosion resistant internal working parts.
4. Solenoid Valves: Two-position, direct acting or pilot operated type, UL listed, with manual opening stem and constructed for servicing without removal from lines. Valves shall have coil housing, stainless steel enclosing tube, replaceable seat, and proper inlet and outlet connections for the type of pipe containing the valve.

K. Gas Cocks:
1. Cocks on 2 inch lines and smaller shall be threaded.
2. Cocks on 2-1/2 inch lines and larger shall be flanged pattern.
3. Gas cocks at boilers shall be lubricated plug type.
4. Provide removable handles for plug cocks.
5. Other special type valves or patterns shall be used where required.
L. Gauge Cocks and Manual Air Vents: Provide brass, lever handle cock, 1/4 inch FPT, as shown on the drawings or as specified herein.

M. Dielectric Unions: Provide dielectric unions at piping connections (except not to valves) between dissimilar metals. Dielectric nipples may be used in place of dielectric unions. Bronze and brass valves are not acceptable substitutes for dielectric unions.

2.3 TEST AND MEASURING DEVICES

A. Thermometers:
1. Thermometers shall be red reading mercury type with 9 inch scale and 3-1/2 inch stem, nonferrous case, bypass separable socket, and glass front. Style shall be straight, angle, or adjustable as required for easy reading from normal eye level.

2. Range shall be appropriate for the temperature of the measured fluid, and accuracy shall be within 1 percent over entire scale.

B. Test Plugs:
1. Test plugs shall be provided where shown on the drawings and at other locations required for testing and balancing purposes. Fittings shall be 1/4 inch MPT to receive a temperature probe 1/8 inch o.d. Fittings shall be solid brass with valve core of Nordel fitted with a cap and gasket.

2. Provide the Authority with six 5 inch stem pocket testing thermometers, 25 degrees F to 125 degrees F for chilled water and 30 degrees F to 220 degrees F for hot water. Also provide a pressure gauge with a fitting compatible with test plugs.

C. Pressure Gauges:
1. Gauges shall be Bourdon tube type with 4-1/2 inch dial, metal case, glass front, and bronze or brass tube and mechanism. Connection shall be 1/4 inch bottom or back as required for easy reading from normal eye level.

2. Range shall be appropriate for the pressure of the measured fluid, and accuracy shall be within 1 percent over entire scale.

3. A lever handle cock, as specified above, and snubber shall be installed at each pressure gauge.

D. Flow Sensors and Flow Meters: Flow sensors shall be capable of measuring total pressure and static pressure of the fluid being conveyed with an appropriate range for the flows expected to be encountered. Use in conjunction with a remote meter having the capability of measuring the resultant velocity pressure for conversion into flow.

2.4 FLANGES

A. Unless otherwise shown, Flanges shall be 150 pounds, A.S.A. forged steel, raised face, weld neck or slip-on.

2.5 HEATING, CHILLED AND CONDENSER WATER SPECIALTIES

A. Strainers: Cast iron, Y-pattern, 125 psi ANSI, 125 psi working pressure WOG, with brass or stainless steel screen and tapped for blowdown connection. Provide per the following:

<table>
<thead>
<tr>
<th>Size (inches)</th>
<th>Perforations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 to 2-1/2</td>
<td>0 mesh screen</td>
</tr>
<tr>
<td>2-1/2 to 4</td>
<td>0.057</td>
</tr>
<tr>
<td>5 and up</td>
<td>0.125</td>
</tr>
</tbody>
</table>

B. Check Valves: Cast iron body, non-slam design.

C. Dual Units: Bronze body, with check valve, stainless steel spring, test lever, strainer, 30 psi relief setting, 12 psi regulator setting.

D. Automatic Air Vents: Instant acting float actuated, valved to isolate for service, discharge piped to drain.

E. Expansion Tanks: Welded steel, ASME coded and stamped for 125 psig working pressure, as shown on the Contract Drawings.

2.6 FLEXIBLE PIPE CONNECTORS

A. Corrugated inner tube of 321 stainless steel with outer braided cover of same material, flanged, and with the following minimum overall lengths:

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>Minimum Length (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 and less</td>
<td>18</td>
</tr>
<tr>
<td>6 and 8</td>
<td>22</td>
</tr>
<tr>
<td>10 and 12</td>
<td>26</td>
</tr>
<tr>
<td>12 and 14</td>
<td>28</td>
</tr>
</tbody>
</table>

2.7 HANGERS AND SUPPORTS

A. Pipe Hangers, Upper Attachments:

1. Individual expansion bolts.
2. Self-drilling expansion shells for 3 inch pipe and smaller may be used in existing concrete structures.

B. Hanger Rods: Galvanized or cadmium plated steel, thread rods, with locknuts.

C. Pipe Hangers, Lower Attachments: Use lower attachments for individual runs of pipe as follows, unless indicated otherwise:
   1. Steel piping up to 5 inches: steel clevis.
   2. Steel piping 6 inches and larger, not subject to thermal expansion: steel clevis and saddle.
   3. Cast iron pipe, sizes: Steel clevis.

D. Vertical Pipe Supports:
   1. Intermediate floors use extension pipe clamps.
   2. At top of risers, use hangers as specified above.

E. Trapeze Hangers:
   1. Where numerous pipes are run in parallel to one another, they may be supported from a trapeze type hanger arrangement. Use roller supports to support each run of piping on trapeze hangers to permit independent movement of individual pipes.
   2. Piping supports: Consist of channels, fittings, pipe brackets, pipe rollers, pipe clamps, post bases, stud nuts, as required to properly support and hang piping.

F. Stiff-legs or Stanchions: Provide stiff-legs or two-leg stanchion supports in cases where support from overhead structure is not possible. Provide pipe rollers for pipe rigidly supported from floor.

G. Alignment Guides: Guides to be constructed with steel base and T-bar with teflon or graphite plates bonded to the steel components to allow minimum static friction and self-lubrication for unlimited movement. Factory paint units in accordance with the specified requirements. Weld guide base to the pipe.

H. Hanger and Support Rust-Proofing: For materials exposed to weather use galvanized steel parts unless otherwise noted.

2.9 PIPE GUIDES

A. Guides: Factory made cast semi-steel or heavy fabricated galvanized steel, consisting of two bolted outer cylinder sections and base with a two section guiding spider bolted or wedged tight to pipe.

B. Design guides to clear pipe insulation and to prevent over travel of spider and cylinder.

C. Minimum 8 inches long and spiders not less than the following:

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>Spider length (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2 and smaller</td>
<td>2</td>
</tr>
<tr>
<td>2 to 3</td>
<td>2-1/2</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5 and larger</td>
<td>3-1/2</td>
</tr>
</tbody>
</table>

2.10 EXPANSION BOLT ANCHORS

A. Anchors: Consist of bolt, expander, star lock washer, and nut.

B. Fabricated of stainless steel, including expander and star lock washer.

2.11 SELF-DRILLING ANCHORS

A. Self-drilling expansion type with self cutting annular broaching grooves.

2.12 PIPE SLEEVES

A. Minimum two sizes larger than pipe size or large enough to accommodate the carrier and covering, and long enough to project 2 inches beyond walls, roof, or floor slabs.

B. Through interior masonry unit walls, use black steel or formed galvanized sheet steel.

C. Through poured concrete interior walls and ceilings, use cast iron with anchor flanges.

D. Pipe sleeves through exterior walls with waterproofing or dampproofing: Cast iron, pressure sealing with membrane clamp; cast body with external fins, internal pressure rings and grommet, and pressure clamp with stainless steel bolts; oversize steel sleeve with neoprene sealing rings. Schedule 40 steel pipe sleeves with waterstop rings may be used for below grade exterior wall with waterproofing or dampproofing. Use “Thunderline Link Seal” or approved equal to waterproof the joint between the sleeve and concrete where hole must be core drilled through exterior waterproofed wall.
2.13 ESCUTCHEON PLATES

A. Finished Area: Chromium plated, pressed or stamped brass, one piece, or split pattern, held in place by internal-spring or set screw.

B. Unfinished Areas: Galvanized metal disk or plates.

2.14 SEALANTS FOR SEALING OF SLEEVES

A. Sealant materials: Single or double compound, primerless, non-sagging type in neutral color.

B. Sealants are specified in Section 07900, “Seals and Sealants”.

C. Butyl: One-part, gun grade, suitable for both horizontal and vertical joints for exterior sleeve penetrations.

D. Use high temperature sealant where indicated on Contract Drawings.

2.15 ACCESS PANELS

A. General: Provide prefabricated wall and ceiling panels for service access to equipment.

B. Access doors are specified in Section 08313, “Access Doors and Frames”.

2.16 CORROSION CONTROL

A. Where shown, underground ferrous pressure pipe and steel encasement for pressure pipes shall be bonded for electrical continuity and provided with test stations.

B. Insulating connections shall be in accordance with Section 13100, "Corrosion Control".

PART 3 - EXECUTION

3.1 GENERAL

A. Materials and equipment shall be installed in accordance with the approved recommendations of the manufacturer and Drawings.

3.2 EXCAVATING AND BACKFILLING FOR PIPING

A. Excavation: Excavate trenching for underground piping to the required depth to insure sufficient cover over the pipe.

1. Cut the bottom of the trench or excavation to uniform grade so that pipe will bear on undisturbed soil.

2. Should rock be encountered, excavate 6 inches below pipe, fill with pea gravel and tamp well.

3. Carefully lay out alignment of pipe trenches to avoid obstructions. Secure approval of proposed route of pipe before any cutting is begun.

4. The bottom of trench shall be shaped to give substantially uniform support to the lower third of each pipe.

B. Backfill: After pipe lines have been inspected, tested, and approved, backfill trenches or excavation with material as recommended by the manufacturer of the type of pipe used. Backfill under buildings and driveways with selected materials as specified in Section 02220, ”Grading, Excavating, and Backfilling”.

C. Restoration: Compact backfill where trenching or excavation is required in improved areas such as pavements, walks, lawns, and similar areas, to a condition equal to undisturbed earth, and restore surface of the area to the condition existing prior to the trenching or excavating operation.

D. Backfilling and excavating shall be in accordance with Section 02220, ”Grading, Excavating, and Backfilling”.

3.3 GENERAL PIPING INSTALLATION

A. Installation of Underground Pipe: Each pipe shall be laid true to line and grade and in such manner as to form a concentric joint with adjoining pipe and to prevent sudden offsets to flow line. As work progresses, the interior of the pipe shall be cleaned of dirt and foreign materials of any kind. Where cleaning after laying is difficult, a suitable swab or drag shall be kept in the pipe and pulled forward past each joint immediately after joining has been completed. Trenches shall be kept free from water during pipe joining work. When work is not in progress, open ends of pipe fittings shall be securely closed to the satisfaction of the Contracting Officer so that no water, earth or other substance will enter pipe or fittings.

B. Erection of Pipe above Grade:

1. Piping shall be properly supported and adequate provisions shall be made for flashing, expansion, contraction, slope and anchorage. Piping shall be cut accurately for fabrication to measurements established at the construction site. Pipe shall be worked into place without springing and/or forcing, properly clearing structural elements, finished rooms, windows, doors, and other openings and equipment. Cutting or other weakening of the building structure to facilitate installation will not be permitted.

2. Changes in direction shall be made with fittings, except that bending of pipe will be permitted providing a hydraulic pipe bender is used. Bent pipe showing kinks, wrinkles or other malformation will not be acceptable.

15060 - 6

DART Standard Specifications – May 2016
C. Joints:

1. Screwed. Make screwed joints using machine-cut USASI taper pipe threads. Apply a suitable joint compound to the male threads only. Ream the pipe to full inside diameter after cutting. All-thread nipples are not permitted.

2. Dissimilar Metals. Make joints between copper and steel pipe and equipment using insulating unions such as Crane Company No. 1259; EPCO as manufactured by EPCO Sales, Inc.; or an approved substitution.

   a. Prior to making joints, cut pipe square and ream to full diameter. Clean exterior of pipe and socket. Apply a thin coat of suitable fluxing compound to both pipe and socket, and fit parts together immediately.
   b. Heat assembled joint only as required to cause the solder to flow. Run the joint full, slightly beaded on the outside, and wipe to remove excess solder.
   c. Use silver brazing alloy or Sil-Fos on refrigerant piping and on underground piping. Use 95.5 solder on other nonpotable water piping. For domestic water piping, use lead-free solder.


5. Flanged.
   a. Prior to installation of bolts, accurately center and align flanged joints to prevent mechanical prestressing of flanges, pipe and equipment. Align bolt holes to straddle the vertical, horizontal or north-south centerline. Do not exceed 3/64 inch per foot inclination of the flange face from true alignment.
   b. Use flat-face companion flanges only with flat-faced fittings, valves or equipment. Otherwise, use raised-face flanges.
   c. Install proper gaskets, suitable for intended service and factory cut to proper dimensions. Secure with a suitable gasket cement.
   d. Use ANSI nuts and bolts, galvanized or black to match flange material. Use 316 stainless steel nuts and bolts underground. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets.
   e. Use carbon steel flanges conforming to ASME B16.5. Use slip-on type flanges on pipe only. Use welding neck type flanges on fittings. Weld slip-on flanges inside and outside.
   f. Keep flange covers on equipment and shop-fabricated piping until ready to install in system.

6. Hubless. Install according to manufacturer’s recommendations, using recommended tools.

7. Mechanical Joints. Provide a stuffing box type mechanical joint adapted to use gasket, cast iron gland and bolts. Coat bolts with bitumastic enamel. Use one of the following or approved equal.
   a. Doublex Simplex Joint manufactured by the American Cast Iron Pipe Company, Birmingham, Alabama.
   c. Boltite Joint manufactured by the McWane Cast Iron Pipe Company, Birmingham, Alabama.
   d. Flexklamp manufactured by the National Cast Iron Pipe Company, Birmingham, Alabama.

8. Compression Joints for Cast Iron Water Pipe. Use Beltite, Tyton or Grip-Tite compression joints. Install in accordance with the manufacturer’s recommendations and with ASTM C443. Use only with pipe and fittings designed for compression gaskets. Provide adequate concrete thrust blocks at changes of direction, as recommended by manufacturer.


10. Ring-Tite Joints. Furnish joints for installation according to manufacturer’s recommendations. Provide adequate concrete thrust blocks at changes in direction, as recommended by manufacturer.
PIPING AND ACCESSORIES

   a. With Schedule 80 or heavier, use threaded joints. Provide sharp, clean pipe dies and Teflon thread tape. Make joints in strict accordance with manufacturer’s recommendations.
   b. With Schedule 40 or lighter, use solvent cement method in strict accordance with manufacturer’s recommendations.


13. Ball Joints. Where shown, provide flexible ball joints, made of carbon steel. Ball joints must have 15 degrees of angular flexibility. Use welded or flanged ends, as required. Furnish with 11N gaskets.

D. Branch Connections:

1. For Pipe 2-1/2 Inches and Smaller: For threaded piping, use straight size of reducing tee. When branch is smaller than header, a nipple and reducing coupling or swaged nipple may be used.

2. For 3 Inches Through 36 Inches: For welding piping, when branch size is the same as header size, use welding tee. Use Weldolet when branch is smaller than header. For threaded branch connections, use 3000-pound full coupling welded to header.

E. Arrangement: Piping shall be run parallel to building lines and shall be arranged so as not to interfere with removal of other equipment or devices nor to block access to doors, windows, manholes or other access openings. Piping shall be arranged so as to facilitate maintenance and operation and adhere to code required clearances and positioning. Piping shall be placed and installed so that there will be no interference with the installation of the equipment, ducts, etc. Piping shall be installed to ensure noiseless circulation. Valves and specialties shall be placed to permit easy operation and access. Piping shall be erected and pitched to ensure proper draining. Piping shall be installed so as to avoid liquid or air pockets throughout the piping system. Eccentric reducers with flat side up shall be used wherever changes in pipe size would cause an air trap. Manual air vents shall be installed at high points in chilled water and hot water heating systems with piping to drains. Provide automatic air vents in condenser water piping. Drain valves shall be installed in low points or traps in the piping system. Expansion and contraction of piping shall be provided by expansion loops, bends or expansion joints to prevent injury to connection, piping, equipment or the building.

F. Slope: Minimum slope of piping shall be in accordance with Table 15060 - 1 unless otherwise specifically shown on the drawings or specified.

G. Connections for Removal: Install flanged connections or unions on bypasses, ahead of traps and at connections to equipment, where shown on the drawings and where required to facilitate convenient removal of equipment.

H. Sleeves: Provide sleeves around pipes passing through walls, floors, ceiling, partitions, structural members, or other building parts.

I. Natural Gas Piping:

1. Gas piping within the building shall be run exposed or enclosed in a sleeve vented to the outdoors, if required by local codes.

2. Piping shall be run straight without sags or traps and shall be pitched as to drain back to the riser and from the riser to the system low points. A dirt pocket consisting of a nipple and a cap shall be provided at the bottom of each riser and at low points of the gas distribution system. Provide access for cleaning of same dirt pocket.

3. Provide connections throughout the system to allow for adequate horizontal and vertical expansion and contraction of piping.

4. Provide a pressure regulator, with relief piping routed to the outdoors, at each gas consuming device or group of devices, where such devices operate at a pressure less than that of the gas supply line. Refer to the Drawings for additional required regulators with others furnishing gas burning equipment.

J. Refrigerant Piping:

1. Refrigerant piping shall not be run concealed in walls or partitions nor underground or under the floor except as indicated on the drawings. Where pipe passes through building structure, pipe joints shall not be concealed, but shall be located where they may be readily inspected.

2. Refrigerant piping shall be brazed with silver solder or “Sil-Fos”. The inside of tubing and fittings shall be free of flux. The parts to be joined shall be cleaned bright with emery cloth and shall be heated to a temperature slightly greater than the solder flow point, and shall be kept hot until the solder has penetrated the full depth of the fitting. Joints
3. Refrigerant lines shall be installed so that the gas velocity in the evaporator suction line is sufficient to move the oils along with the gas to the compressor. Where equipment location requires a vertical riser, the line size shall be as shown and installed to provide sufficient gas velocity or a double riser shall be installed as shown on the drawings. The larger riser shall have a trap, of minimum volume, formed by the use of 90 degree and 45 degree ells. The small riser shall be located with its inlet just upstream of the trap and shall connect to top of the horizontal line. Valves shall not be installed in risers except as shown on the Contract Drawings.

4. Refrigerant driers, sight glass liquid and moisture indicators, and strainers shall be provided in refrigerant piping for remote installations when not furnished by the manufacturer as part of the equipment. Driers shall be installed in liquid line with service valves and a valved bypass line which are the same size as liquid line in which the drier is installed. Drier of 50 cubic inches and larger shall be installed with the cover and the full cartridge being easily removable.

5. Sight glass liquid and moisture indicators shall be installed in the liquid line downstream of the drier. Connections shall be the same size as the liquid line in which it is installed, up to 7/8 inch; 1-1/8 inches and larger shall have a 1/4 inch indicator installed in the "By-pass" position.

6. Strainers shall be located close to equipment they are to protect. A strainer shall be provided in the refrigerant liquid supply to expansion valves. Strainers shall be installed with screen down and in direction of flow as indicated on the strainer's body.

7. Refrigerant Charging Valve: A valved refrigerant charging connection shall be provided for each field piped refrigeration system when not provided as part of the condensing unit. The valve shall be located on the reducing outlet of a full size tee in the liquid line, upstream from the refrigerant drier and sight glass moisture indicator. Valves shall be of the seal cap type, 1/2 inch minimum port size.

8. Solenoid valves shall be installed in horizontal lines with the stem vertical and with flow in direction indicated on the valve. If not incorporated as an integral part of the valve, strainers shall be provided upstream of each solenoid valve, with a service valve upstream of the solenoid valve. The solenoid valve shall be disassembled according to the manufacturers’ recommendations when brazing the valve into the piping.

K. Plates: Provide spring clamp plates (escutcheons) where pipes are exposed in finished locations of the building and run through walls, floors or ceilings. Plates shall be set tight on the pipe and to the building surface.

L. Protection: Properly cap or plug open ends of pipes and equipment to keep dirt and other foreign materials out of the system.

3.4 HANGERS, SUPPORTS, ANCHORS, AND GUIDES

A. Supports, hangers, anchors, and guides shall be provided for horizontal and vertical piping.

B. The Contractor shall be responsible for structural integrity of supports. Structural hanging materials shall have a factor of safety of 5.

C. Anchor points and pipe guides, as shown on drawings or as required, shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.

D. Guide points for expansion joints shall be located and constructed wherever required or shown on drawings, and at each side of an expansion joint or loop, to permit only free axial movement in piping systems, but shall not be further than 3 pipe diameters on each side of joint. Guides for pipe with expansion joints shall be of the roller type securely welded to structural steel.

E. Maximum spacing between pipe supports for steel, cast iron, plastic or copper pipe shall be per local code to prevent excessive stress (this does not apply where there are concentrated loads between supports).

F. For copper tubing, supports shall be especially designed for copper tubing, and shall be of exact O.D. diameter of tubing and shall be copper plated.

G. Roller type supports shall be used for pipes subject to axial movement. They shall be braced so that movement occurs in roller rather than support rods.

H. Provide steel required for support of pipes other than steel shown on structural engineer's drawings.
I. In general, piping shall be supported from only structural building members or approved steel insert embedded in concrete. Where structural members must be increased in strength and/or additional members added to provide for piping support as shown on plans, the mechanical contractor shall include such anticipated costs in his pricing.

3.5 SUPPORT OF VERTICAL RISERS

A. Vertical piping shall be installed in such manner that its weight plus the weight of its contents, covering, and appurtenances cannot be concentrated at locations on slabs, beam, and other structural elements to exceed the carrying capacity of those members as approved by the Contracting Officer.

B. Riser clamps at each floor may be used only for risers which are constructed in segments, with joints capable of taking up longitudinal expansion and contraction, such as cast iron soil piping and storm drainage risers. Steel or copper water risers 2-1/2 inches and smaller may also be supported on riser clamps at each floor when provided with expansion loops or expansion joints, such that no straight rise exceeds 10 floors in structural members which in turn are supported directly from the building structure.

C. Risers having solid joints shall be capable of standing on the lowest available support when expanded and hanging from the highest available support when contracted. The weight of liquid content of a riser shall rest on a vertical “stiff leg” support at the bottom of the riser. Such risers 3 inches and larger shall be supported by one of the following methods:

1. If the riser turns upward at a single elbow and rises straight from that point, and if the elbow is so located that it can be supported by a pipe “stiff leg” to a foundation ongrade or from a suitably designed structural element, this preferred method of riser support shall be used. Such risers shall be guided only, not clamped, at floor penetrations above the support point. Horizontal piping connected to each such riser shall be supported 3 hangers distant from the riser on spring hangers to take up vertical riser movement.

2. Where risers are offset horizontally above the first turn-up and then rise again, each rise must be supported as a separate riser, either at its turned-up elbow or at a single anchor point at some level of the riser. The building structure at the point of support shall be capable of supporting the weight of the riser and its contents. Horizontal piping connected to each such riser shall be supported 3 hangers distant from the riser on spring hangers to take up vertical riser movement, as determined by the location of the main riser support.

3. For tall pipe risers, each rise may be broken into segments by expansion joints and anchored to suitably designed building structure individually. The weight of liquid content, however, can only be supported at the segment which includes the turned-up elbow.

4. In buildings where added structural supports for large riser weights cannot be provided economically, the Contractor shall support each riser with welded clamps resting on springs at sufficient numbers of floors so that weight distribution is not concentrated by expansion or contraction.

D. The Contractor shall coordinate the riser support design with the Contracting Officer. He shall submit drawings showing weights, points of support, and details of support or anchoring for approval. The Contracting Officer must approve the proposed method of support before work is started. The Contractor shall bear responsibility for materials and workmanship described in this section and shall ensure that hangers and supports are properly installed.

3.6 CORROSION CONTROL

A. Install insulating devices at connections with non-Authority owned piping, and on each service connection into a structure or building within five feet of the point of entry inside the structure. Locate insulating devices in meter vaults whenever possible.

B. Install insulating devices in accordance with Section 13100, "Corrosion Control".

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".
<table>
<thead>
<tr>
<th>Type of Piping or Fluid Conveyed</th>
<th>System Component</th>
<th>Length for 1-inch Fall</th>
<th>Direction of Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled Water Runouts to Equipment or Risers</td>
<td>4 feet</td>
<td>Back to Mains</td>
<td></td>
</tr>
<tr>
<td>Chilled Water Supply and Return Mains</td>
<td>40 feet</td>
<td>To Nearest Drain Valve</td>
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</tr>
<tr>
<td>Steam and Condensate Main or Branch</td>
<td>20 feet</td>
<td>Direction of Flow</td>
<td></td>
</tr>
<tr>
<td>Sewer, Sanitary Main or Branch</td>
<td>4 to 8 feet</td>
<td>Direction of Flow</td>
<td></td>
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<tr>
<td>Vent Main or Branch</td>
<td>9 feet</td>
<td>Toward Sanitary Sewer</td>
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<tr>
<td>Equipment Drain &amp; Relief Main</td>
<td>6 feet</td>
<td>Toward Drain</td>
<td></td>
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<tr>
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<td>4 feet</td>
<td>Toward Mains</td>
<td></td>
</tr>
<tr>
<td>Heating Water Supply and Return Mains</td>
<td>40 feet</td>
<td>To Nearest Drain Valve</td>
<td></td>
</tr>
<tr>
<td>Condenser Water Supply and Return Mains</td>
<td>40 feet</td>
<td>To Nearest Drain Valve</td>
<td></td>
</tr>
<tr>
<td>Refrigerant Piping Suction and Liquid Lines</td>
<td>40 feet</td>
<td>To Nearest Drain Valve</td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION 15060
SECTION 15075
VIBRATION ISOLATION AND SOUND CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing vibration isolation and sound control for mechanical equipment and piping, and supporting devices.

B. Work Included:
1. Support isolation for motor-driven mechanical equipment.
2. Rails or beams for distribution of equipment loading to isolation units.
3. Inertia base frames in conjunction with equipment isolation.
4. Duct sound attenuators.
5. Flexible pipe connectors, refer to Section 15060, “Piping and Accessories”.
6. Pipe sleeves.
7. Flexible ductwork connectors.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel

B. National Fire Protection Association (NFPA):
1. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials

C. Sheet Metal & AC Contractors National Association (SMACNA):
1. SMACNA 1481 - HVAC Duct Construction Standards - Metal and Flexible

D. Underwriters Laboratories, Inc. (UL):
1. UL 723 - UL Standard for Safety Test for Surface Burning Characteristics of Building Materials

1.3 PERFORMANCE CRITERIA
A. Vibration isolation for vibration producing equipment shall be selected on the minimum static deflection recommended by the manufacturer for the specific installation.

B. Sound levels within finished spaces shall fall within the recommended ASHRAE Room Criteria (RC) range for each room type, unless noted otherwise.

C. Sound levels shall be measured four feet above the finished floor with normal occupancy of the space and with equipment operating at full capacity or its normal point of operation which creates the highest noise level. The Contractor shall, when required, verify that equipment noise levels meet the ASHRAE - recommended RC range.

1.4 SUBMITTALS
A. Shop Drawings:
1. Design for concrete inertia block and structural steel bases. Include tabulation of design data on isolators including actual deflection; outside diameter; free, operating and solid heights of isolators; method of attachment; bolt sizes; and type and sizes of anchor plates.
2. Shop drawings for materials and equipment.

B. Product Data: Complete catalog information.
C. Certification.
D. Deflection Measurements: Upon completion of vibration isolation work, prepare and submit to the Contracting Officer a report showing measured equipment deflections for each major item of equipment as indicated.
E. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems".

1.5 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specifications, sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the
Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with ASTM, UL, and other applicable standards.

B. Isolating materials shall be supplied by a single supplier to ensure total responsibility. The isolation supplier shall submit for formal approval necessary drawings and installation instructions required for the Project and shall verify vibration and sound levels. Prior to acceptance of the work by the Contracting Officer, the isolation supplier shall inspect the work and furnish the Contracting Officer with written certification that isolation materials furnished by him are installed in a proper manner.

PART 2 - PRODUCTS

2.1 ISOLATION MATERIALS

A. Neoprene Pads: Oil-resistant neoprene sheets, of manufacturer's standard hardness and cross-ribbed pattern, designed for neoprene-in-shear type vibration isolation, and in the thickness required.

B. Cork/Neoprene Pads: Close grained composition cork sheet, laminated between 2 sheets of ribbed, oil-resistant neoprene, in the thickness required.

C. Vibration Isolation Springs: Wound-steel compression springs, of high strength, heated-treated, spring alloy steel; with outside diameter not less than 0.8 times operating height; with lateral stiffness not less than vertical stiffness; and designed to reach the solid height before exceeding the rated fatigue point of the steel.

D. Isolators and Bases:

1. Type 1 Isolators: Precompressed molded fiberglass isolation pads, neoprene-jacketed and stabilized during manufacturer. Pads shall be sized for 40 to 60 psi loading and shall be made of glass fibers produced by a multiple frame attenuation process which generates nominal fiber diameters not to exceed 0.00018 inches. Where the equipment base does not provide a uniform load surface, steel plates shall be bonded to the top of the pads. Neoprene mounts, incorporating completely enclosed metal inserts to permit bolting to the support unit.

2. Type 2 Isolators: Freestanding unhoused, laterally stable spring mounts, incorporating leveling bolts and 1/4 inch thick noise isolation pads. To assure stability, the outside spring diameter shall be equal to or greater than the designed spring operating height, and the horizontal stiffness shall be at least 30 percent greater than the vertical stiffness. Springs shall have a minimum additional travel of 50 percent between the designed operating height and the solid height.

3. Type 3 Isolators: Freestanding, stable spring mounts, shall incorporate vertical limit stops to assure a constant height if the supported weight is removed, and to reduce movement due to wind loads. The limit stops shall be isolated.

4. Type 2 Hangers: Combination spring and fiberglass hangers, incorporating 2 inch thick neoprene-jacketed precompressed molded fiberglass inserts in series with springs, encased in welded steel brackets. The outside spring diameter shall have a minimum of 0.8 times the designed spring operating height, and shall have a minimum additional travel of 50 percent between the design height and solid weight.

5. Type 4 Base: Equipment manufacturers base required, isolators directly attached to equipment.

6. Type 5 & 6 Bases: Structural steel bases, designed and supplied by the isolator manufacturer. The bases are designed with isolator brackets to reduce the mounting height of the equipment. To assure adequate stiffness, the height of the members shall be a minimum of 8 percent of the longest span between isolators, or at least 6 inches.

7. Type 7 Bases: Reinforced concrete inertia bases, the steel members of which are designed and supplied by the isolator manufacturer. The concrete shall be poured into a welded steel channel frame, incorporating relocated equipment anchor bolts, 1/2 inch diameter reinforcing bars on 8 inch centers each way, and isolator mounting brackets to reduce the mounting height of the equipment but yet remain within the confines of the base. The thickness of the bases between isolators, at least 6 inches, or as indicated on the drawings. Where the inertia bases are used to mount pumps, the bases shall be large enough to support the pipe elbow(s).

8. Type 8 Base: Isolation Rail System: Two parallel aluminum rail systems with a continuous neoprene seal shall provide up to 1 inch static deflection. Mount over roof curb on free-standing stable springs.
2.2 DUCT SOUND ATTENUATORS

A. Outer casings of rectangular silencers shall be made of 22-gauge galvanized steel in accordance with SMACNA 1481 and ASHRAE GUIDE recommended construction for high pressure rectangular ductwork. Seams shall be lock formed and mastic filled.

B. Outer casings of tubular silencers shall be made of galvanized steel in the following gauges:

<table>
<thead>
<tr>
<th>Outside Dia.-Inches</th>
<th>Metal Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 - 22</td>
<td>22</td>
</tr>
<tr>
<td>24 - 40</td>
<td>18</td>
</tr>
<tr>
<td>44 - 48</td>
<td>18</td>
</tr>
<tr>
<td>48+</td>
<td>14</td>
</tr>
</tbody>
</table>

C. Interior partitions for rectangular silencers shall be of not less than 26 gauge galvanized perforated steel.

D. Interior construction of tubular silencers shall be compatible with the outside casings.

E. Filler material shall be of inorganic mineral or glass fiber of a density sufficient to obtain the specified acoustic performance and be packed under not less than 5 percent compression to eliminate voids due to vibration and settling. Material shall be inert, vermin resistant and non-absorbent.

F. Combustion rating for the silencer acoustic fill shall be not less than the following when tested in accordance with ASTM E84, NFPA 255 or UL 723:

1. Flamespread Classification - 25.
2. Smoke Development Rating - 50 (vertical construction) and 0 (tunnel applications).

G. Silencers shall not fail structurally when subjected to a differential air pressure of 8 inches w.c. in positive and negative operating modes.

H. Silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with ASTM E477. The test set-up and procedures shall be such that effects due to end reflection, directivity, flanking transmission, standing waves and test chamber sound absorption are eliminated. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self Noise (SN) Power Levels both for FORWARD FLOW (air and noise in the same direction) and REVERSE FLOW (air and noise in opposite directions) with airflow of at least 2000 fpm entering face velocity. Data for rectangular and tubular type silencers shall be presented for tests conducted using silencers no smaller than the following cross-sections:

1. Rectangular - 24 inches by 24 inches by 30 inches, or 24 inches by 36 inches.
2. Tubular - 12 inches, 24 inches, 36 inches and 48 inches.

I. Silencers shall provide dynamic insertion loss and self-noise power levels according to the schedules as indicated in Table 15075 - 1.

J. Static pressure loss of silencers shall not exceed those listed in the silencer schedule as the airflow indicates. Airflow measurements shall be made in accordance with ASTM E477 and with applicable portions of ASME, AMCA and airflow test codes. Tests shall be reported on the identical units for which acoustic data is presented.

2.3 PIPE SLEEVES

A. Sleeves shall be formed of 24 gauge sheet metal, pack void areas with 3 pcf density fiberglass and seal ends with resilient mastic. Sleeves shall be 3 inches larger in diameter than pipe.

2.4 FLEXIBLE DUCT CONNECTIONS: TYPE-1

A. Factory assemble fire retardant flexible material bordered on each side with a mechanically bonded three inch wide galvanized steel edging.

B. Flexible material: 32 ounce fiberglass cloth reinforced neoprene sheet, fire resistant, with a tensile strength rating of not less than 450 psi.

C. Neoprene compound: suitable for continuous operation at 300 deg. F, with deformation limited to 10 percent, shrinkage 0 percent, and loss of tensile strength not to exceed 25 percent.

D. Unclamped width of fabric:

1. Not less than three inches for ducts with perimeter length of 150 inches.
2. Not less than four inches for ducts with perimeter greater than 150 inches.

E. Flexible material: Flute crimped to metal edging, with sufficient material lap to prevent loss of bond. Rivet reinforcement of attachment will be permitted.
2.5 **FLEXIBLE DUCT CONNECTIONS: TYPE-2**

A. Flexible connection consisting of two angle frames, fabric connector material, and fabric securing bars; fabricated from material capable of operating for one hour without failure in an ambient temperature 300 deg. F.

B. Flexible connections designed to allow sufficient radial, axial, rotational and lateral movement of fan-motor unit assembly resulting for expansion, contraction and dynamics of air moving unit operation, without unnecessary slack in fabric connector material.

C. Flexible connections and components thereof designed to be airtight and provided in accordance with the code requirements of the National Fire Protection Association.

D. Fabric Material: Not less than 1/8 inch thick; flexible, flame retardant, abrasion resistant; and, able to withstand, without deleterious effect, saturation with grease and oil. Fabricate the fabric material with one longitudinal seam only. Do not use tap bolts for fastening fabric to securing bars. Flexible portion: minimum of 4 inches wide.

E. Fabricate connection frames from structural steel angle sections conforming to ASTM A36/A36M. Companion angle sections: not less than 3 inches by 2 inches by 1/4 inch. Weld frames with full penetration butt welds.

**PART 3 - EXECUTION**

3.1 **INSTALLATION**

A. Except as otherwise indicated, comply with manufacturer's recommendations for selection and application of vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contact or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.

B. Anchor and attach units to subbases and equipment as required for secure operation and to prevent displacement by normal forces.

C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

D. Install inertia base frames on isolator units as indicated, so that a minimum of 2 inch clearance below base will result when frame is filled with concrete and supported equipment has been installed and loaded for operation.

E. Locate isolation hangers as near the overhead support structure as possible.

F. Duct Sound Attenuators: Install in accord with manufacturer's recommendations.

G. Bond flanges of flexible duct collars to ducts and housings to provide airtight connections. Seal seams and penetrations to prevent air leakage.

H. Flexible Pipe Connectors: Install in accordance with manufacturer's recommendations.

I. Piping shall be installed to be concentric with sleeve.

3.2 **EXAMINATION OF RELATED WORK**

A. The installer of vibration isolation materials shall observe the installation of other work related to the vibration isolation work, including other work connected to vibration/isolation work, and, after completion of other related work, but before equipment start-up, shall furnish a written report to the Contracting Officer listing any observed inadequacies for proper operation and performance of vibration isolation materials. The equipment shall not be started until inadequacies have been corrected in manner acceptable to the Contracting Officer. The report shall cover, but not necessarily be limited to the following:

1. Equipment installation (performed as work of other sections) on vibration isolators.

2. Piping connections including flexible connections.

3. Ductwork connections including flexible connections.

4. Passage of piping and ductwork which is to be isolated through walls and floors.

B. Ductwork Treatment:

1. **Noise within the ductwork of the air handling system shall be satisfactorily controlled by the installation of prefabricated duct sound attenuators as recommended by the manufacturer.**

2. **Flexible Connections shall be installed in the ductwork adjacent to air-moving equipment such that when the unit deflects, the inside edges of the connections do not touch.**
3. Install duct sound attenuators as recommended by the manufacturer.

C. Piping Treatment: Piping three supports away from isolated mechanical equipment of inertia bases and AHU mounted on spring isolators shall be isolated from the structure by means of spring hangers in the supporting rods. Hangers shall be Type 2 as specified. Floor mounted piping shall be supported directly on Type 2 spring mounts, as described above. Flexible connectors shall be incorporated in the piping adjacent to isolated equipment where piping swing arm lengths do not provide required freedom of movement.

D. Equipment Room Penetrations: Piping, conduit, ductwork, etc., penetrating floors, ceiling, or partitions of equipment rooms shall be isolated using sleeves as specified herein. Penetrations shall be airtight. Sleeves through floors shall be extended 3 inches above the floor in mechanical rooms in rooms where water piping is installed.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15075
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installing of pumps except for fire pumps, complete with motor drives, and controls and supporting devices.

1.2 SUBMITTALS

A. Shop Drawings.
B. Product Data:
   1. Catalog Cuts.
   2. Performance Curves: Pump performance curves (total dynamic head vs. flow) showing, brake horsepower, KW input, and full load efficiency.
C. Field Testing:
   1. SCADA: Refer to Section 16030, “Testing of Electrical Systems”.
D. Manufacturer's Data: Equipment mounting instructions.
E. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General".

1.3 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General", also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with ASTM, NEMA, and other applicable standards.

B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of industrial-grade equipment of the type specified herein.
   2. Equipment: Provide documentation that the equipment incorporated into the work duplicates equipment that has been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Temporarily cover the inlet and discharge openings of equipment until final connections are completed.

B. During the construction, store, and protect equipment from being damaged.

PART 2 - PRODUCTS

2.1 GENERAL

A. Select pumps to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25 percent beyond design capacity. In addition, select design impeller diameter so that the design capacity of each pump (GPM and THD) do not exceed 90 percent of the capacity obtainable with maximum impeller diameter at the design speed for that model.

2.2 PUMPS FOR HOT WATER, CHILLED WATER, CONDENSER WATER, AND PLUMBING

A. General Construction:
   1. Pumps shall be centrifugal, frame or in-line mounted with cast iron casings rated for the submersion pressures of the systems which they are to serve and be tested to 150 percent of rated pressure.
   2. Unless otherwise shown, pumps shall be equipped with mechanical seals, with stainless steel shaft mounted on ball or sleeve bearings. Pumps shall be bronze fitted, including bronze impeller. Pumps 3 inch x 4 inch and larger shall be provided so that the impeller furnished shall not exceed 85 percent of the maximum impeller diameter which the casing will accept.
   3. Each pump shall be flexibly coupled to an open, drip-proof motor which shall operate on the appropriate electrical service, at the scheduled rpm. Each pump and motor combination shall be provided so that, with the impeller furnished, the motor will not operate in excess of its nameplate horsepower. Each pump shall be thoroughly cleaned, primed, and then painted with a high quality machine enamel prior to shipment.
   4. Each frame mounted pump and/or motor assembly shall be mounted on a single cast iron or welded steel foundation which, in turn, shall be set and leveled on a housekeeping pad with a mounting base as required in Section 15075, “Vibration and Sound Control”. Each chilled water pump shall be provided with drainage piping to extend over the edge of the concrete base and spill directly into an adjacent floor drain.
2.3 DOMESTIC WATER PUMP UNIT

A. Provide a factory-assembled Constant Pressure Booster System with total flow and head capacity as scheduled.

B. Each unit shall be a duplex unit (unless restricted by local codes) completely assembled on a fabricated steel base with galvanized welded steel or stainless steel suction and discharge header piping, pump suction and discharge gate valves, non-slam check valves, a pressure regulating valve station, bladder-type compression tank sized for design flow and Flow Control with pump sequencing switches and visual flow indicator.

C. The unit shall have a single control cabinet in a NEMA-1 enclosure (NEMA 4 or 4X for exposed or damp or wet locations) with individual pump circuit breakers, magnetic motor starters with temperature compensated overload protection on each phase, pilot lights, HOA selector switches, 120 volts control circuit with separate circuit breakers, and necessary relays cabinet shall be provided with a single point of electrical connection.

D. The individual pump capacities shall be rated at 40 percent and 60 percent of total system demand. The pumps shall be in-line, bronze fitted, single stage with dynamically balanced bronze, enclosed impellers, bronze replaceable wear rings, and bronze shaft sleeves and mechanical shaft seals. Motors shall be close-coupled type, and selected so that they do not operate over their nameplate HP rating throughout the sequence of pump capacity rating.

E. The pumps shall be programmed so that the lead pump shall operate up to 33 percent of the system capacity, the main pump replaces the lead pump at 33 percent to 67 percent of system capacity. For capacities 67 percent to 100 percent the lead pump is restarted.

F. Provide inlet strainer at common inlet to unit, see Section 15060, "Piping and Accessories", or provide as a factory option with the unit.

G. The system pressure shall be stabilized and controlled by a pressure reducing valve station, using a small reducing valve for low flow requirements and a large valve for medium to large capacities.

H. A gauge board with three 3-1/2 inch face pressure gauges and stopcocks shall be provided for suction pressure, pump discharge, pump discharge pressure and system pressure, each gauge shall also be fitted with a pressure snubber.

I. A reliable shutdown system shall be provided to automatically stop the unit during periods of no flow.

J. Provide a low suction pressure shutdown switch on units connection to city mains. Provide a low suction level switch on level/pressure.

K. The unit shall be factory assembled and tested at simulated design conditions. The unit shall be thoroughly cleaned and painted with high quality machine enamel prior to shipment.

2.4 SEWAGE PUMPS AND SUMP PUMPS (VERTICAL WET PIT)

A. Duplex pumps shall be vertical wet pit submerged electric pumps of capacities, arrangement, horsepower, type, speed, and with accessories as scheduled or indicated. Pump units shall be factory assembled and tested.

B. Casing shall be cast iron volute type with flanged suction and discharge. The support column connections shall be cast integral with the casing. Impeller shall be screenless, non-clog type, accurately machined, statically and dynamically balanced, keyed and locked to pump shaft.
C. Pump shafts shall be heat treated, ground and polished and with a replaceable stainless steel stub shaft or shall be stainless steel through the rubber lower bearing. Intermediate bearings, as required, shall be of replaceable bronze bushing type, grease lubricated, and shall be no more than 4 feet apart.

D. Each pump shall be mounted on a sub-plate and shall include a motor support bracket with a sealed thrust bearing located above the floor plate. The shaft shall be sealed where it extends through the sub-plate in order to eliminate escape of moisture and gases. The motor shall be connected to the pump by a flexible coupling.

E. Pumps shall be operated by encapsulated primary and standby float switches. A high water alarm shall be furnished with remote mounted alarm horn. The pump manufacturer shall furnish magnetic starters, disconnect switches, HOA selector switches and electric alternator mounted in one enclosure for wall mounting.

F. Basin covers shall be steel, suitable for use with concrete basin, complete with 12 inch x 16 inch manhole, flanged and gas-tight connections and suitable curb ring for mounting in concrete sump.

G. SCADA Alarm Contacts: Provide two sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the pump controller. The normally open contacts to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Sump high water level alarm.
2. Sump pump failure alarm.

2.6 SEWAGE PUMPS (SUBMERSIBLE)

A. Duplex pumps shall be factory tested, heavy duty, submersible, screenless, electric pumps of capacities, arrangement, horsepower, type, speed, electrical characteristics, and accessories as scheduled or indicated.

B. The motors shall be in a cast iron housing with double sealed bearings, integral motor shaft shall be stainless steel with keyway.

C. The impeller shall be two-vane type accurately machined to the proper diameter to pass 3 inch diameter spheres, statically and dynamically balanced.

D. Mechanical seals, carbon and ceramic, shall prevent leakage into motor and shall not come into contact with pumping media.

E. The pumps shall be operated by polyurethane float switches. The pump manufacturer shall furnish magnetic starters, disconnect switches, HOA switches and electrical alternator mounted in one enclosure for wall mounting. A high water alarm shall be furnished with remote mounting alarm horn.

F. The pumps shall be provided with proper removal systems to allow pumps to be removed from the wet pits without unbolting pumps or disconnecting piping.

G. SCADA Alarm Contacts: Provide two sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the pump controller. The normally open contacts to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Sump high water level alarm.
2. Sump pump failure alarm.
2.7 PNEUMATIC SEWAGE EJECTORS

A. Provide duplex pneumatic sewage ejectors with a stored air system and consisting of grease-lubricated non-clogging type with high-water alarm. Provide internal piping with gate valve, check valve, strainer, and fittings between the basin inlet and the discharge at the pump floor plate. Provide strainer of self-cleaning type and which will automatically flush clean on each discharge cycle. Provide ejector with factory coat of rust resistant paint.

B. Fabricate receiver from cast iron for 50 pounds per square inch gauge (psig) operating pressure; and from steel for higher pressures. Provide units hermetically sealed, and with a minimum of 16 inch diameter manhole in the top.

C. Provide encapsulated float switch controls.

D. SCADA Alarm Contacts: Provide two sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the pump controller. The normally open contacts to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Sump high water level alarm.
2. Sump pump failure alarm.

E. Provide package type air compressor assembly having components factory assembled in a cabinet on a common base. Components include compressor, motor drive, motor controller, oil cooler, oil separator, air storage tank, air filter, moisture separator, automatic drain trap, automatic controls, instrument panel, and pressure gauge. Factory install interconnecting piping and wiring.

1. Provide compressors designed for continuous operation with an automatic capacity regulation. Directly connect compressor to a 3 phase continuous duty electric motor having ball bearings and built-in overload protection. Provide bearings designed for a L50 life of 100,000 hours or a L10 life of 20,000 hours as defined by the Anti-Friction Bearing Manufacturers Association.

2. Provide air storage tank of welded steel, ASME construction, and with ASME stamp of certification. Provide tank with blow-off cock, pressure gauge, low pressure alarm, and low pressure remote indicator.

3. Provide relief valves of combination pressure and temperature dip tube, factory set and having automatic reseating. Provide valve with the ASME and AGA label or stamp. Extend drain piping to a drain.

4. Provide pressure-reducing valve assembly as specified in Section 15060, "Piping and Accessories" and consisting of reducing valve, strainer, 3-valve bypass, ASME relief valve with piped discharge and upstream and downstream pressure gauges. Provide pressure - reducing valve of spring-loaded, self-contained type having bolted spring chamber, bronze body, and nylon diaphragm inserts, and suitable for tight shut-off under dead-ended conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pumps:

1. Pumps shall be located as shown or indicated on the drawings and installed as recommended by the manufacturer.

2. Base mounted pump couplings shall be field checked for proper alignment prior to operation and rechecked following operation of approximately 48 hours. Alignment shall be within pump manufacturer’s tolerances.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".

END OF SECTION 15160
PART 1 - GENERAL

1.1 DESCRIPTION

A. The work specified under this section consist of furnishing and installing thermal insulation and appurtenances for piping, pipe fittings, pipe accessories, equipment, ductwork, and supporting devices as indicated.

B. Factory insulated equipment is excluded from this section of the specification except that the insulating material characteristics shall equal or exceed those of specified materials for similar service.

C. Work Includes:
   1. Piping:
      a. Above ground and below ground domestic hot and above ground cold water piping.
      b. Traps, tailpieces, and supply piping of drinking fountains providing refrigerated water.
      c. Above ground horizontal roof drain and overflow drain piping, and horizontal sanitary drains handling cooling coil condensate.
      d. Interior and exterior, above ground and underground heating, condenser water, steam, steam condensate and chilled water piping. Insulation of pumps is not required except chilled water booster pumps above ceilings.
      e. Plumbing items requiring insulation due to rules and regulations for the handicapped.
      f. Cooling coil condensate drain lines.
      g. Refrigerant suction lines.
      h. Wet-pipe sprinkler systems where freeze protection is required.

   2. Ductwork:
      a. Supply air:
         1) Primary ductwork shall be externally insulated with thermal duct wrap.

2) Secondary ductwork shall be internally lined with acoustic duct liner maximum of 10 feet in every direction downstream of all terminal units and fan coil units.

3) Remaining secondary supply air ductwork shall be insulated externally with thermal duct wrap.

4) Return air: Externally insulated.

b. Exhaust and outside air ductwork: Shall be externally insulated unless indicated otherwise.

3. Equipment:
   a. Chiller Evaporators (factory insulation optional).
   b. Expansion Tanks.
   c. Domestic Hot Water Storage Tank (factory insulation optional).
   d. Heat Exchangers.
   e. Suction Accumulators.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

B. National Fire Protection Association (NFPA):
   1. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems
   2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air - Conditioning Systems

C. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):
   1. SMACNA 1481 - HVAC Duct Construction Standards - Metal and Flexible

1.3 SUBMITTALS

A. Certification.
B. Product Data: Including Thermal Performance Test Data.

C. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General".

1.4 QUALITY ASSURANCE

A. The following Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer’s certificate that materials meet or exceed minimum requirements to comply with ASTM, UL, NFPA, and all other applicable standards.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Keep the inlet and discharge openings of units covered until the units are ready to run.

B. During the erection protect all ductwork, piping, and equipment from dirt and debris. Temporarily cap the open top of vertical ductwork and piping.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Unless otherwise noted, Fire rating of all above ground insulation including jackets, adhesives, coatings, mastics, etc., not to exceed 25 flame spread or smoke developed under ASTM E84 procedure. Fire resistance rating shall meet the requirements of NFPA 90A and 90B.

B. Insulation shall be vermin resistant.

C. Pipe Insulation: Above ground fiberglass type, ASJ/SSL-II. Piping exposed to the weather shall have 0.016 smooth or corrugated aluminum jacket with vapor barrier. Attachment shall be made by 1/2 inch by 0.020 aluminum bands with approved closure system. Armaflex type insulation shall be used, in thermally equivalent thicknesses, for refrigerant suction lines where codes permit.

D. Duct Insulation:

1. External insulation for Metal Ductwork (Flexible Blanket): Foil reinforced kraft (FRK) faced fiberglass Duct Wrap, conforming to the requirements of NFPA 90A and 90B and applicable energy codes.

2. External Insulation for Metal Ductwork (Semi-Rigid Board): Where indicated, provide fiberglass FRK faced board, 3.00pcf density, conforming to NFPA 90A and 90B and applicable energy codes.

3. Internal Acoustical Duct Liner for Metal Ductwork: Duct liner, 3 pcf density with a black neoprene fire-resistant coating, conforming to the requirements of NFPA 90A and 90B and applicable energy codes.

4. Duct liner products shall avoid air erosion up to velocities of 4,000 feet per minute.

E. Chiller Insulation: Armaflex type insulation shall be used.

F. Expansion Tank Insulation: Armaflex type insulation shall be used.

2.2 INSULATION THICKNESS

A. Insulation thickness based on a minimum R value that is the greater of 4.6 square feet per hour per deg. F divided by BTU by inches or that required by the applicable energy codes.

B. Piping Insulation Thickness as indicated in Table 15260 - 1.

C. Duct Liner: Supply acoustic duct liner shall be 1 inch thick unless noted otherwise.

D. Duct Insulation: Supply and return air ductwork, 2 inches thick, with an installed R value of 5.0 minimum.

E. Chiller insulation shall be 3/4 inch thick.

F. Expansion tank insulation shall be 1/2 inch thick.

G. EWC traps and tailpieces insulation shall be 1 inch thick.

PART 3 - EXECUTION

3.1 GENERAL

A. The installation of insulation shall be made by experienced craftsmen in a neat, workmanlike manner and shall be in accordance with the manufacturer's published recommendations for service intended, as interpreted by the Contracting Officer.

B. Adhesives used in conjunction with insulation shall be compatible with the insulation and vapor barrier used and be vermin-proof and mildew resistant.
3.2 PIPE INSULATION

A. Insulation shall be the full specified thickness, continuous through walls, floors, ceilings, etc. Reducing thickness or cutting back of insulation to pass obstructions or through sleeves will not be permitted.

B. Valve and fitting insulation shall be factory prefabricated units with PVC jacket.

C. Any painting of pipe insulation shall be accomplished under the Section 09920, “Interior Painting”. Before finish painting, any insulation showing splits or other signs of poor workmanship shall be replaced.

D. No part of any system shall be insulated until required tests have been completed.

E. Insulation shall be installed so that it does not interfere with the functions of thermometer wells, gage connections and/or cocks, unions, access panels, hand holes, manholes, sight glasses, etc., or obscure serial numbers or other nameplate data.

F. Insulation shall be extended to include stiff leg supports as required to prevent sweating.

G. Continuous vapor barriers to prevent sweating shall be installed on all cold systems and equipment. If a single tape adhesive system or staples are used for closure of the longitudinal lap, a vapor barrier mastic must be used to ensure a vaporproof closure. Edges and abutments shall be sealed, waterproof and vaporproof. Supplier of jacket materials shall certify that the material proposed is approved for use in return air plenums, where applicable.

H. Piping supports shall pass completely around the exterior of the finished insulation. Rigid blocks of insulation material shall be provided at support points. In addition, sheet metal saddles shall be provided at support points in accordance with the following table:

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>Gauge Metal (inches)</th>
<th>Saddle Length (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 2-1/2</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>3 to 5</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>6 to 8</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>10 and Over</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

I. Saddles shall cover the bottom of the insulation, and saddle edges shall be hemmed or suitably covered to prevent damage to the insulation material.

M. The vapor barrier and finish shall be continuous at all support points.

N. Exposed piping lower than 8 feet above the finished floor subject to injury by personnel traffic shall receive an aluminum jacket as specified herein.

3.3 DUCT INSULATION

A. Internal Duct Liner: Insulation shall be installed such that it does not interfere with access panels, damper quadrants, or any other movable component of the ductwork. The duct liner shall be applied to the inside of the duct with the faced side to the airstream and shall be secured to the duct with adhesive, pins, and washers. Adhesives shall completely coat the metal. Joints shall be firmly butt together. Duct liner shall also be installed in accordance with the requirements of SMACNA 1481.

B. External Duct Insulation: External duct shall be installed without sagging or loose fitting sections. Outerjacket shall be sealed with mastic to form a continuous vapor barrier. Install as recommended by the insulation manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”. 
## TABLE 15260 - 1

### PIPE SIZES

<table>
<thead>
<tr>
<th>System</th>
<th>Runouts To 1&quot; &amp; 1-1/2&quot; (12ft.max.)</th>
<th>1&quot; &amp; Less (inches)</th>
<th>1-1/4&quot; &amp; Larger (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating hot water to 250 deg. F. and low pressure steam.</td>
<td>1</td>
<td>1-1/2</td>
<td>1-1/2</td>
</tr>
<tr>
<td>Domestic water, horizontal storm piping and drain bodies. Chilled water and supply piping to remote EWC.</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Condenser water exposed to ambient</td>
<td>1</td>
<td>1</td>
<td>1-1/2</td>
</tr>
<tr>
<td>Refrigerant suction lines</td>
<td>1/2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wet-Pipe Sprinkler Piping</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### PIPE SIZES

<table>
<thead>
<tr>
<th>Recirculating domestic hot water</th>
<th>Up to 1-1/4&quot; (inches)</th>
<th>1-1/2&quot; to 2&quot; (inches)</th>
<th>Over 2&quot; (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>170 deg. F to 180 deg. F</td>
<td>1</td>
<td>1-1/2</td>
<td>2</td>
</tr>
<tr>
<td>140 deg. F to 160 deg. F</td>
<td>1</td>
<td>1</td>
<td>1-1/2</td>
</tr>
<tr>
<td>100 deg. F to 130 deg. F</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### PIPE SIZE

<table>
<thead>
<tr>
<th>Domestic hot water runouts up to 1&quot; (inches)</th>
<th>All ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing of dry standpipes, wet standpipes, wet sprinklers, pre-action dry sprinklers, exterior fire protection, fire department Siamese connections, valves, control, and supporting devices.

1.2 REFERENCED STANDARDS

A. National Fire Protection Association (NFPA):
   1. NFPA 13 - Installation of Sprinkler Systems
   2. NFPA 14 - Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems
   3. NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances
   4. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

1.3 SYSTEM DESCRIPTION

A. Provide a complete fire protection system for the areas, buildings, tunnels, or aerial structures, as specified, as indicated on the drawings, and as required by all authorities having jurisdiction. The drawings show the general arrangement of plumbing, air conditioning, piping, ductwork, and other apparatus. The Contractor shall coordinate this work with all other construction so that there shall be no conflict as to space required. The mechanical and electrical work shall, in general, take precedence over sprinkler work, except where it is absolutely necessary to maintain required coverage.

B. Dry standpipe system: Consists of fire department connection, dry fire line, check valves, automatic air vents, drain valves, and hose valves.

C. Wet standpipe system: Consists of fire department connection, wet fire line, check valves, drain valves, fire water line surveillance valve, hose valves, and capped branch connections for sprinkler systems where shown.

D. Fire suppression system for escalators: Consists of fire line to point inside escalator pit/machine room capped for future extension by escalator contractor, supplied from wet or dry standpipe system.

E. Sprinkler system, other than escalator: Consists of sprinkler lines, fire water line surveillance valve, flow alarm check valve, drain valve, and sprinkler heads as well as heating tracers in areas subject to freezing temperatures, supplied from wet standpipe system or from domestic water line.

F. Exterior fire protection system: Consists of lead-ins to wet standpipe system, valves and accessories, supplied from the City water main.

1.4 SUBMITTALS

A. Certification: Submit certified copies of materials test reports.

B. Product Data: Materials and equipment.

C. Shop Drawings:
   1. Identify methods of joining, welding, fastenings, and anchoring.
   2. Indicate materials and locations for wet standpipe, dry standpipe, sprinkler, and external systems.
   3. Show pipes and piping layout, including pipe hangers, and supports.
   4. Indicate valves, escutcheons, gauges, automatic air vents, pipe sleeves, and mechanical couplings.
   5. Show layout of sprinkler systems.
   6. Submit detail drawings approved by Fire Marshall of jurisdiction in which work is performed. Drawings shall be prepared by State of Texas licensed fire protection engineer. Also include any notes or letters that accompany the approval.
   7. ISO approvals.
   8. Perform flow test on existing city water system and submit results.

1.5 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards and Specifications sections referenced in Section 15001, "Mechanical Systems - General", also apply to this section. When required, provide the Contracting Officer with the manufacturer’s certificate that materials meet or exceed minimum requirements to comply with ANSI, NFPA, UL, ASTM, ASME, OSHA, AISI and other applicable standards.

B. Design and installation shall meet requirements of NFPA 13, NFPA 14, International Building Code, International Fire Code and local authorities. Approval of sprinkler system is based, generally, on Light Hazard Requirements; except Sprinkler Systems installed in janitorial spaces, trash rooms,
and similar areas are sized for Ordinary Hazard Requirements.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. During the erection protect and store piping and equipment from dirt and damage. Temporarily cap the open top of piping installed.

1.7 OPERATION AND MAINTENANCE TRAINING

A. Provide Operation and Maintenance Manuals and Training in accordance with Section 15001, "Mechanical Systems - General".

PART 2 - PRODUCTS

2.1 PIPING

A. Underground pipe to the inside of the building shall be cement lined cast iron or P.V.C. Class 150 (SDR 17) with cast iron Class 250 fittings.

2.2 FIRE DEPARTMENT CONNECTIONS

A. Furnish and install fire department connections conforming to the requirements of NFPA, Siamese type, either polished brass or bronze. Connections shall have either a polished or a chromium plated finish with inlet plugs and chains or caps to match with check valve and approved automatic drip. Fire department connections, unless otherwise noted, shall be Potter Roemer No. 5780 or Authority approved equal, 4 inch x 2-1/2 inch polished brass with caps and chains or approved alternate. Provide complete with escutcheon plate and lettered, as appropriate, "DART AUTO SPRINKLER", "DART DRY STANDPIPE" or "DART WET STANDPIPE". Letters shall be 1 inch high and in raised cast form on the surface of the fitting or the escutcheon. Connections shall contain a self-closing clapper valve in each inlet and inlet hose threads conforming to the local fire department thread specifications and either flush or wall-mounted. Provide escutcheon finish to match body of Siamese. Threads, mounting height and distance to nearest fire lane shall conform to the local fire department standards.

B. Provide UL labeled rack assembly of enameled steel, and of the semi automatic type which automatically releases water as the last fold of hose is pulled from the rack after the valve has been opened. Provide rack with 100 feet of 1-1/2 inch unlined linen hose having a cast brass nipple, drain vent valve, and nozzle. Provide UL listed nozzle and adjustable for Class A, B and C fires. Include with rack a 1-1/2 inch cast brass angle hose valve, escutcheon plate, and spanner wrench.

C. Install at each floor level and in subway tunnel, not more than 5 feet from finished floor and indicating control valve on each standpipe, and a 2-1/2 inch fire department connection with a 2-1/2 inch x 1-1/2 inch reducer with cap and chain. Threads shall conform to the local fire protection district standards.

2.4 FIRE HOSE CABINET

A. Provide cabinet with 2-1/2 inch fire department valve, rack assembly, and provisions for mounting a portable 10 pound dry chemical fire extinguisher. Fabricate side, top, bottom, and back of cabinet from 18-gauge steel having two coats of white baked enamel finish on the inside and a prime coat on the outside. Apply manufacturer's red enamel finish, prime coat and finish paint in accordance with manufacturer's standard procedure. Fabricate door and hollow trim from stainless steel with #4 finish. Provide continuous piano type hinge door with break glass and door lock operator; locks keyed alike. Provide signs on doors not fully glazed with the message "FIRE HOSE" and "FIRE EXTINGUISHER" affixed on the top half of the door where indicated. Furnish each cabinet with a 1-1/2 inch cast brass angle hose valve, escutcheon plate, and spanner wrench.

B. Provide UL approved, 1-1/2 inch rough brass 300 pounds per square inch, (psi) angle hose type with cap, chain, and hose threads conforming to the local Fire Department thread specifications.

2.5 FIRE HOSE VALVE CABINET

A. Provide cabinet with 1-1/2 inch and 2-1/2 inch fire department angle hose valves, and provisions for mounting a portable 10 pound dry chemical fire extinguisher; as indicated. Sides, top, bottom, and back of cabinet of 18-gauge steel having two coats white baked enamel finish on the inside and a prime coat on the outside. Apply manufacturer's red enamel finish, prime coat and finish paint in accordance with his standard procedure. Fabricate door and hollow trim from stainless steel with #4 finish. Provide continuous piano type hinge door with break glass and door lock operator; locks keyed alike. Provide signs on doors with the message "FIRE DEPARTMENT VALVE" and "FIRE EXTINGUISHER" affixed on the top half of the door where indicated. Furnish each cabinet with a 1-1/2 inch x 2-1/2 inch double spanner wrench.
2.6 VALVES

A. Control valves inside buildings shall be listed 175 pound W.O.G. approved indicating type valve.

B. Check valves shall be Listed, 175 pound W.O.G., horizontal swing check valves or approved equivalent such as wafer check valves.

C. Drain and test valves shall be 175 pound W.O.G., bronze threaded globe valves with renewable composition disc.

2.7 WATER FLOW SWITCHES

A. Water Flow Switches: Vane-Type Waterflow Detectors shall be installed on the deluge main and sprinkler mains. Detector shall be designed for mounting on either vertical or horizontal piping, but shall not be mounted in fitting or within 12 inches of any fitting that changes the direction of water flow, and shall have a sensitivity setting to signal any flow water that equals or exceeds 10 gpm. Detector switch mechanisms shall incorporate an instantly recycling pneumatic retard element with an adjustable range of 0 to 60 second. Switches shall be suitable for operation on 24 volts D.C., and shall be actuated by a vane extended into the waterway of piping. Detectors shall be of dust tight construction. Detector switch enclosures shall be secured with a tamper proof bolt that requires the use of a special wrench for removal. Van-Type Waterflow Detectors shall be Underwriters’ Laboratories listed. The detector shall be furnished and installed under this section and wired completely under Section 16721, “Fire Alarm and Detection Systems”.

2.8 TAMPER SWITCHES

A. Tamper switches shall be installed on each valve inside the building. Switches shall be mounted so as not to interfere with the normal operation of the valve control or when the stem has moved no more than one-fifth of the distance from its normal position. The mechanism shall be contained in a weather-proof die cast aluminum housing which shall provide a 3/4 inch tapped conduit entrance and incorporate the necessary facilities for attachment to the valve. Switch housings shall be furnished in red baked enamel. The switch mechanism shall have a minimum rated capacity of one amp, 125 A.C. to 0.25 amps, 24 volts D.C. The entire installed assembly shall be tamper proof and arranged to cause a switch operation if the housing cover is removed or if the unit is removed from its mounting. Supervisory Switches and Gate Valve Switches shall be Underwriters’ Laboratories listed. Supervisory Switches shall be furnished and installed under this section and wired completely under Section 16721, “Fire Alarm and Detection Systems”.

B. Tamper switches shall be Factory Mutual approved.

2.9 SIGNS AND IDENTIFICATION

A. Approved enameled metal signs shall be securely attached at all main drains, auxiliary drains, inspectors' test connections, and control valves, as specified in Section 15055, “Identification of Equipment and Piping”.

B. Provide labeling of piping, valves and accessories as specified in Section 15055, “Identification of Equipment and Piping” and in accordance with code requirements.

2.10 SPRINKLER SYSTEM

A. Automatic Sprinklers: The automatic sprinkler system shall be a wet pipe or dry pipe system. In locations where the system is susceptible to freezing temperatures, a dry pipe system shall be installed with all necessary equipment. Other areas shall have a wet pipe system. Sprinkler heads of proper temperature rating shall be installed throughout the building as required by approving authorities. Where furred of finished ceilings occur, the piping shall be installed above the ceiling with the sprinkler heads nippled through the ceiling and set in metal escutcheon plates. Where lay-in ceilings occur, center the sprinkler heads on each tile. Sprinkler heads shall be provided as follows, unless otherwise shown:

<table>
<thead>
<tr>
<th>Area Served</th>
<th>Type Head Trim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully finished area with</td>
<td>Fully recessed Trim</td>
</tr>
<tr>
<td>gypsum board and/or lay-in</td>
<td>w/factory painted cover</td>
</tr>
<tr>
<td>ceilings</td>
<td>(color by Contracting Officer)</td>
</tr>
<tr>
<td>Semi-finished areas, kitchens</td>
<td>Semi-recessed head</td>
</tr>
<tr>
<td>work areas</td>
<td>w/chrome Escutcheon</td>
</tr>
<tr>
<td>Non-finished areas</td>
<td>Pendant heads, with cage cover</td>
</tr>
<tr>
<td></td>
<td>where head is less than 7 feet FF and in janitor closets.</td>
</tr>
</tbody>
</table>

B. Sprinkler Risers: Shall be equipped with a variable pressure alarm valve including retarding chamber, drain valve, standard trim, and gauges.

C. Water Motor Gongs: Shall be furnished for alarm valve and dry pipe valves and located as required.

D. Drains: Shall be piped to the outside of buildings as part of this work, except in locations where a drain is provided by the plumbing design, specifically for sprinkler system use.
E. Piping System Valves: Shall be approved for fire protection piping systems and shall be installed as required by the NFPA (NFPA 13, NFPA 130 or other applicable NFPA Standards).

F. Fire Hoses: Hose shall be 100 ft. length, hose valves shall be a 2-1/2 inch polished brass valve, with cap, chain and wall escutcheon, when furnished as fire department connection only.

G. Roof Outlets: Shall be a brass double hydrant valve 2-1/2 inches by 2-1/2 inches by 4 inches with two caps and chains.

H. Hangers: Shall be installed as required and shall be listed by the Underwriters' Laboratories for use in a sprinkler system.

I. Sprinkler Cabinet: One cabinet with 6 sprinklers and a head wrench shall be installed as directed by the Contracting Officer.


K. Automatic Dry Pipe Air Compressor System:
   1. In conformance with NFPA 13, NFPA 130 or other applicable NFPA Standards.
   2. Provide air compressor with sufficient capacity to pressurize the dry-pipe system, to a pressure as recommended by the dry-pipe valve manufacturer in conjunction with the local available water pressure, within a period of 30 minutes, and have 25 percent additional air capacity.
   3. Furnish each air compressor complete with motor V-belts, ASME Code air receiver, pressure gauge, high and low pressure switches, starting devices, receiver drain, air intake filter, and belt guards.
   4. Furnish air compressor and receiver with rails or guards.
   5. Compressed air piping:
      b. Black, standard weight, screw-jointed, malleable iron fittings.
      c. Bronze angle, globe, and check valves.
      d. Furnish suitable drips with automatic drain valves provided on the low points of the compressed air mains.

L. Automatic Dry Pipe Valve Assemblies: Furnish automatic dry pipe valve assemblies for the dry-pipe sprinkler system, in conformance with NFPA 13, NFPA 130 or other applicable NFPA Standards, complete with:
   1. Gate and check valves,
   2. Quick-opening device (accelerator),
   3. Air maintenance device,
   4. Pressure alarm switch,
   5. Water motor local alarm,
   6. Air pressure regulating alarm,
   7. Relief valve, and
   8. Pressure gauges.

PART 3 - EXECUTION

3.1 EXCAVATION AND BACKFILL

A. Pipe trenches shall be dug to a line and the bottom cleaned and shaped to provide support of the pipe through its entire length.

B. For requirements for above grade or underground fire main, comply with NFPA 24 Private Fire Service Mains.

C. If plastic pipe (PVC) is installed underground, manufacturer’s instructions shall be strictly followed in regard to cover and backfilling materials and procedures.

D. Comply with requirements of Section 02221, “Utility Excavation and Backfill”.

3.2 SPRINKLER PIPING

A. It shall be installed per NFPA 13, NFPA 130 or other applicable NFPA Standards and insofar as possible, all sprinkler system mains and branches shall be installed as close as possible below structural concrete slabs.

B. Piping for systems shall be coordinated with lighting fixtures, air conditioning ducts, piping, air handling units, and all other obstructions.

3.3 FREEZE PROTECTION

A. Where shown, Install freeze protection for wet-pipe systems as specified in Section 15060, “Piping and Accessories”. Locate heating cable as a spiral around pipe trace for cold water piping, and secure the heat cable to the pipe with full wrap of high temperature pressure sensitive tape at intervals not to exceed two feet.
3.4 **HANGERS AND SLEEVES**

A. Hangers shall be installed and spaced in accordance with NFPA 13, NFPA 130 or other applicable NFPA Standards.

B. Sleeves shall be set for pipes passing through concrete floors and masonry walls.

C. Provide chrome plated escutcheon plates at wall penetrations.

3.5 **AUXILIARY DRAINS**

A. Auxiliary drains consisting of plugs, or globe valves and plugs where the capacity of a trapped pipe section exceeds 5 gallons, shall be provided to drain points in the system that cannot be drained back to a main riser. Field conditions may dictate additional drains which could not be determined for bidding purposes which shall be provided as required by NFPA 13, NFPA 130 or other applicable NFPA Standards.

3.6 **INSPECTORS’ TEST CONNECTIONS**

A. Furnish and install inspectors’ test connections per NFPA 13, NFPA 130 or other applicable NFPA Standards.

3.7 **CONCEALED WORK**

A. No work shall be concealed unless first inspected and approved by the authority having jurisdiction.

3.8 **TESTING**

A. Piping shall be tested per NFPA 13, NFPA 130 or other applicable NFPA Standards in the presence of the Authority's representative and other approving authority and shall be proved tight. Unsatisfactory workmanship shall be corrected to the satisfaction of the above mentioned persons. Defective materials shall be replaced with new materials and defective materials removed from the premises.

**PART 4 - MEASUREMENT AND PAYMENT**

4.1 **GENERAL**

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15300
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing of fire pumps, jockey pumps, and supporting devices as shown.

1.2 REFERENCED STANDARDS

A. National Fire Protection Association (NFPA):
   1. NFPA 20 - Standard for the Installation of Stationary Pumps for Fire Protection

1.3 SUBMITTALS

A. Product Data:
   1. Include manufacturer's literature and data for all equipment and material.
   2. Performance Curves:
      a. Pump performance curves (total dynamic head vs. flow rate) showing brake horsepower, KW input and full load efficiency.
      b. Motor performance curves in accordance with Section 15060, "Piping and Accessories.

B. Shop Drawings:
   1. Indicate pipes and piping layout, pipe hangers and supports, valves, and gauges.

C. Certification: Submit certified copies of the field test reports.

D. Field Testing: Submit a detailed plan of the proposed method of and scheduling of the required field testing at least 30 calendar days prior to initiating the tests.

E. Operation and Maintenance Manuals and Training: Section 15001, "Mechanical Systems - General".

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with NFPA, NEC, UL, FM, NEMA, and other applicable standards.

B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacturer of fire pump systems of the type specified herein.
   2. Equipment: Incorporate in the work fire pump systems that essentially duplicate fire pump systems that have been in satisfactory use for a period of ten years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. During the erection protect and store piping and equipment from dirt and damage. Temporarily cap the open top of piping installed vertically.

1.6 WARRANTY

A. Provide a parts and labor warranty for a period of 4 years in addition to the 1 year requirement of the General Provisions for a total of 5 years.

PART 2 - PRODUCTS

2.1 GENERAL

A. In the selection of equipment provide for interchangeability of piping subassemblies, parts, motors, starters and relays.

B. Provide the pump, driver, controller, and accessories in strict compliance with the latest edition of NFPA 20. Provide for proper operation of the unit assembly, as indicated by field test.

2.2 FIRE PUMPS

A. Pump capacity shall be as scheduled with minimum scheduled suction pressure. The pump shall also be designed to deliver not less than 150 percent of rated capacity at a pressure not less than 65 percent of the rated head. The shut-off pressure shall not exceed 120 percent of the rated pressure.

B. The pump shall be hydrostatically tested to twice the working pressure but in no case to be less than 250 psi.

C. Included with pump shall be the following fittings and/or accessories.
   1. Suction and discharge gages.
   2. Casing relief valve.
   3. Automatic air release valve.
   4. Hose manifold.
5. Three hose valves with caps and chains.

6. Approved fire pump flow meter, orifice plate type or pilot tube type.

D. The pump and driver shall be mounted on a common base plate of fabricated steel and directly connected through a flexible coupling.

E. The driver shall be a horizontal ball bearing, part winding squirrel cage induction motor of open drip proof type, (see Division 16, “Electrical Systems” for voltage) with an ambient temperature not exceeding 104 degrees F, and to be of such capacity that at rated voltage and frequency pump will not exceed the full load ampere rating under any conditions of pump load.

F. Locked rotor motor current shall not exceed the values specified in NFPA 20.

G. The pump unit shall be given a flow test in accordance with NFPA 20.

H. Controls: The motor control shall be specifically approved for fire pump purposes and shall be marked “Fire Pump Controller”. The control equipment shall be completely assembled, wired and tested at the factory. The controller shall alarm in the operations control center (O.C.C.) when the pump starts.

I. Equipment shall be enclosed in one or more approved drip tight enclosures.

J. The controller shall be of the combined manual and automatic type and incorporating the following:

1. Disconnect switch - externally operable, quick break type.

2. Time delay type circuit breaker with trips on all phases set for 300 percent of the motor full-load current. Capacity of the circuit breaker shall be as indicated in Division 16, “Electrical Systems”.

3. Fire Pump Controller: Underwriters' listed, combined manual and automatic reduced voltage, two step closed transition part winding type starter. The part winding starter shall limit the in-rush current to 60 percent of the maximum full voltage locked rotor current of a standard motor per NEC tables. Control equipment with front operated circuit breaker and disconnect switch. Circuit breaker to be approved for use by the Underwriters' Laboratories, Inc. Pressure regulator to have a range of 0 to 300 psi, with pressure settings established at time of field acceptance test. An instantaneous recycling running period timer set to keep the motor in operation for six minutes on automatic start, to be interwired with pressure regulator. Controller shall be provided under this section. Fire pump shall be interconnected with emergency generator as shown on Contract Drawings. Comply with requirements of NFPA 20. Power wiring to be under Division 16, “ELECTRICAL”.

4. Running period timer set to keep motor in operation when started automatically, for a minimum period of one minute for each 10 HP of motor rating, but not to exceed seven minutes.

5. Pilot lamp to indicate circuit breaker closed and power available.

6. Alarm relay to energize an audible or visible alarm through an independent source of power to indicate circuit breaker open or lower failure.

7. Ammeter test link and voltmeter test studs.

8. Manual Selector Station: A two position station shall be provided on the enclosure marked "Automatic" and "Non-automatic".

9. An alarm signal shall operate continuously while the pump is running.

K. Jockey Pump and Controller: Jockey pump shall be close coupled centrifugal type having a capacity as scheduled.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pumps:

1. Pumps shall be located as shown or indicated on the drawings and installed as recommended by the manufacturer.

2. Base mounted pump couplings shall be field checked for proper alignment prior to operation and rechecked following operation of approximately 48 hours. Alignment shall be within pump manufacturer's tolerances.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15380
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the furnishing and installing of plumbing fixtures, and equipment as indicated and supporting devices as shown.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings

B. Industrial Safety Equipment Association (ISEA):
   1. ISEA Z358.1 - Emergency Eyewash and Shower Equipment

C. American Society of Mechanical Engineers (ASME):
   1. ASME A112.19.2M – Vitreous China Plumbing Fixtures

1.3 SUBMITTALS
A. Certifications: Submit certified copies of field test reports.

B. Training Plans and Operation and Maintenance Manuals: Section 15001, “Mechanical Systems – General”.

C. Product Data: Catalog Cuts.

D. Field Testing: Submit a detailed plan of the proposed methods and scheduling of the required field testing at least 30 calendar days before initiating the test.

E. Submit copies of necessary permits and originals of inspection tags.

1.4 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, “Mechanical Systems - General” also apply to this section. When requested, provide the Contracting Officer with manufacturer’s certificate that materials meet or exceed minimum requirements to comply with ANSI, ASME, and all other applicable standards.

B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of plumbing fixtures of the type specified herein.

2. Equipment: Incorporate into the work plumbing fixtures that have been in satisfactory use for a period of ten years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Keep the inlet and discharge openings of fixtures covered until final connections are completed.

B. During the erection protect and store all fixtures and appurtenances from dirt and damage.

PART 2 - PRODUCTS

2.1 FIXTURES
A. Water Closet (Non-Public Areas) - Item P-1 and P-1A for the physically-handicapped:
   1. Bowl: Wall-hung siphon jet vitreous china closet bowl, with elongated rim, 1-1/2 inch spud, and china bolt caps.

   2. Flush Valve: Exposed chrome plated, diaphragm type with oscillating handle, escutcheon, seat bumper, integral screwdriver stop and vacuum breaker.


   4. Wall Mounted Carrier: Adjustable cast iron frame, integral drain hub and vent, adjustable spud. Lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

B. Urinal (Non-Public Areas) - Item P-2 and P-2A for the physically-handicapped:
   1. Urinal: Vitreous china, wall-hung washout urinal with shields, integral trap, 3/4 inch top spud, and steel supporting hanger.

   2. Flush Valve: Exposed chrome plated diaphragm type with oscillating handle, escutcheon, integral screwdriver stop, and vacuum breaker.

   3. Wall Mounted Carrier: Cast iron and steel frame with tubular legs, lugs for floor and wall attachment, and threaded fixture studs for fixture hanger.
C. Lavatory (Non-Public Areas) - Item P-3 and P-3A for the physically-handicapped:


2. Trim: Chrome plated supply fittings with open grid strainer, water economy aerator, indexed handles, chrome plated brass P-trap and arm with escutcheon.

3. Wall Mounted Carrier: Cast iron and steel frame with tubular legs, lugs for floor and wall attachment, bearing plate, and studs.

D. Service Sink:

1. Bowl: Porcelain enameled cast iron roll-rim sink, a stainless steel rim guard, 12 inch high back, concealed hanger, chrome plated strainer, and cast iron P-trap with adjustable floor flange.

2. Trim: Exposed wall type supply with lever handles, spout wall brace, vacuum breaker, hose end spout, eccentric adjustable inlets, integral screwdriver stops with cover caps and adjustable threaded wall flanges.

E. Mop Receptor:

1. Bowl: Molded stone, floor mounted, with not lower than 10 inches and narrower than 2 inches shoulders with stainless steel rim guard and stainless steel strainer.

2. Trim: Exposed wall type supply with lever handles, spout wall brace, vacuum breaker, hose end spout, eccentric adjustable inlets, strainers, integral screwdriver stops with covering caps, and adjustable threaded wall flanges.

F. Self-Contained Emergency Eye-Wash: Gravity flow type with eye/face wash spray; factory assembled complete with Food and Drug Administration rated 16 gallon capacity polyethylene tank with carrying handle, removable fill cap, mounting bracket, anti-bacteria additive, and retainer strap across nozzle.

G. Combination emergency shower/eye wash: Drench shower and eye wash fountain. Emergency shower pull chain which, when pulled down, will activate the water supply. Eye-wash is hand lever-operated. Provide emergency shower with a 3 inch diameter drain below shower head. Provide tempered water supply per requirements of ISEA 2358.1.

H. Electric Water Cooler (EWC) - Item P-5 and P-5A for the physically-handicapped: Wall mounted electric water cooler with stainless steel top, vandalism proof design elevated anti-squirt bubbler with stream guard, automatic stream regulator. Anti-splash basin with non-removable drain strainer, a self-closing lever or push bar. A 120 volts, single-phase, 60 Hz power source. Capacity 7.5 gph.

2.2 STOPES, BIBBS AND HYDRANTS

A. Angle, Straight, and Integral Stops: Lock-shield, loose-key pattern type with supplies. Exposed fixture fittings and trim: Chromium-plated or nickel-plated brass with polished, bright surfaces.


C. Flush Wall Hydrant (WH-1): Encased flush, anti-siphon, complete with vacuum breaker, non-freeze type, nickel bronze casing, bronze interior parts, hose thread spout, and non-turning operating rod with free floating compression closure valve; Box face and hinged cover: Polished nickel bronze complete with operating key lock.

D. Yard Hydrant (YH-1): 3/4 inch loose key type, non-freeze type having an extra deep bronze box for vacuum breaker. Box top: Rough bronze, hinged with internal lock and the word "WATER" cast into the cover.

2.3 DRAINS

A. Floor Drains: Provide floor drains fabricated from cast iron and of double drainage pattern, integral seepage pan, and connection for trap primer where required and with clamping collar for waterproofing membrane. Provide strainer fabricated from chromium-plated cast brass with chromium-plated finish and attached to a brass threaded collar for adjustment to varying floor thickness.

B. Area Drains (AD): Galvanized cast iron body with sump, round nickel-bronze strainer, membrane flange, and membrane clamp with integral gravel stop and waterproofing flange.

C. Planter Drains (PD-1): Galvanized cast iron body with sump; removable cast bronze dome strainer with bronze screen, membrane flange, and membrane clamp with integral gravel stop; waterproofing flange.

D. Trench Drain (TD): Provide trench drain with heavy duty body sections and integral anchor flange, heavy duty loose-set grates with perimeter drainage slots and bottom outlet inside caulk or threaded connection.

E. Roof Drains for Flat Roofs (RD-1): Provide galvanized cast iron body with sump drains of size shown, with large area cast iron dome, combined flashing collar and gravel stop, under deck clamp, spigot, inside caulk or threaded outlet as detailed. Provide for expansion and contraction of piping system as required.
F. Roof Drains for Sloped Roof (RD-2): Provide galvanized cast iron body roof drains of size shown with connections for cast iron hubless pipe or threaded side outlet. Provide drain with a secured bronze dome strainer having integral flashing clamp and flashing flange as required to prevent leaves, paper, or other deleterious material from entering the piping system.

G. Roof Drains Parapet Type (RD-3): Provide galvanized cast iron body roof drains of size shown with secured angle grate integral with flashing clamp shallow sump with flashing flange and 45 or horizontal side outlet threaded connection.

H. Overflow Drain (OD): Provide galvanized cast iron body overflow drain of size shown with flashing flange, threaded bottom outlet, adjustable chrome-plated bronze strainer and standpipe assembly including adjustable collar with ground insert, ground joint adaptor, standpipe and removable dome.

I. Pit Drain (PD-2): Provide pit drain backwater valve of size shown, pit type with bronze swing-check assembly, vertical inlet grate and spigot connection.

2.4 VALVES, INTERCEPTORS, CLEANOUTS AND BOXES

A. Backwater Valve:
   1. Provide swing-check type of size shown, flanged, coated cast iron and bronze swing check assembly and bronze seat.
   2. Provide ball float adapter fabricated from coated cast iron, plastic ball and renewable seat.

B. Sand and Oil Interceptors: Provide epoxy coated sand and oil interceptor, flow rate and oil capacity as indicated; equipped with inlet, outlet, and vent connections (types and sizes as shown), cascade bottom, double wall trap, removable baffle, and sediment bucket adjustable gravity draw-off connections, gasketed non-skid cover and flow control fitting; and constructed with the following additional construction features: concrete body, and flush with floor (recessed) installation.

C. Grease Interceptors: Provide acid resistant grease interceptors of size shown with automatic grease draw-off feature; flow-rate and grease capacity as indicated; equipped with inlet, outlet, and vent connections (types and sized shown), cascade bottom, internal air relief, visible double wall trap, removable baffles, and gasketed non-skid cover; equipped with low pressure chamber (grease accumulating cone), draw-off piping and valve; and constructed with the following additional construction features:
   1. Body: Concrete.

D. Cleanouts:
   1. Provide cleanouts of the sizes indicated, and of cast iron conforming to ASTM A74.
   2. Provide cleanouts in vertical piping where located within finish walls with standard cast iron hubs or no hub with cast brass threaded cleanout plug, with plug drilled and tapped to receive 8 inch diameter chrome or bronze plated as selected cleanout cover plate and vandalproof screw for attachment. Provide cleanout plug with lead seal in sanitary drainage piping.
   3. Provide floor cleanouts of adjustable type, and with lead seal, heavy duty scoriated nickel-bronze cover and, if for membraned floors, a clamping device. Secure cover with vandalproof screws.
   4. Provide exposed cleanouts with tapered caulking ferrule and raised or countersunk brass head cleanout plug.
   5. Provide grade cleanouts with cast iron ferrule countersunk or raised threaded brass plug, and cast iron access frame with anchor flanges and heavy duty scoriated cover secured with vandalproof screws. Provide cleanout plug with lead seal in sanitary drainage piping.

E. Access Boxes (coordinate all locations with Contracting Officer prior to installation):
   1. Walls and Ceilings: Access doors are specified in Section 08313, "Access Doors and Frames".
   2. Floors: Provide plain steel frame with plain nickel-bronze scoriated cover.
   3. Yard Boxes:
      a. Provide cast concrete boxes with cast iron rim and hinged self-closing cast iron lid marked for appropriate service, size as required.
      b. Set flush with finished grades with 4 inch thick concrete pad under perimeter (but not under interior) of box.
PLUMBING

PART 3 - EXECUTION

3.1 INSPECTION

A. Review millwork and other related shop drawings. Confirm location and size of fixture and/or opening before rough-in and installation.

B. Verify adjacent construction is ready to receive rough-in and finish work of this Section.

3.2 INSTALLATION OF PLUMBING PIPING

A. The plumbing piping system shall be installed as specified in Section 15060, "Piping and Accessories", and as specified herein.

B. Lubricate threaded cleanout plugs. Provide clearance at cleanout for rodding of drainage system.

C. Encase exterior cleanouts in concrete flush with grade.

3.3 INSTALLATION OF PLUMBING FIXTURES

A. Install each fixture with trap, easily removable for servicing and cleaning.

B. Provide chrome plated rigid or flexible supplies to fixtures with stops, reducers, and escutcheons to make a watertight finished connection.

C. Install components level and plumb.

D. Install and secure fixtures in place with wall carriers and bolts. Stop-nuts shall be installed in a flat plane to prevent fixture loading from applying any force to the wall.

E. Seal fixtures to wall and floor surfaces with sealant. Use sanitary sealant as specified in Section 07900, "Seals and Sealants".

F. Install fixtures per the schedules shown in Table 15400 - 1.

G. Install fixtures per current State of Texas Accessibility Standards (TAS).

3.4 ADJUSTING AND CLEANING

A. Adjust stops and regulating valves for intended water flow rate to fixtures without splashing, noise, or overflow.

B. At completion, clean plumbing fixtures and equipment.

C. Adjust flow of pumps, setting of tempering valves, and all other items to require flows and temperatures as indicated on the drawings for equipment and accessories furnished under this Section.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".

TABLE 15400 - 1
ROUGH-IN CONNECTION SCHEDULE

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<th>Cold Water (inches)</th>
<th>Waste (inches)</th>
<th>Vent (inches)</th>
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<tr>
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<td>Urinal (Flush Valve)</td>
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END OF SECTION 15400
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installing of water heaters as shown. Include the related work - pipe, pipe fittings, valves and specialties and supporting devices as shown.

1.2 REFERENCE STANDARDS

A. American Society of Heating, Refrigeration & AC Engineers (ASHRAE):
   2. ASHRAE 90.2 – Energy-Efficient Design of Low-Rise Residential Buildings

B. American Society of Mechanical Engineers (ASME):
   1. ASME Boiler and Pressure Vessel Code

1.3 SUBMITTALS

A. Certifications.

B. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General”.

C. Product Data: Catalog Cuts.

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specification sections referenced in Section 15001, "Mechanical Systems - General”, also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with ASME, UL, CSA, and all other applicable standards.

B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of industrial water heaters of the type specified herein.
   2. Product: Incorporate into the work water heaters that essentially duplicate water heaters that have been in satisfactory use for a period of ten years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Keep the openings of all water heaters covered until final connections are completed.

B. During the erection, protect, and store all equipment from dirt and damage.

PART 2 - PRODUCTS

2.1 ELECTRIC WATER HEATERS

A. Storage type water heater and accessories for 20 gallon capacity and less.
   1. Water heater fabricated of steel in accordance with the ASME Code.
   2. Storage capacity - as scheduled.
   3. Water heater recovery - as scheduled.
   4. Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
   5. ASME rated temperature-pressure relief valve on the tank, piped to indirect waste.
   6. Heating elements of the double rod type, 2000 watts or 1500 watts as shown. Voltage as indicated.
   7. Anode rods for cathodic protection of all internal tank surfaces.
   8. Furnished with complete automatic controls, including a temperature protector designed to shut off the power supply if water temperature in tank rises to high limit of temperature range, single temperature control adjustable for a range of 110 degrees F to 170 degrees F, and junction box with terminal block connection.
   9. Provide water heater UL listed and labeled.

B. Capacity of storage-type water heaters and accessories larger than 20 gallons.
   1. Water heaters fabricated of steel in accordance with ASME Code and applicable local plumbing code.
   2. Minimum storage capacity: As scheduled.
   3. Water heaters designed for heat recovery capacity as scheduled.
4. Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.

5. ASME rated temperature-pressure relief valve on tank, piped to indirect waste.

6. Provide heating elements for electric heaters of double rod type for operation at voltage shown.

7. Provide cathodic protection for all internal tank surfaces.

8. Furnished with complete automatic controls, including temperature protector designed to shut off power supply if water temperature in tank rises to 194 degrees F.

9. Provide low-water cut off to prevent electric powered water system from operating when water level drops below probe level.

10. Immersion-type thermostats and dial-indicating temperature gauge.

11. In-line hot water recirculating pump: Section 15160, “Pumps”.

2.2 GAS WATER HEATERS

A. Storage type water heater, self contained, fully automatic.

B. Water heater fabricated of steel shall be 150 psi rated, CSA and UL approved and labeled.

C. Storage capacity - as scheduled.

D. Water heater recovery - as scheduled.

E. Glass lined tank with high density blanket type insulation.

F. ASME rated combination temperature and pressure relief valve installed directly into the storage tank. Pipe to nearest indirect waste.

G. Provide burner to evenly distribute heat to the tank bottom and flue ways. Unit efficiency shall be 80% minimum based on flue gas analysis and standby losses per ASHRAE 90.1 I-P standard.

H. 100 percent shut-off safety pilot and main burner.

I. Pilot shall be of the automatic type, will not burn constantly.

J. Operating controls, to include programmed prepurge cycle spark ignition flame monitoring and normal burner control shall be by an adjustable operating thermostat.

K. Accessories shall include gate and check valves in the cold water supply.

L. Furnished with automatic control to shut off gas if water temperature in tank rises to 180 degrees F.

M. In-line hot water recirculating pump: In accordance with Section 15160, "Pumps".

N. Provide flue piping in accordance with Section 15600, "Heating Systems".

O. Unit shall meet current emissions standards of Texas Commission on Environmental Quality (TCEQ).

2.3 NAMEPLATES

A. Securely attach plate on each water heater showing manufacturer's name, model number, and serial number.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fit equipment and appurtenances to the space provided and make ready for service. Make installation free from obstructions around any part of the heater.

B. Provide supports, concrete pads, hangers, and anchor bolts necessary for proper installation of equipment as recommended by manufacturer.

C. Install complete domestic cold water supply in accordance with Section 15060, "Piping and Accessories".

D. Provide heaters ASME approved and with labeled temperature and pressure relief valve set to relieve full BTU/hr. capacity of heater at 210 degrees F and 125 pounds per square inch gauge (psig).

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".

END OF SECTION 15458
SECTION 15493
HEAT TRACING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installing of a complete system of freeze protection for domestic water piping systems, roof drains, and supporting devices shown on the Drawings and specified herein.

1.2 SUBMITTALS

A. Certification: Submit certified copies of field test reports.

B. Operation and Maintenance Manuals: Section 15001, “Mechanical Systems - General”.

C. Shop Drawings: Provide locations of pipe, appurtenances, and fixtures where heat tracing is applied.

D. Product Data: Catalog Cuts.

E. Field Testing: Submit a detailed plan of the proposed methods and scheduling of the required field testing at least 30 calendar days before initiating the test.

1.3 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, “Mechanical Systems - General”, also apply to this section. When requested, provide the Contracting Officer with manufacturer’s certificate that materials meet or exceed minimum requirements to comply with UL, NEC, and all other applicable standards.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide electric self-regulating heat tape for the purpose of freeze protection made up with copper bus bars embedded in a semi-conductor polymer jacket. Insulation for piping is specified in Section 15260, “Insulation”.

B. Provide heat tracing capable of maintaining a minimum water temperature in the pipe of 40 deg. F at an ambient temperature of minus 10 deg. F. Provide for automatic heater response to temperature conditions at any point along its length without reliance on thermostats or external control devices.

C. Provide self regulating feature to limit current consumption to actual current required to maintain temperature, and to consume no power, when water temperatures are above specified conditions.

D. Provide electric heat tracing consisting of a flat, flexible, low heat density electric tape made up with two 16 AWG copper bus wires with a continuous inner core of self-regulating conductive polymer material. Insulate core with a polyolefin jacket.

E. Electrical characteristics: 120 volts, single-phase, 60 Hz power.

F. For each continuous system of heat tracing, proper sized circuit breaker and enclosure will be provided under Division 16, “ELECTRICAL” as per the requirements of Section 15040, “Electrical Requirements of Mechanical Work”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Generally, install heat tracing wrapped around the pipe to be protected, under the pipe insulation as specified in Section 15260, “Insulation”.

B. Provide connections to and connections between elements by means of special fittings as recommended by the manufacturer.

C. Install the electric heat tracing system in strict accordance with the manufacturers installation drawings and printed installation instructions.

3.2 TESTING

A. Before heat tracing is covered, confirm operation by means of application of dry ice packs alternatively placed at three points along the tape run. Prove current flow by means of a clamp-on ammeter applied at the secondary side of the control circuit breaker. When dry ice pack is removed the current shall be reduced to match the resistance indicated by the manufacturer for the ambient temperature at the time of testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15493
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installing of heating systems and electric unit heaters and supporting devices, as shown, or as specified herein.

B. Work Included:
   1. Boilers.
   2. Steam cleaner.
   3. Flue pipe.
   4. Radiant heating panels.
   5. Gas furnaces.
   6. Infrared heaters.
   7. Electric duct heaters.
   8. Unit heaters.

1.2 REFERENCED STANDARDS

A. American Society of Heating, Refrigeration & AC Engineers (ASHRAE):

B. American Society of Mechanical Engineers (ASME):
   1. ASME Boiler and Pressure Vessel Code

C. CSA America (CSA):
   1. CSA/AM CSA/ANSI Z83.19 - Gas-Fired High-Intensity Infrared Heaters

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
   2. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

1.3 SUBMITTALS

A. Shop Drawings.

B. Certification: Design certification for gas-fired radiant heating systems.

C. Test Reports.

D. Training Plans and Operation and Maintenance Manuals: Section 15001, “Mechanical Systems - General” and Section 01786, “Operation and Maintenance Instructions”.

E. Product Data: Catalog Cuts.

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specification sections referenced in Section 15001, "Mechanical Systems - General", also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with UL, ASHRAE, AGA, standards.

B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of heating equipment of the type specified herein.
   2. Equipment: Incorporate equipment into the work which essentially duplicates equipment that has been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Keep the inlet and discharge openings of all units covered until the units are ready to run.

B. Store and protect all ductwork, piping and equipment from dirt and damage prior to and during erection. Temporarily cap the open top of all ductwork and piping installed vertically.

PART 2 - PRODUCTS

2.1 GAS FIRED WATER BOILER

A. Boiler shall be a gas fired, fire-tube type with force draft burner. Output shall be as scheduled. Unit efficiency based on flue gas analysis shall be not less than 80 percent.

B. Boiler shall be in compliance with the applicable provisions of the State Boiler Rules and Regulations, ASME Boiler and Pressure Vessel Code and UL listed.

C. Boiler shall be constructed to ASME standards for 60 psig, hot water boilers.
D. Boiler shall be furnished complete with, but not limited to:

1. Handholes and washout openings per ASME code requirements.
2. Dual low water cutouts.
3. Combination altitude-temperature gauge.
4. ASME code safety valve.
5. Bottom drain valve connection.
6. Safety high limit control.
7. Gas train with accessories.
8. Power indicating light.
10. Modulating type firing control when available as an optional feature.
11. Low fire hold aquastat.
12. Meter and control board on operating floor.

2.2 ELECTRIC BOILER

A. Electric boiler shall be self-contained, electric, and immersion type.
B. Boiler shall be in compliance with the applicable provisions of the State Boiler Rules and Regulations, ASME Boiler and Pressure Vessel Code and UL listed.
C. Boiler shall be constructed to ASME standards for 125 psig steam working pressure.
D. Boiler shall consist of the following:
   1. UL listed.
   2. 4 inch fiberglass insulation minimum on all sides of vessel.
   5. Drain/blowdown connection.
   6. Gauges: 3-1/2 inch steam pressure gauge and water column gauge glass with dry cocks.

2.3 STEAM CLEANER

A. Provide gas fired steam cleaner unit capable of producing steam vapor at 100 pounds per square inch (psig). Arrange for stationary mounting, with provision for leveling the unit.
B. For the steam cleaner, include an inlet float tank and a detergent tank. Features to be included are temperature control, pressure relief valve, steam pressure gage, and pulsation dampener. Provide steam hose 3/4 inch diameter by 50 foot long two wire braid; steam gun easily attached to the hose and equipped with swivel grips.
C. Equip the steam cleaner with an electric motor of adequate size in accordance with Section 15040, “Electrical Requirements of Mechanical Work”.
D. Provide water inlet pipe connection and gas pipe connection of adequate size on the machine. Furnish and install as indicated, a natural gas regulator, designed to provide a seven to nine inch water column gas pressure from a two inch gas pipe.
E. Provide steam cleaner with quality equal to equipment made by the Sioux Corporation, Beresford, South Dakota.

2.4 BOILER AND WATER HEATER FLUE FOR POWER BURNERS

A. Flue system components shall be UL listed for use with building heating equipment as described in NFPA 211.
B. Flue shall be double wall with stainless steel inner wall and aluminized steel outer wall.
2.5 WATER HEATER FLUE FOR ATMOSPHERIC BURNERS

A. Flue shall be double wall with galvanized finish, UL listed Typed B with AGA approved vent cap, roof flashing and storm collar.

2.6 RADIANT HEATING PANELS - ELECTRIC

A. The required panels shall be constructed of a 24 gauge galvanized steel back overlapping and riveted to a 22 gauge galvanized steel front. The panel heating element shall be a carbon (graphite) element. The surface shall be a multifaceted crystalline type which will demonstrate a watt density of 0.72 watts per square foot at a distance of six feet down from the center of the panel, if a low density panel (62.5 watts/sq.ft.) or 1.00 watt per square foot, if a high density panel (95 watts/sq. ft.). The rated input shall be: 62.5 watts/sq.ft. with a surface temperature of not more than 165 degrees F or 95 watts/sq.ft. with a surface panel heating capacity and voltage shall be as scheduled. All panels shall be provided with not less than a ten year warranty.

2.7 RADIANT UNIT HEATERS - GAS FIRED TUBE TYPE

A. The total heating system supplied shall be design certified by the American Gas Association and CSA/AM CSA/ANSI Z83.19.

B. Each burner shall have affixed a name plate that bears the seal of the American Gas Association.

C. Burners shall be designed for firing in tandem without adverse effects from combustion gases from upstream burners.

D. Burners shall be capable of firing without physical changes either propane or natural gas (Dual Fuel).

E. Burners shall be supplied to fire at the input firing rates as shown on the Drawings.

F. The design of the burners supplied shall provide for maintaining a constant proportion of fuel gas to filtered combustion air.

G. To assure a high degree of fail safe operation, the design shall preclude main flow of gas if any or all of the following abnormal conditions occur in the non-firing mode.

1. Main valve fails in open position.
2. Vacuum pump motor fails to operate.
3. Power fails.

H. To further assure a high degree of safety, the system will be under negative pressure at all times during operation to preclude the possibility of the escape of combustion gases inside the building.
HEATING SYSTEMS

U. Burners shall be pre-wired with a three conductor electrical cord and plug with the third wire for ground circuit.

V. Pre-wired system control circuits shall be supplied in a panel box with each vacuum pump. The panel box for the standard burners shall provide relays and terminals to accommodate up to four temperature zones with a thermostat and associated control circuits for the burners for each temperature zone. The panel box and terminals to accommodate up to two temperature zones with a thermostat and associated control circuits for the burners for each temperature zone.

2.8 GAS FIRED FURNACE

A. Furnish and install gas fired furnaces in the location and the capacity as scheduled. Furnace section shall be AGA approved. Furnace shall have efficiency rating of 80 percent, minimum.

B. Fan section shall have forward-curved blades, double-inlet fan mounted on the motor shaft. Fans shall be statically and dynamically balanced and motor shall have permanently lubricated bearings.

C. Casing shall be made of galvanized steel, bonderized and finished with baked enamel.

D. Heat exchanger shall be cold rolled steel and sectional in design.

E. Burners shall be aluminized steel and tapered for even gas distribution; ignition shall be accomplished by means of an electronic ignition system.

F. Cooling coils, when scheduled, shall be nonferrous construction with mechanically bonded smooth plate fins. Tube joints shall be brazed with phosphorus copper or silver alloy.

G. Controls shall include: Gas valve, with 100 percent automatic main burner and pilot shutoff; fan and limit control, prewired indoor fan relay with transformer; and a low-voltage automatic heating/cooling thermostat.

H. Install 1 inch extended surface disposable panel filters with minimum 20 percent efficiency in units and provide to Authority, one complete set of extra filters.

2.9 INFRARED HEATERS - GAS-FIRED CERAMIC

A. Heaters shall be equipped with a 120 volts AC, 60 Hz, single-phase, spark pilot ignition control system. Heaters shall be Design Certified by A.G.A., comply with current OSHA requirements, accepted by FIA/FM and be listed by UL.

B. The heater's combustion surface shall be made of perforated ceramic refractory, shall be capable of operating continuously at 1810 degrees F. and shall withstand thermal shock when water quenched. Heaters shall have secondary radiating surfaces.

C. The manufacturer shall warrant the heater's infrared element assembly for a period of ten years. The secondary radiating surface (rods or screens) shall be warranted for ten years against deterioration and failure, and manufacturer shall warrant its original position from the ceramic by providing a ten year warranty on the (rod or screen) retaining device. Heaters shall operate satisfactorily on natural gas at an inlet pressure of 4 ounces.

2.10 ELECTRIC HEATING COILS, DUCT INSERTION TYPE

A. Heaters shall be slip-in type heaters. Heaters shall be suitable for installation in lined ducts with up to 1 inch of interior insulation.

B. Heaters shall have 80 percent nickel, 20 percent chromium resistance coils, insulated by floating ceramic bushings and supported in aluminized steel frames. Bushings shall be recessed into embossed openings and staked into supporting brackets spaced 3-1/2 inches maximum center-to-center. Coils shall be machine crimped in stainless steel terminals which are insulated with high temperature phenolic bushings.

C. Heaters shall be furnished:

1. With one disk type, automatic reset thermal cutout for primary over-temperature protection. Heaters shall also be furnished with disk type, load-carrying manual reset thermal cutout factory-wired in series with each heater stage for secondary protection. Heat limiters or other fusible over-temperature protection devices shall not be acceptable.

2. At rated voltage indicated on the Electrical Drawings. Internal wiring shall be suitable for 221 degrees F.

3. With thermal cutouts, Mercury contactors and fuses.

D. Provide a differential pressure type airflow switch with each heating coil to verify air flow before energizing coil.

E. Terminal blocks shall be sized for installation of 167 degrees F. copper wire of the appropriate gauge to handle 125 percent of the total heater load.

F. Heaters shall be listed by Underwriters' Laboratories and shall meet the requirements of the National Electrical Code. UL listing shall allow installation with zero clearance to combustible surfaces.
HEATING SYSTEMS

G. Heaters shall be furnished with the following steps of control, unless otherwise noted:

1. Single stage 0-10 kW
2. Two stage 11-20 kW
3. Three stage 21 kW and larger

2.11 ELECTRIC UNIT HEATERS

A. Unit heaters shall have steel housing, adjustable discharge louvers, mounting bracket, fan and motors with guard, enclosed finned tube type heating element, safety controls and wiring per NEC. Provide 24 volt thermostat for remote mounting. Provide capacity as scheduled.

2.12 HOT WATER UNIT HEATERS

A. Unit heaters shall have steel housing, mounting bracket, fan motor, heating coil, safety controls, with control as noted on the schedule or provision for control of fan by a thermostat by controls contractor. Provide capacity as scheduled. Heaters shall be in accordance with ASHRAE standards.

B. Fan shall have aluminum blades, factory balanced.

C. Coils shall be single or multiple circuits, with aluminum fins mechanically bonded to seamless copper tubing. Coils to be tested at 200 psig. Supply and return connections to be threaded steel or malleable iron pipe.

D. Motors shall be totally enclosed, permanent split capacitor type with permanently lubricated bearings.

E. Louver diffuser shall be adjustable steel blades held in set position by spring steel clips.

2.13 GRAVITY VENTED GAS-FIRED UNIT HEATERS

A. Provide natural gas fired unit heater(s) of the capacity as scheduled.

B. Heat exchanger shall be aluminized steel, die-formed burners shall be of same construction, with stainless steel inserts.

C. Unit shall have combination redundant gas valve with intermittent spark pilot and electronic flame supervision with timed lockout. Unit shall bear AGA and UL label.

D. Units shall have propeller fan and motor with internal overload and safety fan guard.

E. Horizontal and vertical louvers shall be provided for directing air flow.

F. The unit must be arranged for ceiling suspension with threaded hanger connections and provided with hanger kits.

G. The unit shall be constructed of cold-rolled steel and finished with bake-on enamel.

2.14 SEPARATED COMBUSTION GAS-FIRED UNIT HEATERS

A. Provide high-efficiency, separated combustion, gas-fired unit heaters of the capacity as scheduled with a factory-supplied vertical vent terminal assembly. The vent terminal assembly shall be arranged to provide preheating of the combustion supply air and to allow a single wall or roof penetration.

B. Each unit shall be equipped for use with natural gas. The heat exchanger shall be of aluminized steel and include burner air shutters and a stainless steel insert.

C. Unit shall have combination redundant gas valve with intermittent spark pilot and electronic flame supervision with timed lockout. Unit shall bear AGA and UL label.

D. Units shall have propeller fan and motor with internal overload and safety fan guard.

E. Horizontal and vertical louvers shall be provided for directing air flow.

F. The unit must be arranged for ceiling suspension with threaded hanger connections and provided with hanger kits.

G. The cabinet shall be constructed of cold-rolled steel and finished with baked-on enamel.

H. Provide factory furnished single stage thermostat.

I. Gas-fired unit heaters must bear the AGA label.

2.15 SEPARATED COMBUSTION GAS-FIRED DUCT FURNACE

A. Provide high-efficiency, separated combustion, gas-fired duct furnaces of the capacity as scheduled.

B. The combustion air supply pipe and flue exhaust pipe shall be run parallel to a factory-supplied horizontal or vertical vent terminal assembly. The vent terminal assembly shall be arranged to provide preheating of the combustion supply air and to allow a single wall of roof penetration.

C. Each unit shall be equipped for use with natural gas. The heat exchanger shall be of aluminized steel and include burner air shutters and a stainless steel insert.

D. The unit shall be provided with a 24 volt control transformer, a single-stage electronic modulation with ductstat and remote set-point adjustment gas control system with a regulated combination redundant gas valve and an intermittent spark pilot with electronic flame supervision and timed lockout. Also provide all limit and safety controls, including a
combustion air pressure differential switch to verify proper vent flow before allowing operation of the gas valve.

2.16 BASEBOARD HEATERS

A. Furnish heating unit assemblies consisting of a minimum 14 gauge, two side, aluminum cabinet with a minimum 14 gauge extruded bar-type louvers for intake air at the front or bottom and discharge air at the top.

B. Ensure that the heating element and wiring is accessible from the front cabinet by the removal of a minimum 14 gauge front assembly. Secure the front cover to the cabinet by tamperproof locking devices. Furnish front covers without visible screws.

C. Where cabinets are to be installed continuously from end to end, ensure that they form neat, butt joints and that they are fastened to each other internally by the use of screw-type fasteners.

D. Furnish heaters with an aluminum tube and fin element assembly for corrosion resistance and with full thermal overheating protection. Provide elements free to expand without objectionable noises.

E. Furnish the heating element and enclosure protected from overheating by a linear type high temperature limit switch, with automatic reset. Locate switch in the heater cabinet. Provide high temperature type wiring, suitable for the wattage capacity of the unit. Wire the heating element in series with high temperature limit switch and terminate wires at each end of the cabinet.

F. Factory wire the heaters at each cabinet to permit easy field power wiring from either end of the cabinet. When cabinets are installed end to end, provide for possible field interconnecting adjacent cabinets through a chase nipple supplied with each cabinet. Provide for possible interconnection of up to 30 ampere branches in any individual heater. Furnish individual heaters available for single-phase electrical supply.

G. Accessories to include: end caps; inside and outside corner pieces; sleeves; blank sections; conduit risers; and control sections.

H. Control sections with factory mounted and wired components consisting of:

1. Mechanical contactors rated at the proper value for the heater (silent operating relays optional).

I. Integral Thermostats and Disconnect Switches: Factory installed in the individual heaters. Provide for tamperproof setting of the thermostat, with access to the thermostat accomplished through the discharge grille at the top of the heater.

J. Provide UL approved and listed components and heating assemblies.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed in accordance with the manufacturer's recommendations.

3.2 EQUIPMENT START-UP

A. Prior to operation, the factory start-up representative shall, in the presence of the Contracting Officer, perform system and equipment checks for electrical and gas-fired boilers as prescribed by the manufacturer in his written start-up procedures.

B. The factory authorized start-up representative shall place the equipment in operation and record all start-up data. Three copies of data shall be given to the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15600
SECTION 15780
SELF-CONTAINED AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the furnishing and installing of self-contained air conditioning units and supporting devices as shown on the drawings and/or specified herein.

1.2 REFERENCED STANDARDS
A. Air-Conditioning And Refrigeration Institute (ARI):
   1. ARI 270 - Sound Rating of Outdoor Unitary Equipment

B. American Society of Heating, Refrigeration & AC Engineers (ASHRAE):

C. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

1.3 SUBMITTALS
A. Certification.
B. Shop Drawings.
C. Test Reports.
D. Product Data: Design Data and Calculations.
E. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General".
F. Performance Statement: From the Manufacturer submit EER (Energy Efficiency Rating) or C.O.P. (Coefficient of Performance) in accordance with ARI applicable standards.

1.4 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001 "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with NEC, ASHRAE, and all other applicable standards.
B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of industrial-grade equipment of the type specified herein.

2. Equipment: Provide that the equipment incorporated into the work essentially duplicates equipment that has been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

C. Source Quality Control: Factory testing of assembled unit for capacity, control sequencing, and performance as specified on drawings.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Keep the inlet and discharge openings of units covered until the units are ready to run.
B. During the construction store and protect ductwork, piping and equipment from dirt and damage. Temporarily cap the open top of ductwork and piping installed vertically.

1.6 WARRANTY
A. Guarantee mechanical equipment and workmanship for a period of one year in accordance with the warranty clause of the GENERAL PROVISIONS.

PART 2 - PRODUCTS

2.1 ROOFTOP AIR CONDITIONING UNIT
A. Furnish and install a self-contained single package air conditioning unit as scheduled. The unit shall be completely factory assembled and tested and shall include hermetic compressor, condenser coil, evaporator coil, fans and motors, heating section (if scheduled) interconnecting wiring, low voltage control transformer, prewired control panel and other necessary components mounted in weather-resistant steel cabinet with baked-on enamel finish. The unit shall be A.G.A. listed and labeled accordingly. Units shall be ARI certified and listed. Unit shall be noise rated per ARI 270. Unit shall have a minimum E.E.R. in accordance with ASHRAE 90.1 I-P.

B. Compressor System: The unit shall contain a hermetic compressor. The compressor shall have a high and low pressure protection, sump heat and internal line break overload protection. Refrigerant circuit shall include service pressure tap ports, refrigerant liquid line filter-dryer and factory furnished operating charge of R-22. Compressor shall be designed, manufactured and warranted by the air conditioning unit manufacturer for a minimum of five years. Provide units with compressor short-cycling protection.
C. Condenser Section: The condenser (outdoor) coils shall be constructed of aluminum plate fins mechanically bonded to seamless refrigerant tubes. There shall be single speed, direct drive, vertical air discharge outdoor fans. Unit shall, as factory shipped, cycle one fan motor on outdoor thermostat for low ambient cooling down of 20 deg. F outdoor temperature.

D. Evaporator Section: The evaporator (indoor) coil shall be constructed of plate fins mechanically bonded to seamless refrigerant tubes. The evaporator coil shall have expansion valve refrigerant control and be equipped with evaporator defrost control. Evaporator (indoor) fan shall be of the centrifugal type forward curved and shall be driven by a belt drive, adjustable pulley and motor.

E. Electric Heating Section: Electric heat (if scheduled on Contract Drawings) shall be provided by electric heat modules for installation within basic unit and be UL approved. Provide nickel chromium elements. Each heater shall have its own line break high limit control. Each heater package shall have automatic reset high limit control. Heaters shall be individually fused from the factory when required, and meet NEC requirements. Provide assemblies with single-point wiring connection.

F. Gas Heating Section: The unit gas heating exchanger (if scheduled on Contract Drawings) shall be heavy gauge, aluminized steel with stainless steel burner tubes. Combustion blower shall provide positive pressure, forced combustion air with of combustion chamber. Ignition shall be by electronic igniter for direct electric ignition and flame detection. Controls shall include automatic fan and limit controls and two stage gas valve.

G. Roof Curb: Shall be 8 inch factory fabricated, aluminum, insulated unit.

H. Duct Hood shall be completely factory assembled, lined with 1 inch insulation and have baked enamel finish to match unit. Duct hood shall include filter racks and section for easy installation of 0-25 percent fresh air damper kit.

I. Manual 0-25 percent Make-Up Air Damper: Shall be provided (if used) for installation in duct hood. Kit shall consist of one damper assembly, bug screen and rain hood.

J. Provide factory furnished economizer cycle components and controls to operate as a fully integrated economizer cycle.

K. Provide programmable thermostat assembly with clear plastic locking cover. Assembly shall provide staged heating and cooling with:
   1. Two programmable energy saving periods available each 24 hours.
   2. Seven day programmable.

3. Occupied and unoccupied dual setpoints.

4. Automatic heat/cool change over.

5. Digital clock.


7. Function LCD’s.

8. Subbase compatible with units furnished.

9. Provide remote sensor, as located on the Contract Drawings, for thermostat.

L. Install with 1 inch extended surface disposable filters with 20 percent minimum efficiency in unit and provide to the Contracting Officer, one complete set of extra filters.

M. Install duct type smoke detectors per NFPA 90A, 4.3 in units of 15,000 cfm or greater. Install a detector in the supply air stream of RACU’s of less than 15,000 cfm capacity. Detector is furnished and wired by Division 16, “ELECTRICAL”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed as shown or indicated on the Drawings and as recommended by the manufacturer.

3.2 EQUIPMENT START-UP

A. Provide start-up service by factory certified technician.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15780
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the furnishing and installing of self-contained air to air heat pumps and supporting devices as shown.

1.2 REFERENCED STANDARDS
A. American Society of Heating, Refrigeration & Air-Conditioning Engineers (ASHRAE):
   1. ASHRAE 15 – Refrigeration.
   2. ASHRAE/IESNA 99.1 – Minimum COP/Efficiency Levels.
B. Underwriters Laboratory (UL):
   1. UL 484 – Room Air Conditioners.

1.3 SUBMITTALS
A. Shop Drawings.
B. Product Data.
C. Certification.
D. Test Reports.
E. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General".

1.4 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply UL, ASHRAE, and other applicable standards.
B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of industrial-grade equipment of the type specified herein.
   2. Equipment: The equipment incorporated into the work shall essentially duplicate equipment that has been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. The inlet and discharge openings of all units shall be kept covered until the units are ready to run.
B. Store and protect ductwork, piping, and equipment from the dirt and damage prior to and during erection. Cap the open top of ductwork and piping installed vertically.

1.6 WARRANTY
A. Provide a parts and labor warranty for a period of four years on compressors in addition to the 1 year requirements of the General Provisions for a total of five years.

PART 2 - PRODUCTS

2.1 SINGLE PACKAGE UNITS
A. Cabinets: Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a baked enamel finish. Cabinet interior shall be insulated with one-inch thick neoprene coated fiberglass. Cabinet panels shall be easily removable for service to all operating components. A condensate drain for the cooling coil shall be provided.

B. Controls:
   1. Protect the heat pump cooling/heating system with high pressure-stat, low pressure-stats, loss-of-charge protection, indoor coil freezestats, and current and temperature sensitive overload devices.
   2. Wire each of these devices through the control circuit to prevent compressor restart until reset at the thermostat. The standard room thermostat to contain a COMPRESSOR MALFUNCTION LIGHT designed to illuminate if any of the before mentioned safety controls trip out the compressor through the lockout circuit. Units to have separate and independent refrigeration and control systems designed to allow for standby operation of either compressor if one is locked out.
   3. Units to have 2-stage compressor heat and cool with built-in electric strip heat lockout to prevent resistance heat operation above 40 deg. F ambient, except in emergency situations.
C. Defrost Control: Incorporate an outdoor coil defrost control system into the base unit to prevent frost accumulation during heating cycle. The defrost cycle to function on the basis of time and coil temperature. Provide a 90 minute timer to actuate a defrost mode only if coil temperature is low enough to indicate a heavy frost condition. Defrost to have a positive termination time of a maximum of 10 minutes, or when the defrost thermostat is satisfied, to prevent prolonged operation on a defrost cycle. Electric resistance heaters to operate automatically during the defrost cycle.

D. Unit Electrical Connections: Provide unit with factory-installed electric heat with single point power connection to a terminal block. Cabinet to contain suitable openings for routing of utility connections. The base unit to contain a terminal strip in the control compartment to allow for terminal-to-terminal connection of room thermostat and field-installed accessories.

E. Roof Curb: Provide roof curb of the same manufacture as unit and include an insulated panel under compressor section to prevent condensation from forming on the bottom. Allow for easy duct location and connection to roof curb prior to unit placement. Roof curb to be a minimum of 14 inches high to allow for proper defrost meltage runoff. Design curb design to comply with National Roofing Contractors Association requirements.

F. Economizer control: Provide economizer control including return air and outside air dampers, outdoor air filter and hood, and fully modulating electric control system with outside air thermostat and adjustable mixed air stat. Economizer control to be capable of introducing up to 100 percent outdoor air. Provide a control changeover from mechanical cooling to economizer operation to be fully automatic through an adjustable outdoor air changeover thermostat.

G. Electric Heaters: Provide electric resistance heaters with 4 selections (low, 0.75:1, 1:1, 1.5:1 heat-to-cool ratio) with open wire nichrome elements for all necessary safety and operating controls. Provide factory installed, UL listed and approved heaters. Units with factory-installed heat to have single power entry by terminal blocks suitable for copper or aluminum wires.

H. Controls Accessories:
1. Provide thermostat assembly to allow staged heating and cooling, manual or automatic changeover and fan control. Standard subbase to include COMPRESSOR MALFUNCTION light designed to illuminate if compressor lockout is activated.
2. Provide emergency heat control consisting of emergency heat control box complete with emergency heat relays and outdoor thermostat(s); and an emergency heat thermostat subbase (with warning light). Control to allow for manual bypass of compressor and outdoor thermostats if compressor becomes inoperative or for service. Subbase light to illuminate if compressor lockout is activated. Provide outdoor thermostats to allow for staging of electric resistance heat according to outdoor temperature. Wire thermostats into the electric heater contactors and have an adjustable set point to provide economical resistance heat staging.
3. Provide remote control panel to allow central unit control of heating, cooling, indoor fan and outdoor air damper. Panel to contain indicator lights for up to 6 unit functions.
4. Provide time Guard circuit to prevent compressor from short cycling as a result of a rapid change in thermostat setting, and to automatically prevent compressor restart at least 5 minutes after shutdown.
5. Head pressure control: Provide a solid-state outdoor fan speed control to maintain head pressure control down to design outside air temperature on cooling cycle.

I. Install duct type smoke detectors per NFPA 90A, 4.3 in units of 15,000 cfm or greater. Install a detector in the supply air stream of HP's of less than 15,000 cfm capacity. Detector is furnished and wired by Division 16, "ELECTRICAL".

J. SCADA Alarm Contacts: Provide two sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the pump controller. The normally open contacts to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:
1. Compressor malfunction alarm.
2. Emergency heat alarm.
3. Heat pump unit failure alarm.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install in accordance with manufacturer's printed recommendations, and referenced standards and details shown on drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. In accordance with Section 15001, "Mechanical Systems - General".

END OF SECTION 15840
PART 1 - GENERAL

1.1 DESCRIPTION

A. The work specified under this section consist of the furnishing and installing of air handling units (factory assembled), cooling and heating coils, fan coil units, air curtains, filters, relief and intake hoods, and supporting devices.

B. Variable speed drives/controllers are specified in Section 15040, "Electrical Requirements of Mechanical Work".

1.2 REFERENCED STANDARDS

A. Air-Conditioning and Refrigeration Institute (ARI):
   1. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
   2. ARI 430 - Central Station Air-Handling Units

B. American Society of Heating, Refrigeration & AC Engineers (ASHRAE):
   1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

C. National Fire Protection Association (NFPA):
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems

D. Air Movement & Control Association (AMCA):
   1. AMCA 210 – Laboratory Methods of Testing Fans for Rating.
   3. AMCA 301 – Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

1.3 SUBMITTALS

A. Shop Drawings.

B. Certification.

C. Test Reports.

D. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General".

E. Product Data: Catalog Cuts.

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with UL, ASHRAE, NFPA, and other applicable standards.

B. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of industrial grade equipment of the type specified herein.
   2. Equipment: Incorporate equipment into the work which essentially duplicates equipment that has been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Keep the inlet and discharge openings of all units covered until the units are ready to run.

B. Store and protect ductwork, piping, and equipment from dirt and damage prior to and during erection. Temporarily cap the open top of all ductwork and piping installed vertically.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNITS; FACTORY ASSEMBLED

A. Units shall be furnished complete with water coils as scheduled, centrifugal fan, adjustable V-belt drive, insulated drain pan extending under the complete fan and coil section, and filter boxes. Fans shall be AMCA rated and units shall be rated in accordance with ARI 430.

B. Unit casings shall be 18 gauge minimum with removable panels or access panels. All sheets shall be provided with an approved rust resisting finish on all interior and exterior surfaces. Casing shall be reinforced with heavy welded structural steel framework. Casings shall have 1 inch mineral fiberglass insulation.

C. Filter box sections shall be serviceable from either side or from the top or bottom as required by access restrictions.
D. Fans shall be double-inlet multi-blade centrifugal type. Fan shaft shall be supported by a minimum of two bearings of self-aligning type. Exposed drives shall have belt guard.

E. Each fan shall be dynamically balanced and run tested while installed in fan casing. Fans shall not pass through their first critical speed at any cataloged rpm.

F. Bearings shall be provided with extended tubing to grease fittings.

G. Coils shall be as specified within and shall be easily removed from the unit. When the air handling unit employs two or more stacked cooling coils, the upper coil shall be provided with a drain channel to prevent condensation runoff from the upper coil from passing through lower coil air stream.

H. Draw-Through and Blow-Through Units:
   1. Units shall be standard cataloged, sectional air handling units of the vertical or horizontal type as indicated, complete with coils as scheduled. Components shall be as specified above.
   2. Variable air volume units shall be provided with a variable frequency drive as specified below.
   3. Multizone units shall be furnished with low leakage zone damper assemblies. Actuators shall be by controls contractor.

2.2 HOT WATER COILS

A. Tubes: Seamless deoxidized round copper tubes, minimum 0.025 inch thick wall; provide connections on the same end. Expand tubes into fin collars for permanent fin-tube bond and expand into header for permanent leak proof joints. Circuit tubes for maximum water velocity of six feet per second and maximum pressure drop of 15 feet water gauge (6.491 psi).

B. Fins: Continuous aluminum or copper, configured plate fin type with full fin collars for accurate spacing and maximum fin-tube contact. Space fins not closer than 8 per inch of tube.

C. Headers: Round seamless copper tubes or close-grained cast iron; designed with continuous circuits from inlet header to outlet header, self venting type. Inlet and outlet headers internally threaded for direct pipe connections. Headers removable bolted to flat steel plates and gasketed. Tubes rolled into steel plates and headers to form permanent pressure tight mechanical joints.

D. Casing: Continuous zinc-coated, rust resistant steel, 16 gauge for width up to 33 inches and 14 gauge for width of more than 33 inches, with formed end supports, and top and bottom channels. Furnish casing for coils mounted inside duct where shown.

E. U-Bends: Round seamless copper tubes, machine die-formed on each end to provide accurate fit. Mount coils for counter-flow service.

F. Testing: Proof test each coil at 300 psig and leak test at 200 psig air under water. Certify water coil capacities, pressure drop and selection procedures in accordance with ARI 410.

G. Capacity: Cooling capacity of each coil as scheduled.

2.4 DIRECT EXPANSION COILS

A. Tubes: Seamless deoxidized copper tubes, minimum 0.025 inch thick wall, arranged in parallel pattern with respect to maximum air velocity of 550 fpm through coil face.
B. Fins: Continuous copper or aluminum, plate type producing identical capacities. Fins either mechanically bonded or soldered to tubes for lasting reliability. Fins spaced not closer than 8 per inch of tube.

C. Headers: The refrigerant distributor of Venturi type of low pressure drop design, arranged for down feed with male sweat connections. Provide two distributors when more than 12 circuits are required or for the system requiring a split evaporator. Suction headers of either seamless copper or brass tubes. Distributors of either seamless copper or brass tubes.

D. Casing: Continuous zinc-coated, rust resistant steel, 16 gauge for coil width up to 33 inches and 14 gauge for coil width of more than 33 inches; with formed end supports, and top and bottom channels. Furnish casing for coils mounted inside duct where shown.

E. U-Bends: Round seamless copper tubes, machine die-formed on each end to provide accurate fit.

F. Testing: Proof test each coil at 300 psig and leak test at 200 psig air under water. Certify coil capacities, pressure drop and selection procedure in accordance with ARI 410.

G. Capacity: Cooling capacity of each coil as scheduled.

2.5 ELECTRIC HEATING COILS

A. Casings:

1. Frame members, casings, terminal box, terminal box cover and similar sheet metal parts fabricated of minimum 18 gauge, die-formed steel with integral corrosion-resistant coating.

2. Casing assembled into rigid structure by means of welding or threaded fastenings.

3. Flanged-in-line heater for inclusion in duct or ventilating unit.

B. Coil section panels factory-insulated.

C. Heating element:

1. Heating elements composed of individual flange-mounted finned tube heating elements with nickel-chromium alloy resistor wire centered within tubes and embedded in compacted insulating material.

2. Flanges and fins permanently furnace-brazed to elements for rigid support and rapid heat transfer.

3. Finned tubes of copper-plated or ceramic-coated steel.

2.6 FAN COIL UNITS

A. Each unit shall be complete with casing, coils, fan, drive, motor and filter section.

B. Motors shall be 3-speed, tap wound type with thermal overload protection. Motor bearings shall be of the sleeve type with oil tubes and oil reservoirs. Permanent split capacitor motors shall be provided.

C. Fans shall be centrifugal, forward curved type. Fan wheels shall be statically and dynamically balanced. Fan wheels and housing shall be steel.

D. Units shall have drain pans lined with 1/2 inch fire retardant closed cell foam.

E. Cabinet shall be of 18 gauge galvanized steel acoustically and thermally insulated with 1/2 inch coated glass fiber insulation. Panels shall be removable for access.

F. Units shall be provided with necessary transformers and wiring to allow single point electrical connection.

G. Install duct type smoke detectors per NFPA 90A, 4.3 in units of 15,000 cfm or greater. Install a detector in the supply air stream of FCU's of less than 15,000 cfm capacity. Detector is furnished and wired by Division 16, “ELECTRICAL”.

4. Ceramic coating suitable to be fired at minimum of 1,500 deg. F and capable of continuous resistance to corrosion without cracking, checking, or spalling under operating conditions.

D. Controls:

1. In accordance with Section 15950, “Control Equipment”, with the following additional requirements:

a. Heaters provided with built-in step controllers.

b. Heaters of 30 KW or less with manufacturer's standard steps.

c. Heaters larger than 30 KW having six equal steps.

d. An automatic reset snap-action thermal overheat switch provided to instantly de-energize heating coil when safe operating temperatures are exceeded.

e. Heating coil interlocked with fan to prevent energization of heating coil while fan is not running.
2.7 AIR CURTAINS

A. Provide a self-contained unit, direct fired automatically controlled heater having an air handling capacity as schedule. Provide for ambient air at 70 degrees F delivered against an external static pressure as shown by gauge. Provide an automatically controlled air damper to prevent the flow of air through the unit during non-operating periods. Provide fan of the double width, double inlet centrifugal type, belt driven on a shaft designed to place the first critical speed at 125 percent or more above maximum rpm.

B. Design unit for use with natural gas as a fuel delivered to the unit. Provide the burner of the nozzle mixing type using no other air than that delivered by the main blowers to effect complete combustion of the fuel. Provide a burner capable of a 30:1 turndown ratio and gas pilot ignited at all input rates. Design the unit for a temperature rise through the unit of 50 degrees F with an outside design temperature of 18 degrees F. Provide the unit with a remote operating panel.

C. Integrate the control system to provide all functions listed below. Complete all wiring at the factory except the wiring to the remote control panel. Mount and wire all controls. The control system to include the following:

1. Furnish remote, panel mounted, Selector Switch to provide selection of VENT, OFF and HEAT operation.

2. Provide remote, panel mounted, Indicating Light to indicate operation of FAN, HEAT and ALARM.

3. Furnish Air Flow Sensing Switch and Blower Motor Starter interlock to prove air flow through unit, prior to, and during burning operation.

4. Provide rectification type of flame safety control with spark glow plug gas pilot ignition of the main flame.

5. Design for Outside Air Thermostat to start burner when outside temperature drops below set point.


7. Provide Modulating Gas Valve to maintain discharge air temperature by varying the burner firing rate through its 30:1 turndown range.

8. Provide Main and Pilot Gas Controls including manual shutoff valves, main and pilot gas pressure regulators, pilot solenoid valve, main gas valve, and high and low gas pressure switches.

9. Furnish and install starters, overloads, and control circuit fuse.

10. Accessories: Provide main power disconnect switch, IRI controls, filters, control transformer, weatherproofing, air nozzles, intake hoods, and high gas pressure regulator.

2.8 FILTERS

A. Air filters for air handlers shall be 2 inches, medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton fabric media, media support grid and enclosing frame. Filters shall be installed in the factory fabricated boxes furnished by the unit manufacturer. In each unit there shall be the size and number of filters that are standard with the manufacturer for that size unit and of the thickness specified.

B. Filter media shall be of the non-woven cotton fabric type and shall be reinforced by a woven scrim backing.

C. The filter media shall have an average efficiency of 30-35 percent an average arrestance of not less than 92 percent in accordance with ASHRAE 52.1. The filter shall be listed by Underwriters' Laboratories as Class 2.

D. The effective filter media shall be not less than 4.5 square feet of media per 1.0 square feet of filter face area and shall contain not less than 16 pleates per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed .30 inches w.g.

E. Filters for fan coil units and other air moving equipment, except fan powered boxes, shall be 1 inch thick throwaway fiberglass media type.

F. Filters shall be installed in the factory fabricated boxes furnished by the unit manufacturer. In each unit there shall be the size and number of filters that are standard with the manufacturer for that size unit and of the thickness specified.

G. At the time of construction and until final acceptance by the Contracting Officer, filter sections shall be loaded with filters to fully protect all coils and air distribution systems from dirt and debris, roll media prefilters may be used to protect the unit filters during the construction period. Also, replace such filters as directed by the Contracting Officer during construction period. Provide clean specified filters for final acceptance at a time as directed by the Contracting Officer and remove all used filter media from premises.

2.9 INTAKE/RELIEF HOOD

A. Penthouse shall be extruded aluminum ventilator with welded construction. Ventilator top shall have an anti-condensate insulative coating, and be removable from the exterior. Birdscreen shall be provided on all openings.
B. Provide 8 inch factory fabricated, aluminum, insulated curb.

C. Each roof mounted intake or relief hood shall be provided with a motorized, low leakage, control quality damper, as specified and furnished under Section 15950, “Control Equipment”.

2.10 DRAIN PAN

A. Provide a secondary drain pan under air handler condensate pans and surfaces subject to sweating. Pipe the drain to a point where its discharge can be observed without causing damage. Comply with applicable codes and ordinances.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed as shown or indicated on the drawings and in accordance with the recommendations of the manufacturer.

3.2 VAV AIR HANDLERS

A. Mount the speed control panel near the AHU in such a location that will allow the manual adjustment of the fan speed at the panel while observing the fan pulley.

B. Install the duct static pressure sensor approximately 2/3 distant from the AHU and 15 feet away from any turn or upstream transition.

C. Install fan speed control components as recommended by the manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15850
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the manufacture, testing, delivery, installation, and lubrication of all axial-flow and centrifugal fans except those for cooling towers, furnaces, and fan coil units.

1.2 REFERENCE STANDARDS

A. Air Movement and Control Association (AMCA):

1. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
2. AMCA 300 - Reverberant Room Method of Sound Testing of Fans.
3. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

1.3 SUBMITTALS

A. Shop Drawings.
B. Product Data.
C. Certified Test Results:
   1. Required for each fan type and diameter above 5,000 cfm.
   2. Notify the Contracting Officer of the factory test date not less than 21 calendar days prior to the factory test.
   3. Furnish three certified and two uncertified copies of each test result to the Contracting Officer within 10 calendar days of the completion of the tests, stating the test standard used and that the test has been carried out in accordance with that standard. Provide copies of the raw test data to the Contracting Officer as requested.
   4. Do not ship fan until test results are accepted by the Contracting Officer.
   5. Previous certified test results of similar fans, will be accepted by the Contracting Officer in lieu of new tests, providing that:
      a. The casing diameter is the same,
      b. The hub and blading configuration are identical,
      c. The rpm and operational modes are same, and
      d. Both the fan capacity and the total pressure of the fan previously tested are equal to or greater than those required for the project fan.

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the contracting officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with all applicable standards.

B. Factory Standards: Test factory fan performance in accordance with AMCA 210, 300 and 301, except as noted herein:

C. Factory Testing:
   1. Plot a minimum of eight points on each performance curve. Include plots for fan total pressure, fan static pressure, efficiency and input power required as a function of flow rate. Plot the curves from zero airflow (shutoff) to free delivery. Plot the forward flow mode of operation. If the fan is reversible, plot the reverse flow mode of operation.
   2. Develop and provide this performance data for fan blade angles two and four degrees greater than and two and four degrees less than the design point fan blade angle.
   3. Present results in inch-pound units, referenced to an air density of 0.075 lb/cu.ft.
   4. Fan speed within five percent of that of the actual fan application.
   5. Conduct performance tests for one typical fan of each type and diameter. Test the fan which requires the greatest input power and current plotted as a function of airflow delivered. The selection of the fans to be tested is subject to the approval of the Contracting Officer.
   6. Make certified Sound Power Level measurements at the design operating points (all modes of operation) for each fan tested. For all fans except propeller fans,
take measurements in decibels based on 10 to 12 watts for the following octave bands:

<table>
<thead>
<tr>
<th>Band Number</th>
<th>Center Frequency (Hz)</th>
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<tbody>
<tr>
<td>1</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>125</td>
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<td>3</td>
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<td>7</td>
<td>4000</td>
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<tr>
<td>8</td>
<td>8000</td>
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7. Fans tested: (1) equal or exceed the pressure versus capacity requirements shown on the drawings; (2) will not exceed the operating point input power requirements or the operating point sound power levels shown on the drawings.

D. Experience:

1. Manufacturer: Select a firm regularly engaged in the manufacture of industrial-grade fans of the type specified herein.

2. Equipment: Incorporate into the work fans that essentially duplicate fans that have been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Keep the inlet and discharge openings of all fans, and other terminal units covered until the units are ready to run.

B. During the erection, store and protect ductwork, piping, and equipment from dirt and damage. Cap the open top of all ductwork and piping.

1.6 JOB CONDITIONS

A. Safety Requirements: Properly guard belts, pulleys, chains, gears, couplings, projecting set screws, keys, and other rotating parts to prevent danger to personnel.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Nameplates:

1. Attach nameplates to each fan showing the following:
   a. Manufacturer's Name.
   b. Model Number.
   c. Serial Number.
   d. Fan rpm.
   e. Nominal Airflow (cfm) and Total Pressure (in. wg).
   f. Motor kW.
   g. Number of Phases.
   h. Rated Voltage.
   i. Frequency.
   j. Phase Current or Power Factor.

2. Provide the nameplate in a conspicuous location for convenient maintenance access.

B. Indicate the forward direction of operation of the fan on the nameplate or by painting it on the outside of the fan housing in a location that provides convenient maintenance access.

C. Finishes:

1. Standard Finishes: Supply fans and appurtenances having a factory applied zinc-rich primer and two finish coats of baked enamel providing a total dry film thickness (DFT) of at least 0.006 inch applied in accordance with the shop painting procedures in Section 05120, "Structural Steel - Bridges".

2. High temperature finish: Tunnel ventilation fans having a factory-applied cured silicone-acrylic enamel over zinc-rich primer providing a DFT of at least 0.004 inch applied in accordance with the shop painting procedure in Section 05120, "Structural Steel - Bridges".

2.2 AXIAL FLOW FANS (EXCLUDING PROPELLER FANS)

A. Whirl-test all axial flow fans having a diameter greater than or equal to 24 inches at 125 percent of maximum rated RPM for 3 minutes duration.

B. Design, test and certify fans to have operating characteristics which enable them to pass between zero air delivery and the specified delivery in either direction without appreciable increase in the specified amplitude of vibration, or damage to the fan assembly or any component thereof for the layouts, ducting and fan arrangements shown on the drawings.
C. Weld end flanges continuously around the entire periphery of the fan housing or roll directly from the fan housing. Provide end flanges with bolt holes for bolting to a transition or inlet bell.

D. Manufacture housings to provide true circular sections, with joints continuously welded.

E. For fans having a diameter greater than 18 inches provide a tapped drain fitting at the low point of the fan housing.

F. Provide lifting eyes of the fan housing and motor.

G. Provide bolts, nuts, and washers of high strength steel with cadmium plating.

H. Fabricate fan hubs from high strength, heat treated aluminum alloy or ferrous metal.

I. Provide fan blades of high strength aluminum alloy or ferrous metal, suitable airfoil configuration and accurately fitted to fan hub and securely held in position by a positive means. The means of securing the blades shall not be subject to loosening due to torque, vibration or operational stresses.

J. Provide all fans having a diameter greater than or equal to 24 inches with manually adjustable blades. Adjust the blades without removing the impeller from the fan and measure the blade angle settings by either index marks on the blades and hubs or templates. The gradation of the blade angle adjustment not to exceed a maximum of two degrees. If index marks are used, do not stamp or engrave them on a high-stress area of the blade or hub. If templates are used, provide two metal or durable plastic templates for each size and type of fan. Provide a minimum of seven blade angle settings with at least two of these on either side of the design blade angle.

K. Provide direct drive fans. Attach rotor to the motor shaft extension by means of a zero-clearance key and a positive locking device to ensure it will not loosen during operation.

L. Dynamically balance the fan rotating assembly to peak-to-peak vibration amplitude less than 0.0016 inch at the motor shaft when operating at the specified rotational speeds.

M. Totally enclose motor and impeller within the fan housing so as not to protrude at either end of the housing, exclusive of attached end bells or transitions.

N. Design fan bearings for a L50 life of 200,000 hours or a L10 life of 40,000 hours, as defined by the Anti-Friction Bearing Manufacturers Association.

O. Use 15 seconds or less for fan start-up time.

P. The Tunnel Ventilation Fan shall meet the following requirements:

1. Provide reversible fans with a reverse capacity not less than 90 percent of the forward capacity and capable of reversing from full speed forward to full speed reverse and vice versa within 45 seconds.

2. Perform reversibility tests for each size of reversible fan. Demonstrate that the fan can operate for four full reversals during a 10 minute period from full speed forward to full speed reverse and vice versa within 45 seconds, with 300 deg. F air flowing through the fan having a density of not be less than 0.045 lbs. per cu. ft.

3. Perform a high-temperature test for each size of fan. Demonstrate that the fan can operate for one hour with 300 deg. F air flowing through it, having a density of not be less than 0.045 lbs. per cu. ft.

4. Ensure that fans, motors and cables will not suffer mechanical, electrical, or structural failure when operating at full capacity at an ambient air temperature of 300 deg. F for one hour. Certify that the design meets this requirement.

5. Provide adequate clearance between blade tips and housing at points to allow for expansion and contraction over a temperature range of from 0 deg. F to 300 deg. F without developing interference. Show the clearance on the shop drawings at 0 deg. F and 300 deg. F as well as any point of minimum clearance in between.

6. Integrate weld guide vanes to the fan housing or vane section. Locate on the discharge side of the impeller to straighten the flow of the air leaving the blades. If the manufacturer can demonstrate that guide vanes do not increase the efficiency of the fan, then guide vanes are not required.

2.3 PROPELLER FANS

A. Provide fans of the sizes, capacities, and with the accessories as scheduled.

B. Direct-drive or belt-driven fans.

C. Fan wheels shall have steel or aluminum blades; statically and dynamically balanced at the factory to operate within the stable range on its performance curbs.
D. Fans shall be provided with fan guards.
E. Wall mounted fans shall be provided with wall collars and backdraft dampers, unless otherwise indicated.
F. Fans shall carry the certified rating seal authorized by AMCA.

2.4 CENTRIFUGAL FANS
A. Fan shall carry the certified rating seal authorized by AMCA.
B. Provide regreasable antifriction bearings with readily accessible inlet fittings and outlet plugs for in service grease metering and protection against over greasing.
C. Dynamically balance all fans to an amplitude of less than 0.0016 inches at the fan shaft when operating at required speeds.
D. V-belt drives:
   1. Provide with belt tension adjustment devices.
   2. Provide guards.
   3. Furnish adjustable sheaves on motor allowing a plus or minus 20 percent adjustment in fan speed, with design capacity setting at approximately midpoint of adjustment.
E. Provide spark-proof motors on battery room fans.
F. Provide fans with a backward inclined airfoil blade and a non-overloading characteristic.
G. Split housings to facilitate assembly and disassembly of fans having an impeller diameter greater than 48 inches.
H. Fans having an impeller diameter less than 12 inches or utility fans having a total pressure requirement less than 0.75 inch WG may have forward curved blades, providing the fan motor is selected to prevent overloading.
I. Design fan bearings for a L50 life of 200,000 hours or a L10 life of 40,000 hours, as defined by the Anti-Friction Bearing Manufacturers Association. As the basis of design use maximum radial and thrust loads anticipated for the application.
J. Provide smoke extract fans capable of operating with an inlet air temperature of 300 deg. F for two hours.

K. Either test one smoke extract fan to confirm 300 deg F operation for two hours or provide previous certified test results.

2.5 TUBULAR CENTRIFUGAL FANS
A. Housing: Manufacturer's standard heavy-gauge steel construction.
   1. Flanged inlet and outlet for connection to ductwork, with inlet and outlet identical in size.
   2. Welded, cylindrical construction, braced to prevent vibration.
   3. Fan bearings and drive enclosed and isolated from airstream.
B. Fan wheels:
   1. Welded construction, centrifugal wheel, with backward inclined blades.
   2. Fan wheels 27 inches in diameter or larger supplied with double thickness, air foil blades.
   3. Fan wheels less than 27 inches in diameter supplied with plate-type blades.
   4. Fan wheels statically and dynamically balanced.
C. Fans supplied with stationary conversion vanes on discharge side of wheel designed to reduce turbulence.
D. Fan shaft accurately machined and ground for proper fit to wheel hub and bearing and designed to operate well below first critical speed.
E. Fan driven by V-belt rated at 150 percent of driving motor brake horsepower. Adjustable sheaves furnished on motor allowing 20 percent adjustment in fan speed, with design capacity setting at approximately midpoint of adjustment.
F. Fan wheels and sheaves splined or keyed and fastened to the shaft with set screws.
G. Internal and exterior belt guards as necessary for complete protection.

2.6 LUBRICATION LINES AND LUBRICANTS
A. Lubrication Lines: High tensile strength, seamless metallic tubing.
B. Lubricants: Type recommended by the bearing or motor manufacturer.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Fit fans and appurtenances within space provided and make readily accessible.

B. Provide support beams, concrete pads, support legs, platforms, hangers, and anchor bolts required for proper installation of equipment as recommended by the manufacturer.

3.2 LUBRICATION LINES AND LUBRICATION

A. Bring lubrication lines from each bearing to fittings located on the exterior of the fan housing. Fabricate the lines of high tensile strength, seamless metallic tubing. Do not crush or score the tubing during installation and do not allow lines to be installed with kinks or sharp bends. Where the lines penetrate the fan housings, rigidly secure lines to the housings in a secure manner, so as to prevent vibration of the lines and the leakage of air. Terminate grease-supply lines in straight lubrication fittings. Terminate grease-release lines, where used, in spring-loaded relief fittings. Provide grease fittings with covers which exclude water and dirt between lubrications.

B. Lubricate in accordance with the recommendations of the bearing or motor manufacturer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".

END OF SECTION 15860
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installing of air distribution equipment including turning vanes and dampers, sheet metal splitter dampers, transitions, air devices, and accessories and supporting devices, as shown.

B. Duct-mounted photoelectric smoke detectors are specified in Section 16721, “Fire Alarm and Detection Systems”.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):
   1. AASHTO M36 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM C361 - Standard Specification for Reinforced Concrete Low-Head Pressure Pipe

C. National Fire Protection Association (NFPA):
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air - Conditioning Systems

D. Sheet Metal & AC Contractors National Association (SMACNA):
   1. SMACNA 1481 - HVAC Duct Construction Standards - Metal and Flexible

E. Underwriters Laboratories, Inc. (UL):
   1. UL 181 - UL Standard for Safety Factory-Made Air Ducts and Connectors

1.3 SUBMITTALS

A. Shop Drawings.
   1. Plans, elevations, and sections.
   2. Duct connections to equipment with duct sizes indicates.

B. Product Data: Include Manufacturer's equipment data and installation instructions.

C. Certification.

D. Operation and Maintenance Manuals: Section 15001, "Mechanical Systems - General".

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specification sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer’s certificate that materials meet or exceed minimum requirements to comply with ASHRAE, NFPA, UL, SMACNA, and all other applicable standards.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Keep the inlet and discharge openings of all terminal units covered during construction.

B. Store and protect all piping and equipment from dirt and damage. During construction, cap the open top of all ductwork and piping when such work is installed vertically.

PART 2 - PRODUCTS

2.1 SUPPLY GRILLES AND REGISTERS

A. Type: Removable core, adjustable.

B. Size, capacity and airflow pattern as scheduled.

C. Horizontal adjustment: By means of individual adjustable vertical bars or vanes.

D. Vertical adjustment: By means of individually adjustable horizontal bars or vanes placed behind the vertical bars.

E. Horizontal bars or vanes space 3/4 inch apart maximum.

F. Grilles, frames and dampers constructed of aluminum or steel.

G. Supply grilles and registers provided with airtight felt, neoprene or plastic sealing strips at edges, designed to prevent leakage.

H. Corner joints finished to provide neat, trim appearance.

1. All grilles and registers provided with factory-fabricated volume control damper.
2. Volume dampers: Group-operated, opposed-blade, key adjustable.
3. Volume adjustment: By inserting key through face of grille.
4. Operating mechanism not projecting through grille face.

2.2 RETURN GRILLE AND REGISTER
A. Fabricated in accordance with the requirements specified for supply grilles and registers except for the following: Single set of nonadjustable horizontal face bars or vanes having a maximum of 3/4 inch spacing.

2.3 EXHAUST GRILLE AND REGISTER
A. Fabricated in accordance with the requirements specified for supply grilles and registers except for the following: Single set of nonadjustable horizontal face bars or vanes having a maximum of 3/4 inch spacing.
B. Furnish integral volume control dampers where shown.

2.4 TRANSFER GRILE AND REGISTER
A. Fabricated in accordance with the requirements specified for supply grilles and registers except for the following:
   1. Single set of non-directional, non-adjustable and non-see-through bars or vanes.
   2. Provide one grille face on both sides of openings through walls or partitions without duct connections.

2.5 CEILING DIFFUSERS
A. Types: Circular, square, rectangular, or linear as shown.
B. Diffuser ring or frame: Compatible with ceiling construction in which they are installed.
C. Diffusers fabricated to meet sizes and capacities as scheduled.
D. Transitions provided where necessary to connect ducts to diffusers.
E. Equip diffusers with baffles or other devices necessary to achieve uniform distribution of air unless indicated otherwise.
F. Turning vanes factory-fabricated, furnished by diffuser manufacturer, at each diffuser or take off except where flexible ductwork is used.
G. Single-key, opposed-blade volume damper factory-fabricated for each diffuser, furnished by diffuser manufacturer.
H. Fabricate diffusers of aluminum or steel, with edges exposed to view rolled or otherwise stiffened and rounded.
   1. Internal parts removable as unit to permit cleaning of diffuser and provide access to ducts.
   2. Removable parts constructed to prevent reassembly so as to produce incorrect air distribution pattern.
   3. Internal assembly fastened to permit removal and reassembly without special tools.
I. Omit air pattern control from diffusers used for return air or exhaust air.
J. Air duct or plenum connections secured to diffusers in accordance with manufacturer’s recommendations.
K. Circular ceiling diffusers provided with two or more concentric circular elements designed to delivery air radially, in a generally horizontal direction.
L. Square and rectangular ceiling diffusers provided similar to circular diffusers, except that outer elements to be square or rectangular.
M. Where diffuser is located at end of rectangular duct, duct extended minimum one neck diameter beyond centerline of neck.

2.6 LINEAR AIR DIFFUSERS
A. Size and capacity: As scheduled.
B. Diffusers and components parts constructed of extruded aluminum, internally lined, and finished as specified.
C. Where diffuser length necessitates sectional installation, provide alignment slots with insertion key strips or with other concealed means to align exposed butt edges of diffuser.
   1. Joints between diffuser sections to appear as hairline.
   2. Corner joints of frames and flanges exposed below ceiling or sidewall to appear as hairline cracks with unexposed sides or corner joints welded or secured with alignment keys.
D. Air delivery patterns: Manually adjustable from face of diffuser after installation. Full 180 deg. air pattern, from horizontal left or right, vertical, or
intermediate pattern for each slot independent of other slots.

E. Damper blades:
   1. Independent of pattern blades.
   2. Damper designed for manual adjustment from face of diffuser.

F. Screws or bolts prohibited in exposed face of diffused flames or flanges.

2.7 FINISHES

A. Items exposed to public view, unless otherwise shown: Two coats factory-finished in white baked enamel or color as approved by Contracting Officer.

2.8 SHEET METAL DUCTWORK

A. Ducts shall be constructed of new galvanized steel sheets and erected in a first class manner, straight and smooth, with joints neatly finished, anchored securely to the building and free from vibration.

B. Curved elbows shall have a centerline radius equal to 1-1/2 times the width of the duct. Air turns consisting of curved metal vanes, arranged to permit the air to follow abrupt turns without appreciable turbulence shall be installed in square elbows. Air turns shall be the manufacturer's standard products, and shall be quiet and free from vibration.

C. Primary and secondary ductwork of variable air volume systems shall be fabricated in accordance with the SMACNA1481, and the ASHRAE Guide. Primary ductwork upstream of air terminals shall be fabricated to withstand static pressures which the system fan is capable of producing at zero air flow, with no credit for coil, filters, or other system dynamic losses. Secondary ductwork downstream of air terminals shall be fabricated to withstand the maximum static pressure that can be developed downstream of any wide open terminal unit with the system air handling unit fan operating at its maximum external static pressure. The requirements for the seal class corresponding to the above static pressures shall be met.

D. Primary and secondary ductwork of constant volume systems shall be fabricated in accordance with the SMACNA 1481. The duct static pressure rating for this duct shall be equal to or greater than the external static pressure of the system fan as scheduled plus 0.35 inch w.c. The requirements for the seal class corresponding to the above static pressure shall be met.

E. Longitudinal joints shall be Pittsburgh lock or Acme grooved seam. Side panels greater than 10 inches in depth shall be cross-broken for added stiffness.

F. At each major branch from a primary rectangular or square trunk duct, and where shown on the drawings, install a splitter damper or multiblade adjustable air pickup. Splitter damper shall have end bearings and consist of a blade constructed of 20 gauge galvanized steel securely riveted or welded to a square operating rod. The length of the splitter blade shall be 1-1/2 times the width of the split in the main duct, but in no case less than 12 inches. Multi-blade adjustable pickup shall be with operator adjustable from the duct exterior.

G. Each individual air supply duct tap shall be equipped with a volume control device for the manual adjustment of air flow in each tap. Face bars, blanks, and equalizing grids shall not be used to regulate air flow.

H. Volume dampers shall be installed within ducts or plenums where shown on the drawings. Volume dampers shall have end bearings and be multi-blade type with opposed acting blades linked together and controlled by a single operator. Multi-blade dampers shall be not less than 16 gauge galvanized steel mounted to plenum or ductwork per SMACNA 1481 requirements.

I. Round or oval ductwork shall be fastened together with a minimum of three sheet metal screws equally spaced around the perimeter of the duct and sealed with an approved duct sealer. Ductwork shall be furnished complete with all factory fabricated starting collars, Y shaped branch takeoffs, adjustable elbows, etc.

J. Where ducts are in mechanical rooms or unfinished areas, or where dampers operate above lift out ceilings, regulators shall be stamped galvanized steel, lever type with locking screw mounted on face of ductwork. For all other areas, where damper adjustments cannot be accessed through the ceiling, regulators shall be the concealed type with adjustable cover plate, a 2-1/4 inch diameter cover plate.

K. On the inlet and outlet of each piece of air moving equipment or terminal unit, unless noted otherwise, install a flexible connection made with sufficient slack to render it flexible. Refer to Section 15075, "Vibration Isolation and Sound Control".

L. Where air intakes and/or discharges are indicated on the drawings and no air device is indicated, install 1/4 inch bird screens over each duct opening set in galvanized steel frames and securely attach to the openings.

M. Furnish and install 26 gauge galvanized steel counterflashings for all ducts penetrating roofs and for all roof mounted equipment unless directed otherwise by the Contracting Officer.

N. Install a manual volume control damper in each zone duct at the discharge of each multi-zone AHU.
2.9 DUCT ACCESS DOORS

A. Provide stamped steel duct access doors at each fire damper, fire and smoke damper, where control devices occur within ductwork, and as indicated on the drawings. Duct access doors shall be fully insulated where duct is lined internally. Provide with mounting flange, double thickness door with cam latch, gasket and retaining wire. No tools shall be required to open the duct access door.

B. The minimum size of each duct access door shall be sufficient to provide adequate access for the intended purpose of installation.

2.10 ACCESS DOORS

A. Access doors in walls and inaccessible ceilings are specified in Section 08313, “Access Doors and Frames”.

2.11 FLEXIBLE DUCTWORK

A. Flexible duct shall be factory insulated and secured with metal draw-bands. Duct shall meet the requirements of NFPA 90A and 90B and UL 181.

B. Duct shall be suitable for the various temperatures and pressures where used in the duct system.

2.12 BELOW GRADE DUCTWORK

A. Below grade ductwork shall be aluminum coated continuous welded seam helically corrugated steel pipe. The pipe exterior shall be coated with a bituminous coating. Pipe shall be 12 gauge construction with 2-2/3 pitch by 1/2 inch deep corrugations. Pipe shall be fabricated in accordance with the AASHTO Specification M36 for aluminum coated welded seam helically corrugated steel pipe. Pipe shall be joined using coupling bands (with plugs and lugs) constructed of the same base metal and coating as the pipe. Bands shall be 0.064 inch thick and 10-1/2 inches wide with corrugations 7-5/8 inches center to center. Between the corrugations the band shall be flat to allow seating of two O-ring gaskets to be installed in the first corrugation of each pipe to be joined. O-rings shall conform to ASTM C361. Band laps shall be joined with two galvanized bar, bolt and strap connectors. The installed ductwork assembly shall be tested in accordance with Section 15990, “Testing and Balancing”.

2.13 VARIABLE AIR VOLUME BOXES

A. Boxes shall be normally closed, pressure independent, single duct, variable volume units complete with primary air variable volume damper designed for complete shut-off but factory set for minimum 5 percent of nominal flow. Provide two flow measuring taps, and flow chart affixed to the box. Dampers shall incorporate a velocity reset controller which shall hold delivered CFM to plus or minus 5 percent of the set point regardless of duct inlet configuration, or of upstream or downstream pressure variation. Provide factory installed and calibrated operator capable of control to 5 percent of nominal air flow. The device shall be controlled by room thermostat furnished by temperature control contractor.

B. Unit and accessory interior surfaces shall be acoustically and thermally insulated with a minimum of 1/2 inch acoustic liner of 1-1/2 pounds per cubic foot density, coated to prevent erosion, complying with the requirements of NFPA 90A and 90B.

C. At scheduled capacities and under installed conditions, room sound level shall not exceed sound levels per requirements in the following subsection.

D. actuators shall be provided to the box manufacturer by the temperature controls manufacturer for installation on the box at the factory.

E. Maximum primary air valve pressure drop shall not exceed 0.3 inch W.C. at full flow.

2.14 FAN POWERED VAV BOXES

A. Provide units of types and capacities as scheduled. Coordinate with electrical controls sections.

B. Blower powered section shall consist of a three speed, permanent split capacitor electric motor directly connected to a forward curved centrifugal fan mounted in an acoustically lined metal cabinet section. Blower shall operate at medium speed flowing approximately 2/3 of the cooling CFM. The electric motor shall be of a permanently lubricated design, and shall have integral overload protection. Blower/motor assembly shall be resiliently isolated from acoustically lined cabinet section. Blower cabinet section shall be factory constructed of galvanized steel. Acoustic lining shall be factory applied to all interior surfaces of cabinet. Exposed surfaces and edges of lining shall be coated to prevent erosion. Lining shall be a minimum of 1/2 inch thickness and 1-1/2 pounds per cubic foot density fiberglass and comply with the requirements of NFPA 90A and 90B and UL 181.

C. Heating elements or coils shall comply with the requirements of Section 15850, “Air Handling”, and shall not be located upstream of the fan motor. A backdraft damper shall be factory installed to prevent back flow through the blower. Damper shall not require periodic maintenance.

D. Mixing plenum section shall be of similar construction to blower cabinet section to include acoustical lining.

E. As an integral part of the fan powered box, provide a primary air valve complying with all requirements for Variable Air Volume Boxes as specified herein.

F. Each unit shall be sound rated in accordance with the following criteria and shall be capable of being
tested to demonstrate such rating. Rating and tests shall be based upon a 1200 CFM unit (cooling), fan on medium speed, 800 CFM at 0.4 inch w.c. ESP. Sound power levels, given in dB re: 10 to 12 watts, shall not exceed the following values:

<table>
<thead>
<tr>
<th>Octave Band</th>
<th>Frequency, HZ</th>
<th>Sound Power Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>125</td>
<td>68</td>
</tr>
<tr>
<td>3</td>
<td>250</td>
<td>61</td>
</tr>
<tr>
<td>4</td>
<td>500</td>
<td>55</td>
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<tr>
<td>5</td>
<td>1000</td>
<td>51</td>
</tr>
<tr>
<td>6</td>
<td>2000</td>
<td>49</td>
</tr>
<tr>
<td>7</td>
<td>4000</td>
<td>48</td>
</tr>
</tbody>
</table>

G. The fan of each unit shall be set at the required fan speed, and the space noise level is not to exceed NC values.

H. In those cases where sound levels exceed the above criteria, provide factory fabricated sound attenuation furnished by the box manufacturer and provide documentation that the box then complies with the above requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ductwork accessories shall be provided as specified or shown or indicated on the drawings, install as recommended by SMACNA 1481 and the manufacturer.

B. Ductwork shall be installed as recommended by SMACNA 1481 and as shown or indicated on the Drawings. Coordinate ductwork with Other trades and elements of the building construction.

C. Install duct-mounted photoelectric smoke detectors furnished and wired by Section 16721, “Fire Alarm and Detection Systems”.

D. Ductwork shall be installed in a neat, workmanlike manner with ducts generally parallel to structure and tops of ducts as high as possible against building construction. Provide offsets as necessary to avoid obstructions, piping, or structural members.

E. Flexible ductwork shall be installed and supported as recommended by SMACNA 1481 and the manufacturer.

F. Below grade ductwork is not to be installed in direct contact with soil. Concrete or other means is to be provided for keeping water away from below grade ductwork.
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SECTION 15911
LOUVERS AND DAMPERS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing fixed louvers, gravity dampers, motorized dampers, control dampers, fire dampers, splitters, tunnel and ventilation dampers, and supporting devices.

1.2 REFERENCED STANDARDS
A. Air Movement and Control Association (AMCA):
   1. AMCA 500 - Test Methods for Louvers, Dampers and Shutters
B. National Fire Protection Association (NFPA):
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
C. Sheet Metal & AC Contractors National Association (SMACNA):
   1. SMACNA Architectural Sheet Metal Manual
D. The Society for Protective Coatings (Formerly known as Steel Structures Painting Council) (SSPC):
   1. SSPC SP 6 - Commercial Blast Cleaning NACE No. 3
   2. SSPC SP 1 - Solvent Cleaning
E. Underwriters Laboratories, Inc. (UL):
   1. UL 555 - UL Standard for Safety Fire Dampers

1.3 SUBMITTALS
A. Product Data: Complete catalog information for material and equipment.
B. Shop Drawings:
   1. Submittals include, but are not limited to, the installation details for weather louvers, air intake louvers and motorized dampers to be installed in wall openings.
   2. Verify size of each opening prior to ordering louvers and dampers.
C. Certification.
D. Operations and Maintenance Manuals: Section 15001, "Mechanical Systems - General".

1.4 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specification sections referenced in Section 15001, "Mechanical Systems - General", also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with ASHRAE, AMCA, NFPA, UL and all other applicable standards.
B. Manufacturer's Qualifications:
   1. Select a damper manufacturing firm regularly engaged in the manufacture of heavy duty, industrial grade dampers of the type specified.
   2. The dampers incorporated into the work shall essentially duplicate dampers that have been in satisfactory use for a period of five years, prior to the Notice To Proceed of this Contract.
C. Source Quality Control:
   1. Performance Certification: Certify that the dampers meet the following performance requirements specified herein:
      a. Leakage.
      b. Pressure drop.
      c. Pressure reversals.
   2. Factory Testing for Tunnel Ventilation Dampers. Prior to the manufacture of any of the dampers furnished under this Contract, subject one complete damper, measuring not less than 48 inches square, to a performance test; or submit the results of a factory certified test of a similar unit. Conduct the test in a test facility located either at the manufacturer's plant, or at a suitably equipped testing laboratory. Have the test facility approved by the Contracting Officer prior to the start of tests.
      a. Test the damper in accordance with the "Test Method for louvers, dampers and shutters" of AMCA 500, using a test setup approved by the Contracting Officer as appropriate for the intended installation of the dampers. Record test data on AMCA data submittal forms, or the equivalent thereof as approved by the Contracting Officer. Submit certified test data, and certified performance curves for all of the coordinates indicated to the Contracting Officer for approval.
b. Conduct tests to determine the following:

1) Maximum leakage at shut-off in percentage of flow with 10 inches water gauge pressure differential across closed damper;

2) Maximum pressure drop across damper in full open position with a uniform face velocity of 2000 feet per minute.

c. Plot damper performance curves as follows:

1) Curve plotted with ordinate as pressure drop across fully open damper in inches of water versus velocity in feet per minute.

2) Curve plotted with ordinate as duct pressure in inches of water versus leakage across closed damper in percentage of maximum flow.

B. Each damper shall be furnished complete with 18-gauge galvanized factory sleeve and damper operator (pneumatic or electric to conform to control system) factory installed on exterior of sleeve and properly linked to damper operating shaft. Operators shall be UL listed and labeled as Fire Damper Operators.

C. Each damper shall be activated by a duct smoke detector provided by Division 16, "ELECTRICAL" and installed under Division 15, "MECHANICAL".

2.4 EXTERIOR LOUVERS

A. Exterior louvers are specified in Section 10210, "Wall Louvers".

2.5 LOUVERS FOR VENTILATION FANS FOR TUNNELS

A. Furnish and install air-intake louvers for tunnel ventilation as indicated on Contract Drawings and as specified hereinafter.

B. Louvers shall be stationary type entirely contained within a 6 inch wide frame, constructed from extruded aluminum alloy.

C. Louver components such as heads, jambs, sills, blades and mullions shall be factory assembled by the louver manufacturer.

D. Field assemble louver sizes too large for shipping from factory assembled sections to provide overall sizes required.

E. For louver design, incorporate structural supports required to withstand a wind load of 20 pounds per square foot.

F. For pressure loss through louvers at 1000 fpm air velocity do not exceed 0.25 inch of water gauge.

G. Provide louvers of architectural style with continuous appearing stationary blades. Provide intermediate support mullions which do not interrupt blade appearance when viewed from outside.

H. Louver construction:

1. Frame: 0.125 inch wall thickness minimum.

2. Blades minimum: 0.125 inch wall thickness on approximately 4-3/4 inch centers.

3. Screen: 1/2 inch mesh expanded flattened aluminum in removable frame.

I. Submit louver performance data for approval prior to construction.

J. Furnish louvers ferrous metal surfaces with SSPC SP 6 surface preparation and non-ferrous metal extrusioned surfaces a SSPC SP 1 surface preparation with a prime coat of vinyl wash primer
applied and top coat of silicone Alkyd Enamel (gloss finish) applied DFT 1 to 2 mils.

2.6 CONTROL DAMPERS

A. Furnished and installed under this Section.
B. Factory fabricated, opposed blade, balanced type with factory assembled linkages, mounted in galvanized steel frames.
C. Rectangular dampers 12 inches or larger: Multi-blades.
D. Blades: Flat or formed galvanized steel constructed of double thickness of 22 gauge. Install butyl rubber seals on all blade edges, as well as the sides, top and bottom stops of all dampers.
   1. Air temperature range of seals: Suitable for operation from zero degrees F to 200 degrees F.
   2. Supported by thrust bearings for vertically mounted blades.
   3. Length of blades between bearings maximum 48 inches.
   4. Multi-blades maximum 8 inches wide.
   5. Opposed blade dampers: Adjoining blades rotate in opposite directions so that the air stream is not over 8 inches wide.
E. Leakage when closed: Maximum 20 cfm per square foot at a static pressure of 4 inches water gauge.
F. Frames: Bar or channel, galvanized steel constructed of 16-gauge solid sheets, with corner bracing for rectangular dampers larger than 4 square feet in area.
G. Damper Operating Linkage:
   1. Adjustable length galvanized steel rods capable of withstanding load of at least twice the maximum operating force of the damper operator without deflection.
   2. Joints: Brass pins and clevises or brass ball and socket joints.
H. Steel parts: Hot dip galvanized after fabrication.
I. Damper operator mounting provisions designed for outside of the damper frames.
J. Motor mounting supported so that the operator will not deflect from its normal path when operating under load.
K. Valve and Damper Electric Operators:
   1. Spring return type.
   2. Two-position motor operation.
   3. Spring returns valve or damper to power off in the event of a power failure, either in the normally open or normally closed position as required for freeze, moisture, smoke or fire protection.
   4. Adjustment provisions: Adjustable stops to control the open and closed positions of damper operators.
   5. Opening time no greater than 5 seconds.

2.7 MOTORIZED DAMPERS

A. Factory fabricated automatic dampers as indicated. Provide gaskets at blade-ends and at sides to provide airtight construction.
B. Provide modulating dampers having opposed blades; two position dampers having parallel blades; unless otherwise specified, or shown.
C. Provide self-lubricated bearings. Externally mounted damper operators; unless otherwise specified or shown.

2.8 BACK DRAFT DAMPERS

A. Provide factory fabricated back draft dampers of the counter-balanced automatic construction.
B. Provide axles fabricated of 3/16 inch diameter rod steel with a maximum panel width of 30 inches.
C. Provide bearings of oil impregnated bronze. Provide blades with felt cushions to insure adequate sealing.
D. Locate blade linkage outside the air stream of galvanized steel, or extruded aluminum same as that specified for ductwork or fan housing.

2.9 TUNNEL VENTILATION DAMPERS

A. General:
   1. In selecting equipment, provide for interchangeability of items of dampers and parts.
   2. Ventilation dampers to be the product of a single manufacturer and like components furnished by a single supplier.
   3. Each damper assembly to consist of one or more damper modules assembled together by means of intermediate structural
supports. Design dampers with frames for mounting in concrete openings, as shown.

4. Furnish damper assemblies and damper modules in accordance with Ventilation Damper Schedule. Damper dimensions shown on drawings include damper frames. Construct modules complete with frames, mullions, blades, shafts, bearings, and interconnecting linkage for blade operation. Furnish electric damper operators, damper operator mounting plates, brackets for damper frame mounting, jack shafts, and linkage between the operator and damper blades.

5. Fully assemble each damper operator, mounting bracket and linkage, and have operation tested at the factory. If necessary, the damper operator and linkages may be removed for shipment, provided adequate written instructions for the reassembly in the field are furnished.

6. Install complete damper assemblies including damper operators, operator mounting brackets, linkages and connections to electric power and control wiring. Furnish intermediate structural supports required between damper modules as part of the damper assembly. Provide structural members required to mount the damper assembly within framed concrete openings, as required.

7. Structural opening dimensions and damper module sizes given on the Drawings are nominal. Install dampers listed in the schedule in these openings and size the assembly 1 inch smaller at all sides than the nominal structural opening dimensions. Prior to the fabrication of damper assemblies, verify in-place all dimensions and configuration of structural openings in the field.

8. Provide temporary supports and bracing to maintain dampers and damper companion flanges square and rigid at all times during shipping, handling and erection.

B. Damper Requirements:

1. Provide ventilation dampers suitable for installation in a vertical or horizontal plane as shown.

2. Design dampers to be assembled in the field from modular panels. Each damper panel to be of the multiple-parallel-blade type, with an independent channel frame, and factory-assembled complete with frames, blades, shafts, bearings, seals, linkage, and accessories required to erect the panels into composite dampers which are functional as indicated.

3. Multiple modular panel dampers may be operated by use of jack shafting.

4. Arrange dampers for electric-motor operation in two blade positions: fully-open, and fully-closed. Furnish each damper complete with electric-motor operators sufficient in number and capacity to actuate all modular panels of the damper in unison under the operating conditions indicated, and end switches to indicate the fully open and fully closed position of each damper module.

5. Dampers to have a net free face area of not less than 80 percent measured to the inside of the damper frame clear opening when blades are fully open.

6. Upon a loss of power, ensure dampers move to the "power-off position" (open or closed) as indicated.

7. Design dampers so the dampers will be fully operational in accordance with the performance requirements specified after exposure for a period of one hour to an airstream temperature of 300 degrees F. Demonstrate dampers and components capable of withstanding the stresses caused by reversal of air flow and thermal shock caused by temperature changes of from 300 degrees F to zero degrees F.

C. Damper Performance Requirements:

1. Performance requirements as specified herein are based on standard air having a density of 0.075 pounds per cubic foot.

2. When the dampers are fully-closed and holding against a maximum differential pressure of 10 inches-water-gauge, leakage through the damper is not to exceed two percent of the flow encountered in the fully open position for damper size of 48 inches square, with a face velocity of 2000 feet per minute.

3. With the dampers of 48 inches square size in the fully-open position, and air flowing across the damper at a uniform velocity of 2000 feet per minute, the static-pressure drop across the dampers is not to exceed 0.15 inches water gauge.

4. Ensure the dampers and their associated structural supporting systems are capable of withstanding the following loads when in the fully closed position and installed in accordance with the published directions of the manufacturer:

   a. Maximum differential static pressure of 16 inches water gauge in either direction.
D. Damper Components and Construction:

1. Fabricate damper blades having an airfoil cross-section of aluminum alloy, extruded to a minimum thickness of 0.08 inch. The width of the blades measured in the direction of airflow is not to be less than 4 inches, and not greater than 8 inches. Ensure damper blades in the full open position do not extend beyond the damper frame and the blades have metal to metal overlap in the closed position. Do not substitute blade edge sealing strip overlap for blade to blade overlap, regardless of the blade edge sealing strip composition.

2. Fabricate damper-blade shafts and jack shafts of aluminum alloy or stainless steel, except for drive shafts. Drive shafts to be stainless steel and not less than 1/2 inch in diameter. Incorporate in the design of the damper-blade shafts, the devices required for locking the blades onto the shafts and ensure damper blade shaft axis are always horizontal.

3. Damper blade deflection, with blade supported by shaft, not to exceed 1/180th of the span length between centers of shaft bearings with damper in closed position, while withstanding the maximum combined differential pressure and the maximum temperature as indicated.

4. Support the damper blade and shaft assemblies at each end by means of double bearings consisting of an inner bearing rotating inside an outer bearing; design the bearings so there are neither metal-to-metal nor metal-to-polymer riding surfaces. Secure the outer bearings mounted in the damper frames so as not to rotate, and fabricate of fibrous-glass-reinforced thermoplastic, or stainless steel as approved by the Contracting Officer. Secure the inner bearings fitted to the damper-blade shafts to rotate with the shafts, and fabricate of fibrous-glass-reinforced polyphenylene sulphide. Other bearing materials suitable for the specified operating conditions may be used, subject to the approval of the Contracting Officer.

5. Fabricate damper-blade seals and damper-frame seals of an extruded silicone compound, or other material suitable for the specified operating conditions, as approved by the Contracting Officer. Factory install the seal in dove-tail grooves of the blades and frames and make easily replaceable in the field. Provide damper blades with end seals.

6. Fabricate damper linkage of stainless steel rods not less than 1/4 inch in diameter. Interconnect linkage from damper blade shaft to crank arms. Fabricate damper blade crank arms of stainless steel or aluminum alloy of equal strength, as approved by the Contracting Officer. Fabricate linkage bearings of polytetrafluoroethylene or other material suitable for the specified operating conditions, as approved by the Contracting Officer. Attach linkage brackets either to the damper-blade shafts or side-mounted and mechanically interconnected with the shafts. Center mounted hardware may be provided if approved by the Contracting Officer. Linkage to be capable of transmitting a minimum of 150 percent of operator load.

7. Fabricate damper frames having a channel cross-section with not less than a 4 inch and not more than 8 inch web and 1-1/2 inch flanges of aluminum alloy extruded to a minimum thickness of 1/8 inch. Weld to mounting sides of damper frames, built-up flanges of aluminum alloy not less than 3 inches in width and not less than 1/4 inch thick unless otherwise indicated. In lieu of 3 inch welded built-up flanges, the Contracting Officer will accept damper frames extruded to 3 inch width with 3/8 inch thickness on mounting sides. Provide reinforcing bosses and dovetail grooves for mounting frame seals as integral parts of the channel configuration. Weld or reinforce the corners of the frames by means of riveted gusset plates. Provide damper assembly flanges with 3/4 inch diameter slotted holes equally spaced not more than 12 inches on centers.

8. Furnish damper modules complete with structural support elements necessary for assembly of the damper modules, including but not necessarily limited to the following: intermediate supports, both horizontal and vertical; clip angles and other framing members required at the head, sill, and jambs of each damper assembly; screws, bolts, nuts, washers, and other hardware required to complete the assembly. Fabricate intermediate supports, framing members, and hardware required for assembly of the damper modules of aluminum or stainless steel.

9. Reinforce damper modules corners by gusset plates.

10. Provide lifting lugs of similar material as damper frame and weld on exterior of damper frame to facilitate future on-site installation and removal of damper frames.

E. Damper Operator Requirements:

1. Capable of actuating the dampers, as indicated, against a differential pressure of
10 inches water-gauge across the dampers; capable of changing the position of the dampers from fully-closed to fully-open, or from fully-open to fully-closed within a period of not more than ten seconds; select to provide a capacity of not less than 50 percent in excess of normal duty requirements; and to operate under the ambient temperature conditions, as indicated.

2. Connect linkage from the damper operator to the inter-connecting blade linkage, such that full force of operator is applied to the blade-connecting linkage.

3. Motors: Not larger than 1/2 horsepower, totally enclosed and wound for 120 volts AC, single-phase, 60 Hertz. Provide motor windings and motor leads of copper and insulated so the temperature rise of the insulated motor windings does not exceed 176 degrees F, measured by resistance method, above an ambient temperature of 104 degrees F.

4. Equip motors with factory installed resistance space heaters within the motor enclosure to prevent condensation of moisture in the motor windings. Provide heaters with leads terminated in the conduit box. Operate the heaters on 120 volts, single-phase.

5. Furnish motor-operators with spring-actuated devices capable of driving the dampers to their "power-off" positions within a period of 15 seconds after the operators are deenergized. The "fail safe" position of a damper (normally open, or normally closed) is defined as the position which the damper assumes when its operators are deenergized. The spring return devices shall be fully operational as indicated throughout exposure to ambient and airstream temperatures of 300 degrees F for a period of one hour. The "power-off" position of each damper assembly is shown on the Drawings.

6. Furnish motor-operators with auxiliary limit switches at both ends of the motor travel. Provide these switches in addition to end switches specified in Paragraph 2.9.B.4. of this section having a minimum of two sets of single-pole contacts, one normally-open and one normally-closed; single-pole, double-throw contacts will be acceptable, provided that the circuits are electrically separate and fully insulated to permit their use on opposite polarities. The contacts to have an electrical rating of not less than 5 amperes at 120 volts, 60 Hertz alternating current.

7. Factory-wire motor leads and limit-switch contacts in cast iron weatherproof conduit boxes. Provide conduit boxes with tight-fitting, gasketed covers designed to resist the entrance of dust and fluids, and with threaded conduit openings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify size of each opening prior to ordering dampers and/or louvers.

B. Install dampers with stainless steel hardware.

C. Where dampers are installed on steel frames, provide solid neoprene gasket of 1/4 inch thickness between the two dissimilar metals.

D. Install dampers and/or louvers in walls to completely fill the opening. Install gasket and caulk frame to make dampers and/or louvers air tight.

3.2 TESTING

A. Field Testing. Upon completion of the installation of the motor operated dampers, perform field tests as indicated under the technical guidance and supervision of the manufacturer’s field representative as follows:

1. Subject each damper to rotation reversal tests. A cycle of rotation reversal is defined as reversal from fully-open to fully-closed position, and then back to fully-open position. Each fan, isolation and bypass damper requires five cycles of rotation reversal.

2. Upon completion of reversal tests to each damper, and and the damper has been de-energized by the operator; check to ensure that it is driven to its "power-off" position within 15 seconds after being deenergized.

3. Report and correct any defect that develops within the damper equipment during the test at no additional cost to the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15911
SECTION 15950
CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing automatic temperature controls, remote surveillance and control and local control systems.

1.2 REFERENCED STANDARDS
A. American Society for Quality (ASQ):
   1. ASQ Z1.11 - Quality Assurance Standards - Guidelines for the Application of ANSI/ISO/ASQC Q9001 or Q9002 to Education and Training Institutions

B. American Society of Mechanical Engineers (ASME):
   1. ASME Boiler and Pressure Vessel Code

1.3 SUBMITTALS
A. Product Data:
   1. Complete catalog information and shop drawings for material and equipment including wiring and control diagrams.

B. Shop Drawings:
   1. Submittals include, but are not limited to the equipment needed for a pneumatic or electric control system.
   2. Complete set of floor plans of rooms showing by means of graphic coding actual location and mounting heights of thermostats and zone served by each thermostat.

C. Operation and Maintenance Manuals:
   1. Submit Operation and Maintenance Manuals in accordance with the requirements of Section 15001, "Mechanical Systems - General" with the additional requirements specified herein.
   2. Complete electrical schematic of each system showing and identifying each internal and external component and internal and external wiring.
   3. Detailed piping and/or wiring diagrams showing graphic coding.
   4. Terminal numbers for wire or pipe connections.
   5. Complete parts list of internal and external components.

D. Training Plan in accordance with Section 15001, "Mechanical Systems - General".

1.4 QUALITY ASSURANCE
A. The Codes, Regulations, Reference Standards, and Specification sections referenced in Section 15001, "Mechanical Systems - General" also apply to this section. When requested, provide the Contracting Officer with manufacturer's certificate that materials meet or exceed minimum requirements to comply with ASME, ASTM, NEC, NEMA, and all other applicable standards.

B. Manufacturer's Qualifications:
   1. Select a control system manufacturer regularly engaged in the manufacture of control systems of the type specified herein for a period of five years prior to the Bid Opening in this Project.
   2. Ensure that the Control System Manufacturer has a full-time organization for installation and service in the Dallas/Fort Worth Metroplex area.
   3. Have instruments, piping, and wiring installed by authorized representatives of the control equipment manufacturer.
   4. Ensure that the equipment manufacturers have a quality assurance program which meets the requirements of ASQ Z1.11 and which satisfies safety related quality requirements imposed by the local regulating agencies.

C. Source Quality Control:
   1. Test and stamp air storage tank in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.
   2. Identify each transducer according to type, sensitivity, accuracy, and operating range.
   3. Install each remote indication system with accuracy as specified.

PART 2 - PRODUCTS

2.1 GENERAL
A. Automatic Temperature Control Systems:
   1. Design systems to perform functions and operate in sequence as shown or specified for air conditioning, heating and ventilation of buildings, ancillary rooms, tie breaker stations, power substations, and chilled water systems.
2. Maintain the design conditions shown or specified.

3. Supervise and control operation of chilled water plant including chilled water pumps, chiller, condenser water pumps and cooling tower as shown or specified.

4. Operate and control motor-operated dampers.

5. Design control system to interface with fire and smoke detection system as specified in other sections to shut off the following fans on activation of fire and smoke detection system.
   a. Battery room fans.
   b. Air-conditioning and ancillary area fans, except the following:
      1) Tunnel ventilation fans.
      2) Emergency power generator room ventilation system.
      3) Rooftop exhaust fans.

B. Remote Surveillance and Control Systems:

1. Continuously measure parameters, as required, including pressure, temperature and flow. Convert analog values of sensing transducer into seven-bit binary code and transfer to designated interface data transmission system (DTS) terminals by relays.

2. Monitor abnormal operations, such as high and low limits on pressure, temperature, humidity water level, water flow, damper position, mode selector switch position and air flow as shown.

3. Design system to compensate for electrical losses in wiring. Design DC power supplies and signal amplifiers, as necessary.

C. Interchangeability: In design and purchase of equipment, provide for interchangeability of items of piping equipment, subassemblies, parts, motors, starters, relays, and transducers.

D. Wherever possible, control system shall be full Direct Digital Controls (DDC), fully compatible and functional with existing central monitoring and control systems currently employed by DART. See mechanical schedule for central monitoring requirements.

2.2 MATERIALS

A. Room Thermostats: Thermostats shall be of the gradual acting type with adjustable set points. Pneumatic thermostats shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree, and shall control the space temperature to plus or minus 1 degree F. Electric thermostats shall have an electronic sensing element to respond to temperature changes, and should control the space temperature plus or minus 1 degree F.

1. Covers for the thermostats shall include tamperproof socket head screws.

2. Calibration shall be possible from the front of the thermostat without removing the thermostat body from the wall mounting plate.

3. Temperature setpoint adjustment shall be concealed.

4. Space thermostats shall be without exposed thermometers.

5. Temperature in each space or zone shall be controlled by a single thermostat.

6. For zones with heating and cooling capacity provide a thermostat dead band of at least 2 degrees F.

7. Provide thermostats with a heating mode shall have a night setback feature.

B. Transmitters: Temperature, relative humidity and pressure transmitters shall be direct acting instruments capable of transmitting a proportional [pneumatic, electric] signal in direct proportion to the change in input. Pneumatic transmitter output shall change from 3 psi to 15 psi or other suitable pressure range over the stated range of the transmitter. Humidity transmitters shall incorporate inorganic film or solid state sensing element.

C. Receiver-Controllers: Receiver-controllers shall be of the single, dual or three input models as required to meet the specified sequence of operation. They shall have mechanical setpoint adjustment, proportional band adjustment and authority adjustment. Provide a locking device for set point adjuster. Proportional band shall be adjustable from 2 percent to a maximum of 170 percent and authority adjustment shall be a minimum of 0 to 200 percent. Provide direct or reverse acting controllers as required, with temperature ranges to match the respective transmitters. Receiver-controllers shall be capable of receiving signals from either bleed type or relay type transmitters. Field adjust each controller to prevent temperature variation in controlled fluid from exceeding plus or minus 1 degree F from set point.

D. Pneumatic Temperature Sensors: Sensors shall employ pneumatic feedback and shall be capable of transmitting a linear signal over the required span. Sensors shall be designed for wall, pipe or duct mounting as required by the application. Insertion
CONTROL EQUIPMENT

DART Standard Specifications – July 2014

CONTROL EQUIPMENT

A. Controls shall be installed as recommended by the manufacturer to accomplish the implied or intended functions of the following described sequence of operation.

B. Control devices accessible to building occupants shall be mounted to conform to all applicable sections of the state program for the elimination of architectural barriers for the handicapped.

WIRING

A. Provide control wiring required to interconnect all control components furnished under this Section, all interlocks to components furnished by others, and to accomplish the control functions described in the sequence of operation.

B. Wiring shall be run in conduit.

SEQUENCE OF OPERATION

A. Chilled Water System: Chillers shall operate with their respective condenser water and chilled water pumps simultaneously. Proof of flow switches as specified herein will prove water flow before chillers can be started. An automatic controller shall sequence the chillers, by using a sensor in the return chilled water.

1. Provide a means of manually selecting any chiller or chillers to operate.

2. Automatic butterfly valves shall close to prevent water flow through an idle chiller. These valves shall be opened to allow full flow when chiller is operated.

3. A pilot differential pressure controller shall control a chilled water bypass valve.
CONTROL EQUIPMENT

B. Hot Water System: Provide the following control for the hot water heating system:

1. Interlock boiler recirculation pump with the burner to only operate the pump with the burner.
2. Provide flow switch to prove system hot water pump flow prior to firing burner.
3. Provide diverting valve controlled by temperature sensor in boiler return piping.

C. Terminal Units:

1. Typical interior zone temperature control shall be maintained by use of a modulating variable air volume valve. Each valve shall be controlled by an individual thermostat, by opening upon a call for more cooling and closing to a minimum position of 5 percent nominal flow upon a decreasing demand for cooling.
2. Typical exterior zone temperature controls shall be maintained by use of modulating a fan powered box with an electric heating coil. The air valve in the box shall modulate in a cooling mode to maintain the respective thermostat setting. As the zone calls for less cooling, the air valve shall throttle down to 5 percent of nominal flow. At that point, when the zone requires heat to satisfy the thermostat setting, the fan will start and draw return air from the ceiling plenum and discharge it into the space. If additional heat is needed, the heating coil shall, if flow is proven by a flow switch (for electric heating coils), cycle as required to maintain the thermostat setting. Upon a call for cooling the reverse will occur. There shall be a dead band between heating and cooling actions of at least 2 degrees F. Each zone shall be controlled by a single thermostat. Hot water coils shall use 2-way control valves except the last box on each major branch which will use a 3-way valve.

D. VAV Air Handling Units: These AHU shall be provided with an automatic fan speed control system furnished and installed by the Mechanical Contractor. Provide a manual reset high duct static pressure shut down switch for each unit. Set 3 inches WC (adjustable).

E. Multi-Zone Air Handling Units: For each MZ unit, provide all zone damper actuators selected for the duty required. Provide 2-way control valve for hot/cold deck, each controlled by a deck air temperature sensor to the scheduled temperature (adjustable).

F. Fan Coil Units and Constant Volume Air Handling Units: Each shall be controlled by a space thermostat.

G. Unit Heaters: Provide controls for unit heaters when not noted otherwise on the unit heater schedule.

1. Electric Unit Heaters; provide relay, wiring, and accessories for control by remote 24 volts wall thermostat.
2. Hot Water Unit Heaters; provide PE switch and pneumatic wall thermostat or speed controller for control of unit fan.

H. Bypass Valve: Provide a bypass valve between the chilled water supply and return mains. The valve shall respond to a pilot signal sampling the differential pressure of the mains and shall maintain the differential pressure of the mains within plus or minus 0.5 psig.

I. Enthalpy Economizer Cycles: Provide outdoor enthalpy sensor, mixed air sensor and controller, minimum outdoor air positioner, and all required control dampers and accessories. The O/A damper shall assume its minimum position during heating operation and shall close completely when the AHU is shut down. The motorized damper in the building relief hood(s) shall open fully when the economizer cycle is in operation.

J. Elevator Relief Damper: A motorized damper behind the relief louver shall open fully upon activation of the fire alarm.

K. Alarms: Within the main mechanical room or central plant, provide an alarm panel with the following features:

1. Each alarm point listed below shall be identified and displayed as a red light mounted in the front of the panel. Also, an alarm horn with silencing button shall be provided. Separate cooling/heating alarms through a summer/winter switch.
   a. Low cooling tower sump level.
   b. High condenser water return temperature (90 degrees F) (adjustable).
   c. High chilled water supply temperature (50 degrees F) (adjustable).
   d. Low heating water temperature (150 degrees F) (adjustable).
   e. Low control air pressure (15 psig) (adjustable).

L. SCADA Alarm Contacts: Provide two sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the generator control panel. The normally open contacts to be
connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Separate cooling/heating alarms through a summer/winter switch.
   a. Low cooling tower sump level.
   b. High condenser water return temperature (90 degrees F) (adjustable).
   c. High chilled water supply temperature (50 degrees F) (adjustable).
   d. Low heating water temperature (150 degrees F) (adjustable).
   e. Low control air pressure (15 psig) (adjustable).

M. Traction Power Substation and Auxiliary Power Room Ventilating Unit Controls:

1. Two-stage thermostat, selector switch and automatic alternator.
2. Control sequence:
   a. When room temperature rises to 85 degrees F: Open lead-fan dampers and start lead fan.
   b. When room temperature rises to 95 degrees F: Open lag-fan dampers and start lag fan.
   c. Reverse control process on falling temperature.
   d. Automatic alternator reverses lead-lag sequence after each lead fan operating cycle.

N. AC Switch Gear Room Ventilating Fan Controls:

1. Two-stage thermostat, flow switches, time-delay relay, selector switch, and automatic alternator.
2. During each operating cycle, one fan to serve as primary fan and second fan as stand-by.
3. Control sequence:
   a. When room temperature rises to 85 degrees F, relief damper(s) open, and lead fan starts.
   b. When temperature rises to 95 degrees F: Open lag-fan dampers and start lag fan.
   c. Control sequence to reverse when room temperature falls.
   d. After each operating cycle, automatic alternator to reverse functions of lead and lag fans.

O. DC Breaker Room and Tie Breaker Station Ventilating Fan Controls:

1. Single-stage space thermostat.
2. Switch labeled HAND/OFF/AUTOMATIC.
3. Operation:
   b. Off: Fan off, dampers closed.
   c. Automatic:
      1) When room temperature rises to 90 degrees F, open dampers and start fan.
      2) Reverse control process on falling temperature.

P. Battery Room Fan Controls:

1. Battery room exhaust fan to operate continuously.

3.4 INSTALLATION

A. Upon completion of the installation, the equipment supplier and contractor shall start-up the system and perform necessary testing and debugging operations. An acceptance test in the presence of the Authority’s representative, the Contracting Officer, and the Engineer shall be performed.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, “Mechanical Systems - General”.

END OF SECTION 15950
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies work required to provide complete and balanced heating, ventilating, air conditioning systems, and plumbing systems.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM E1120 - Standard Specification for Liquid Chlorine
   2. ASTM E1229 - Standard Specification for Calcium Hypochlorite

B. Associated Air Balance Council (AABC):
   1. AABC MN-1 - National Standards.

C. National Environmental Balancing Bureau (NEBB):
   1. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

D. Sheet Metal & Air Conditioning Contractors National Association (SMACNA):

1.3 SYSTEM DESCRIPTION

A. Plumbing:
   1. Perform tests of plumbing systems and plumbing equipment as specified herein and as required to obtain approvals from authorities having jurisdiction.
   2. Provide instruments, materials and labor to perform the testing and balancing and to obtain and record measurements.

B. Mechanical:
   1. The balancing, testing, and adjusting of the heating, ventilating, and air conditioning systems will be performed by an independent technical firm or balancing agency with a minimum of five years specialized experience in testing and balancing the system, a licensed Engineer overseeing the work, and equipment furnished under Division 15. The testing and balancing agency shall possess calibrated instruments, qualified engineers, and skilled technicians to perform required tests, and shall be fully certified member of the Associated Air Balance Council whose business is limited to testing and balancing the system and equipment furnished under Division 15, “MECHANICAL”.

2. The Contracting Officer and the Authority will approve selection of independent technical balancing agency.

3. The testing and balancing firm is to be an independent firm separate and distinct from; not be associated with, or be subsidiary of a firm performing work under other Sections of Division 15, “MECHANICAL”.

4. The testing and balancing firm will not instruct or direct the Contractor in any way of the work but will make such reports as are necessary directly to the Contracting Officer. The plans and specifications have indicated valves, damper, and other adjustment devices for the purpose of responsibility of the Contractor to install those devices in a manner that will leave them accessible and readily adjustable.

5. The test and balance firm is to guarantee that the test and balance work will be performed in accordance with the latest NEBB and AABC standards and procedures.
   a. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
   b. SMACNA 1143.
   c. AABC MN-1.

6. Prepare and submit to the Contracting Officer, applicable certificates of firm and personnel and report format and forms proposed for use in testing and balancing.

7. Prepare and submit to the Contracting Officer the complete reports on the balance and operations of systems. Forms shall comply with NEBB standards.

8. Make a total of three inspections within 90 days after occupancy of the building to insure that satisfactory conditions are being maintained.

9. Make an inspection in the building during the opposite season from that in which the initial adjustments were made. At that time, make any necessary modifications to the initial adjustments required to produce optimum operation of the system for all seasons.
C. Corrosion Control: Perform tests in accordance with Section 15060, “Piping and Accessories” and Section 13100, “Corrosion Control”.

1.4 QUALITY ASSURANCE

A. The Codes, Regulations, Reference Standards, and Specifications sections referenced in Section 15001, “Mechanical Systems - General” also apply to this section.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 PIPING AND EQUIPMENT TESTS

A. Plumbing:

1. Soil, waste, vent, and water piping shall be tested by the Contractor and approved by the Contracting Officer and all approving authorities before acceptance. Underground soil and waste piping shall be tested before backfilling.

   a. Drainage and venting system piping shall be tested with water or air before the fixtures are installed and as required by local authorities. After the plumbing fixtures have been set and their traps filled with water, the entire drainage and venting system shall be submitted to a final test if required by the local authorities.

   b. The water test shall be applied to the drainage venting system either in its entirety or in sections. If the entire system is tested, all openings in the pipe shall be tightly closed except the highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening except the highest opening of the section under test shall be tightly plugged, and each section shall be filled with water and tested with at least 10 feet of head of water.

   c. In testing successive sections, at least the upper 10 feet of the next preceding section shall be tested so that each joint or pipe in the building except the uppermost 10 feet of the system has been submitted to a test of at least a 10 feet of head of water. The water shall be kept in the system, or in the portion under test, for at least 15 minutes before the inspection starts; the system shall then be shown to be watertight.

   d. Air Test: If tests are made with air, a pressure of not less than 5 pounds per square inch shall be applied with a force pump and maintained at least 15 minutes without leakage.

   e. Final Test: When the smoke test is employed, the smoke shall be produced by a smoke machine, and a pressure equal to 1 inch water column shall be maintained for 15 minutes before inspection starts. When the peppermint test is used, 2 ounces of peppermint shall be introduced into each line or stack.

2. Domestic Water System: When the roughing-in is completed and before insulation is applied or fixtures are set, each pressure zone of the hot and cold water piping system shall be tested at a hydrostatic pressure of not less than 100 pounds per square inch gauge at its top, and proved tight at this pressure for not less than 30 minutes in order to permit inspection of all joints.

   a. Where a portion of the water piping system is to be concealed before system completion, this portion shall be tested separately to the pressure which would be imposed upon it if it were tested as part of a zone, as specified above.

3. Roof Drains - Downspouts: Test in the same manner as the drainage system.

4. Natural Gas System: The complete gas piping system shall be tested with air at a pressure of fifteen psi and proved tight at such pressure for twenty-four hours. Test may be done in segments as dictated by construction requirements. Peppermint fumes or soap bubbles shall be used to locate leaks. All tests shall be approved by the local authorities and also by the Contracting Officer before the test are removed.

5. Defective Work: If inspections or tests reveal defects, such defective work or material shall be replaced or repaired as necessary and inspections and tests shall be repeated. Repairs to piping shall be made with new materials. Patching of screwed joint or holes shall not be acceptable.

6. Cleaning, Testing, and Adjusting:

   a. Equipment, piping, valves, fittings, and fixtures shall be cleaned of grease, metal cuttings, and foreign matter that may have accumulated from operation of the system during
b. When the work is complete, the water systems shall be adjusted for all required flows. Flush valves and automatic control devices shall be adjusted for proper operation. Hot water heaters shall be tested for proper operation of safety and operating controls as recommended by the manufacturer. Demonstrate that supply and recirculating systems are balanced for specified flows and temperatures as shown on the drawings.

7. Sterilization: After pressure tests have been made, the entire domestic water distribution system shall be thoroughly flushed with water until all entrained dirt and mud have been removed, and shall be sterilized by chlorinating material. The chlorinating material shall be either liquid chlorine conforming to ASTM E1120 or hypochlorite conforming to ASTM E1229. The chlorinating material shall provide a dosage of not less than 50 parts per million shall be introduced into the system in an approved manner. The treatment water shall be retained in the pipe long enough to destroy all non-spore forming bacteria. Except where a shorter period is approved, the retention time shall be at least 24 hours and shall produce not less than 10 ppm of residual chorine at the extreme end of the system at the end of the retention period.

8. Valves and faucets in the system being sterilized shall be opened and closed several times during the contact period. The system shall then be flushed with clean water until the residual chlorine is reduced to less that 1.0 ppm. Samples of water shall be taken from several points in the system in properly sterilized containers for bacterial examination. The sterilizing shall be repeated until tests indicate the absence of pollution for at least two full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

B. Corrosion Control: Perform tests in accordance with Section 15060, “Piping and Accessories” and Section 13100, “Corrosion Control”.

3.2 PIPING TESTS

A. Chilled Water, Heating Water, Steam, Condensate Return, and Condenser Water Piping:

1. Air Testing: Test welded piping for leaks, under air pressure with soap bubbles; this test shall be precede the specified hydrostatic test.

2. Hydrostatic Pressure Test: Test piping hydrostatically to one and one-half times the maximum working pressure, but in no case to less than 100 psi at the top of the system, for at least 4 consecutive hours, during which time pressure shall remain constant without pumping. Subject welded joints to hammer test while under hydrostatic pressure.

3.3 EQUIPMENT AND SYSTEM TESTS

A. General: The Test and Balance firm shall test equipment and systems and make all final adjustments and corrections necessary to place the system in proper operating condition.

B. Air Handling and Air Distribution: Adjust individual air handling unit speed, air terminals, dampers, registers, and diffusers so that air distribution will be as scheduled for the entire system with tests showing air quantities indicated for each inlet and outlet that do not vary by more than plus or minus 10 percent from those indicated on the drawings. Air handlers shall be tested and balanced to deliver total flow that varies from 0 to plus 10 percent.

1. Determine air velocity at outlets with a velometer or anemometer and using air devices manufacturer’s data, calculate the delivery cfm, or determine cubic feet per minute flow with a test hood.

2. Obtain approval of the desired method of taking velocity readings before starting balancing or tests.

3. Instruments shall be calibrated accurately before use.

4. Submit report of final tests using approved forms.

C. Secondary air distribution from each variable volume system air control terminal shall be balanced to achieve the air quantity shown for each outlet, with flow through the air valve equaling the sum of outlets.

D. Variable volume air systems shall be proportionally balanced with the air handling unit at its specified speed, delivering an air quantity equal to or not exceeding 5 percent of the scheduled air quantity. Each individual air terminal shall simultaneously deliver air quantity equal to the zone peak air flow.
for the terminal as noted on the drawings; divided by the sum of the individual flows as noted for air terminal units in the system times the actual air quantity being delivered by the system air handling unit at the completion of the balancing operation.

E. Constant volume air systems shall be balanced to provide the scheduled cfm of air flow at each air device with the unit fan operating at the specified air flow volume.

F. Delivery CFM scheduled for each air handling unit is scheduled for the block load of the area served. The CFM scheduled for each VAV and PIP terminal is scheduled for the zone peak air flow of that air terminal. The sum of all CFM scheduled for all terminals may exceed that of the air handling unit.

G. Water flow through individual water coils shall be balanced to the flow, pressure difference, and temperature difference values shown on the approved submittal for each coil.

H. Water pumping systems shall be proportionally balanced with all coil control valves blocked open and with the system differential bypass valve (if present) closed. Water flow through each coil shall equal the design flow for that coil divided by the sum of the design flows for coils in the system times the actual flow being delivered by the pump(s) at the completion of the balancing operation.

I. Central plant pumps, refrigerating equipment water flows and temperatures are scheduled at operating points representing the block load of the Project in temperature equilibrium. Water flows and temperatures for individual air handling unit and fan coil unit coils are scheduled for the zone peak of each individual air handling unit and fan coil unit coils are scheduled for the zone peak of each individual zone. The sum of all scheduled GPM or BTU of air units is not expected to match the values scheduled for the central plant equipment.

J. Control System Tubing: Test pneumatic control system under 50 psi air pressure for 24 hour period, during which time pressure loss shall not exceed 5 psi. Test connections with soap bubbles.

K. Controls: The Contractor shall calibrate and adjust all thermostats and other controlling devices.

3.4 SYSTEM OPERATING TESTS

A. After the successful completion of all equipment start-up and test requirements, the following formal testing and balancing shall be performed on the complete mechanical system:

B. Testing and Balancing: The contractor shall prove the operation of the mechanical system and shall adjust and set balancing cocks, valves, dampers, and similar items to ensure that the mechanical system performs as intended. At least 10 days' notice shall be given the Contracting Officer in advance of such tests. Should any item of the system fail to perform in an approved manner, this test shall be repeated until approved by the Contracting Officer. During or before this test, the contractor shall balance circulation of air and fluids conveyed to provide proper quantities to all equipment.

C. Checking by Authority and Contracting Officer: Following the successful completion of first operating tests by the Contractor, the Authority and the Contracting Officer shall have the privilege of making such tests as they may desire during a period of three weeks to ascertain in detail if any corrections are to be made to the system. At the end of testing by the Authority and Contracting Officer, the Contracting Officer shall direct the Contractor in writing to make such corrections to the system as are within the scope of the contract.

D. Contractor's Corrections to System: The Contractor shall make all required corrections to the system and shall notify the Contracting Officer in writing that he has completed the corrections outlined and shall give at least seven days notice of a final operating test.

E. Final Operating Test: An operating test shall be performed by the Contractor to the satisfaction of the Contracting Officer and the Authority for a period of not less than 8 hours. Should any element of the system not perform properly, the Contractor shall make all required corrections, and the test shall be repeated until successfully performed.

1. Measurements: All spaces provided on the report forms submitted for review shall be completed by typing the required information. Forms not fully completed or not legible will be returned to the Contractor for retesting of the equipment involved.

2. Report: The final operating test shall be submitted to the Contracting Officer for approval and subsequent transmittal to the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 15001, "Mechanical Systems - General".

END OF SECTION 15990
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies basic requirements specifically applicable to Division 16, "ELECTRICAL", in addition to Division 1, "GENERAL REQUIREMENTS".

B. Division 16, "ELECTRICAL", specifies work required to provide complete electrical systems, as indicated and specified. In addition, this division specifies the complete installation of systems as specified herein and as shown, and the provision of special devices, fittings, fabrications, cutting and patching and items required to fit the respective systems into the construction. Work done under this division shall be coordinated with the provisions of Division 1, "GENERAL REQUIREMENTS".

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

2. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts

3. ASTM F436 - Standard Specification for Hardened Steel Washers

4. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

B. Institute for Electrical & Electronic Engineers (IEEE):


C. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC)

1.3 DEFINITIONS

A. Drawings: The Drawings for electrical work are diagrammatic and not intended for use in determining the exact locations of the components of the electrical systems, except where specifically dimensioned or indicated with specific spacing, nor do the Drawings indicate boxes, devices, accessories, etc., required for the complete installation. Refer to the drawings of "other contracts" as referenced in General Provisions, to determine the location of equipment to be furnished by this Contract, and by other contracts as referenced.

B. Where the word "concealed" is used in connection with insulating, painting, piping, ducts and the like, the word is understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. “Exposed” is understood to mean open to view.

1.4 EXISTING UTILITIES AND TEMPORARY SERVICES FOR CONSTRUCTION

A. Verify the location and capacity of existing utility services pertaining to work of Division 16, "ELECTRICAL ". Relocate existing utilities unearthed by excavation as directed by the utility service companies affected.

B. Temporary Services for Construction: Provide temporary services in strict accordance with the provisions of these Specifications.

1.5 EXCAVATION AND BACKFILLING

A. Perform excavation and backfilling necessary, including compaction as specified, for the installation of Division 16, "ELECTRICAL" work.

B. Perform excavation and backfilling associated with the work of Division 16, "ELECTRICAL", in strict accordance with the provisions of these specifications including trench safety requirements.

1.6 JOB CONDITIONS

A. Examine the areas and conditions under which work of this Division will be performed. Include required work to correct conditions detrimental to the timely and proper completion of Division 16, "ELECTRICAL" work.

B. Where ducts, pipes other mechanical items are shown in conflict with locations of structural members and other equipment, include labor and materials required for extensions, offsets, and supports to clear the encroachment.

C. Although such work is not specifically indicated, furnish and install supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure and complete installation.

D. Verify dimensions and distances. No additional compensation will be allowed because of minor differences between work shown on the Drawings and actual dimensions and distances at the jobsite.
1.7 PREPARATION AND COORDINATION WITH OTHER TRADES

A. Perform coordination work associated with work of Division 16, "ELECTRICAL", in accordance with provisions of these Specifications and the following:

1. Coordinate as necessary with other trades to assure proper and adequate interface with work.

2. Coordinate accepted equipment changes from those scheduled or specified with other trades affected. Additional compensation to other trades for equipment changes are the responsibility of the contractor making the change.

B. The Electrical Drawings are diagrammatic, but are required to be followed as closely as actual construction and work of other trades will permit. Conduit arrangements have been designed for maximum economy consistent with standard industry practice. Install the systems arranged as shown on the Drawings, except as otherwise approved in advance by the Contracting Officer.

C. Where items such as boxes, switches, and control panels are not specifically located on the Drawings, locate as determined in the field by the Contracting Officer. Where such items are installed without such specific direction, relocate as directed by the Contracting Officer and at no additional cost to the Authority.

1.8 QUALITY ASSURANCE

A. Comply with the requirements of Section 01450, "Quality Control".

B. Provide quality control assurance in accordance with the provisions of these Specifications.

C. Perform work in accordance with the most recent edition of the following codes:

1. State and city building, and electrical codes.

2. NFPA 70

3. IEEE C2


5. Authorities having jurisdiction.

D. Where conflicts occur between drawings, specifications or code requirements, the most stringent requirement shall take precedence.

1.9 CUTTING AND PATCHING

A. Cutting and patching associated with the work of Division 16, "ELECTRICAL", shall be in strict accordance with Section 01731, “Cutting and Patching”, and other pertinent provisions of these Specifications:

1.10 TEMPERATURE RANGE

A. Unless noted otherwise, electrical equipment shall be capable of operating in the range of ambient temperatures listed below, at possible values of ambient humidity.

1. Indoor equipment: 0 degrees F to 100 degrees F.

2. Outdoor equipment: negative 10 degrees F to 120 degrees F.

1.11 PROJECT RECORD DOCUMENTS

A. Provide project record documents associated with the work of Division 16, "ELECTRICAL", in strict accordance with Section 01330, "Submittals", and other relevant provisions of these Specifications.

B. Throughout progress of the Division 16, "ELECTRICAL", work, maintain an accurate record of changes and revisions in the Contract Documents that apply to work of Division 16, "ELECTRICAL" and record the actual locations of installed piping and equipment on the project record documents.

C. Accuracy of Records:

1. Thoroughly coordinate changes within the Project Record Documents, making adequate and proper entries on each page of Specifications and each sheet of Drawings and other documents where such entry is required to show the change properly.

2. Accuracy of records shall be such that a future verification of items shown in the Contract Documents may rely reasonably on information obtained from the approved Project Record Documents.

D. Maintain the job site set of Project Record Documents completely protected from deterioration and from loss and damage until completion of the Work and transfer of recorded data to the final edition of Project Record Documents.

E. Project Record Documents (Final Edition):

1. The purpose of the final edition of the Project Record Documents is to provide factual information regarding aspects of the work, both concealed and visible, to enable future modification of the work to proceed without lengthy and expensive Site measurement, investigation, and examination.
2. Deliver one set of as-built drawings to the Contracting Officer in accordance with Section 01785, "Project Record Documents", prior to the date of substantial completion.

1.12 OPERATION AND MAINTENANCE (O&M) MANUALS

A. Operation and Maintenance Manuals: Provide manuals as specified in Section 01786, "Operation and Maintenance Instructions".

1.13 EQUIPMENT FOUNDATIONS

A. Provide equipment foundations and housekeeping pads for electrical equipment such as generators, switchgear, motor control centers, and supporting devices associated with the work of Division 16, "ELECTRICAL", in accordance with the provisions of Division 3, "CONCRETE".

1. Reinforcing: As specified in Section 03200, "Concrete Reinforcement".

2. Concrete: Mix S-7, as specified in Section 03305, "Portland Cement Concrete".

3. Anchor bolts (Bolts, nuts, and washers):
   a. Anchor Bolts: ASTM F1554, Grade 55, unless noted otherwise on drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers.
   b. Galvanized per ASTM A153/A153M.
   c. Bolts hooked, unless otherwise shown or recommended by manufacturer of structure being anchored.
   d. Two nuts and one washer for each anchor bolt for plumbing pole or leveling structure.

4. Pads shall be 6 inches high above finished floors or grades (unless otherwise noted) and shall protrude 2 inches beyond sides of equipment.

5. Provide chamfer of 1/2 inch on edges. Obtain dimensions for pads by certified and approved shop drawings, or by measuring the equipment to be installed.

6. Provide shop drawings showing method of anchoring housekeeping pads to concrete floor construction. Anchor pads to prevent lateral movement under conditions of vibration.

7. Set anchor bolts to template as required in strict accordance with details provided by the equipment manufacturer.

8. Remove and reset any anchor bolt that is set out of plumb, or has been displaced after installation.

1.14 PAINTING

A. Equipment shall be delivered to the Worksite with specified factory finish. Should the finish be damaged in transit or during the installation, it shall be finished to present a neat workmanlike appearance to the satisfaction of the Contracting Officer.

1.15 TESTING AND INSPECTION

A. Provide personnel and equipment, make required tests, and secure required approvals from the Contracting Officer and governmental agencies having jurisdiction.

B. Make written notice to the Contracting Officer adequately in advance of each of the following stages of construction:
   1. When rough-in is complete, but not covered.
   2. As specified in Division 16, "ELECTRICAL", sections.
   3. At the completion of the work in Division 16, "ELECTRICAL".

1.16 PROJECT COMPLETION

A. Upon completion of the work and prior to testing and final inspection, thoroughly clean exposed portions of the electrical systems; removing traces of soil, labels, grease, oil, and other foreign material; and using only the type of cleaner recommended by the manufacturer of the item being cleaned.

1.17 REGULATORY REQUIREMENTS & PERMITS

A. Comply with the General Provisions "PERMITS AND RESPONSIBILITIES" for permits and licenses required to complete the work.

1.18 RECOMMENDED SPARE PARTS LIST (RSPL)

A. Prepare a form listing of recommended spare parts on a Recommended Spare Parts List (RSPL) for each individual piece of equipment that is of a maintenance significant nature as specified in Section 01790, "Spare Parts and Maintenance Materials".
1.19 TRAINING
A. Operation and Maintenance Training: Provide training as specified in Section 01786, "Operation and Maintenance Instructions".

1.20 SYSTEMS STARTUP
A. The Contractor shall be responsible for a 30 day start-up period, during which time electrical and mechanical equipment, fixtures, and associated devices shall be energized and operated under local and automatic controls. The Contractor shall be present during the startup period with adequate labor and support personnel to adjust equipment and troubleshoot system failures that might arise.

1. Should a piece of equipment fail within the 30 day start-up period, then the start-up period shall start over at day zero.

B. When a piece of electrical equipment fails to perform in accordance with specifications, an adjustment shall be made to the item by an experienced representative of the manufacturer.

C. If adjustments fail to correct the operation of a piece of equipment or fixture, remove the equipment or fixture from the Worksite and replace it with a workable replacement that will meet the specification requirements.

1.21 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)
A. For equipment which have monitored SCADA points, these points/dry contacts shall terminate at one location/interface cabinet. Contact shall be normally open in non-alarm condition.

B. Submit comprehensive list or diagram SCADA System points with their designations. Make submittal in a format acceptable to the Contracting Officer.

PART 2 - PRODUCTS
2.1 PRODUCTS
A. Supply products, including spare parts, as specified in the sections of Division 16, "ELECTRICAL", and as described elsewhere in the Contract documents.

B. Supply spare parts per Division 1, "GENERAL REQUIREMENTS", and in accordance with Paragraph A above.

PART 3 - EXECUTION
3.1 GENERAL
A. Comply with requirements for installation, field testing and adjusting as specified in this section, Section 16030, "Testing of Electrical Systems", and other sections of this division. Provide O&M manuals and training as described above in Article 1.18 of this section.

B. Work in Place: Inspect the work in place and verify ability to make connections to the work in place or being installed under other current contracts. Work in place generally consists of: support inserts embedded in the construction; piping embedded in the construction and below the base slab; penetrations through floors, walls, roof, or other structural elements; and cast-in-place concrete duct systems and shafts.

C. Connections to Existing Facilities: Make connections to existing facilities in accordance with details as shown or as approved by the Contracting Officer. Where material specified under this Contract differs from material in place, provide adapters, dielectric fittings, or special connectors as required. Use the requirements of applicable codes and recommendations of material manufacturers as a basis for determining exact type of adapters and fittings to be provided under this Contract.

D. Connections to Work by Others: Connect new work provided under this Contract to work installed under other contracts, or required for equipment furnished by other contractors. Make required connections of this Contract to work by others in a proper and workmanlike manner. Refer to the Drawings and Specifications for other contracts as referenced.

E. Alterations to Existing Facilities: If it is determined that, in order to make proper connections to existing conduits, support systems, and structures, existing facilities must be altered, make such alterations in accordance with Section 01731, "Cutting and Patching", or a manner as directed by the Contracting Officer, using materials compatible with existing materials and as approved.

PART 4 - MEASUREMENT AND PAYMENT
4.1 GENERAL
A. The work specified under the individual sections under Division 16, "ELECTRICAL", will be paid for under the Contract lump sum price for Electrical Work wherein no measurement will be made.

B. The Contract lump sum for Electrical Work will include warranties, training of Authority personnel, and light pole bases for light poles.

END OF SECTION 16001
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the testing of electrical equipment to include the furnishing of required labor, instruments, wiring, cable, and incidentals to perform the required tests and adjustments for electrical systems and equipment.

B. Perform the tests specified in accordance with the General Provisions and in accordance with additional testing as described and specified elsewhere.

1.2 REFERENCE STANDARDS

A. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (NEC)

1.3 SUBMITTALS

A. Submit a detailed plan of the proposed methods of and scheduling of the overall systems and equipment testing program at least 45 calendar days prior to initiating the testing program.

B. Submit three complete bound sets of certified test reports upon completion of the project. Reflect in the reports test title, list personnel, and time spent in participating in test, describe significant change with previous product testing and describe adjustments required during test.

C. Provide NFPA 70 (NEC) Inspection and certification of the jurisdictional authorities.

1.4 QUALITY ASSURANCE

A. Comply with requirements of Section 01450, “Quality Control”.

B. Insure that upon completion of tests, systems, and equipment are in satisfactory working order. Provide adjustments and replacements required to ensure this in accordance with the Contract, and as specified for each system or piece of equipment.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 GENERAL

A. Mechanical and electrical equipment including the interfaces with the supervisory and control system and communication system and alarm and operating modes for each such piece of equipment shall be tested by the Contractor to the satisfaction of the Contracting Officer before any facility is put into operation. Tests shall be as specified in these Specifications and shall be made to determine whether the equipment has been properly assembled, aligned, and connected. Any changes, adjustments, or replacements required to make the equipment operate as specified shall be carried out by the Contractor as part of the work.

1. At least 30 days before the time allowed in his construction schedule for commencing testing and startup procedures, the Contractor shall identify if any additional support will be required from other Contractors of the Authority and/or the Authority; and shall submit his request to the Contracting Officer together with, in duplicate, details of the procedure he proposes to adopt for testing and startup of mechanical and electrical equipment, except when such procedures have been covered in the Specifications. These procedures shall be submitted for review and acceptance.

2. The Contractor's testing and startup procedures shall include detailed descriptions of preoperational electrical, mechanical, and instrumentation testing work. Each control device, item of mechanical, electrical, and instrumentation equipment, and control circuits shall be considered in the testing procedures, which shall be designed, in a stepwise, logical sequence to ensure that equipment has been properly serviced, aligned, connected, calibrated, and adjusted prior to operation. The Contractor is advised that failure to observe these precautions may place the acceptability of the subject equipment in question, and he may either be required to demonstrate that the equipment has not been damaged, or replace it as determined by the Contracting Officer. Testing procedures shall be designed to duplicate as nearly as possible conditions of operations, and shall be carefully selected to ensure that the equipment is not damaged. Once the testing procedures have been accepted by
the Contracting Officer the Contractor shall produce checkout, alignment, and adjustment, and calibration signoff forms for each item of equipment, which shall be used in the field by the Contractor and the Contracting Officer jointly, to ensure that each item of electrical, mechanical, and instrumentation equipment has been properly installed and tested. Cooperate with project-wide systems contractors' startup and testing to be conducted concurrently where applicable.

B. Before startup, the Contractor shall properly service equipment and other items which normally require service in accordance with the maintenance instructions. The Contractor shall be responsible for lubrication of equipment throughout the entire equipment "break-in" period.

1. The Contractor shall be responsible for the startup, adjustment, preliminary maintenance, and checkout of equipment and instrumentation. Systems shall be carefully checked for conformance with the design criteria.

2. If any equipment or system does not operate properly, the Contractor shall immediately replace or repair components until it operates properly.

3. When the equipment startup is complete, the Contractor shall submit a test report to the Contracting Officer.

C. Perform execution in accordance with the applicable requirements of:

1. The Occupational Safety and Health Standards (OSHA).

2. NFPA 70 - National Electrical Code (NEC).

D. Provide qualified technical personnel thoroughly familiar with the electrical systems being tested.

E. Perform tests in the presence of witnesses selected by the Contracting Officer, if he so chooses.

F. Notify the Contracting Officer if the equipment or its components fail to meet the specified inspection and test criteria. Do not repair or modify the equipment without written approval from the Contracting Officer. After replacement, repair, or modification, repeat the specified inspections and tests to the satisfaction of the Contracting Officer.

G. Where applicable, test individual components of a system before testing the complete system to meet the requirements of the applicable specifications.

3.2 TESTING LOW VOLTAGE, SWITCHBOARDS, AND MOTOR CONTROL CENTER (Sections 16425, 16470 and 16915)

A. Check control and metering circuits for proper operation.

B. Check contact alignment on contactors, switches and circuit breakers.

C. Check and set trips for proper coordination.

D. Check circuit breakers and switches to ensure the protective device nearest the fault will open before other devices upstream open.

E. Perform insulation resistance test between phase-to-phase and phase-to-ground.

F. Test grounding conductors and enclosures for continuity to ground bus.

G. Test system ground.

H. Perform dielectric withstand test of 60 seconds duration on entire assembled and erected switchgear using 60 Hertz voltage level at 1000 volts AC or 80 percent of factory test voltage, whichever is more stringent.

I. Inspect and clean busses and contacts.

J. Check voltage at no load and full load (total connected load) on the busses of the switchgear, switchboards, and the secondaries of transformers. After the transformer voltage tests are performed adjust transformer primary taps.

K. Check space heaters on equipment for proper operation. Energize space heaters as soon as the equipment with space heaters is received on the site.

L. Low Voltage Switchboards:

1. Check wiring for accuracy, open circuits and short-circuits, ground connections and insulation integrity by means of high-potential, continuity and operational tests.

2. Subject wiring to high-potential test of 1,500 volts AC to ground for one minute.

3. Verify that wiring is in accordance with manufacturer's wiring diagrams.

4. Check wiring complete, including interconnections at shipping breaks.
3.3 Testing Wire and Cable

A. Check wires for continuity and identification by means of a D.C. test device with bell or buzzer or by means of battery operated phones before terminal connections are made.

B. Perform insulation resistance tests on wiring after final terminations and splices have been made but prior to energizing. Perform the tests with disconnecting devices in the open position to include only the circuits to be tested.

C. Cable Rated Above 600 Volts:
   1. After completion of terminations and prior to connection to the apparatus, perform insulation resistance tests on cable. Perform the tests on each phase to ground with the remaining 2 phases grounded.
   2. Perform tests by means of a D.C. step-voltage type tester with the steady-state leakage current being recorded at each of 10 equal steps from zero to maximum test voltage (80 percent of final factory test voltage).
   3. Record the leakage current each minute for a period of five minutes when the maximum test voltage is achieved.

D. Cable Rated 600 Volts and Below:
   1. Perform insulation resistance tests on feeders and subfeeders. This includes cables to the final points of distribution (panelboards, motor control centers, and other incidental items). Measure and record the insulation resistance for each phase conductor to ground.
   2. Perform the tests by utilizing a megger insulation tester with a full range scale from 0 to 200 megohms and using 1000 volts D.C. The minimum acceptable reading on any feeder is 2 megohms.

3.4 Ground Resistance Tests

A. Perform testing using ground resistance direct-reading single test meter utilizing alternating current fall-of-potential method and two reference electrodes.

B. Perform the tests by driving two reference electrodes. Locate one reference electrode 50 feet from the ground under test and locate the other reference electrode an additional 50 feet in the same direction away from the ground under test.

C. Performed ground resistance tests on driven ground rods and ground counterpoise systems.

D. Provide the maximum scale range for ground resistance tests of 0 to 200 megohms and using 1000 volts D.C. For the resistance to ground for equipment and system grounds do not exceed the maximum resistance values specified in Section 16450, “Grounding and Bonding”.

E. If ground resistance exceeds the specified maximum values, install additional ground electrodes to meet resistance requirements.

3.5 Testing of Transformers (Section 16460)

A. Submit certified manufacturer's test data for each type and rating of transformer confirming performance and test data previously submitted in accordance with Paragraph 1.3 of Section 16460, "Transformers".

B. Perform field testing in accordance with the requirements of Section 16030.

C. Test voltage ratio of each tap. Results deviating by more than 0.5 percent from calculated ratio will not be accepted. Set taps as directed.

D. Check polarity by means of vector check.

3.6 Testing of Motors

A. Before making final connections, use a motor rotation meter to determine the proper connections and to insure proper rotation when the motor is energized.

B. Megger test motors before connection and check for rotation before motors are coupled to fans or pumps. Verify that motor rotation is the same as fan rotation. Verify that motor is magnetically centered before coupling.

C. Perform the following motor tests prior to start-up:
   1. Check wiring connections in accordance with wiring diagram.
   2. Check motor nameplate data. From the nameplate full load amperes, determine, for motors, the rating of the overload heaters necessary to provide proper overload protection.
   3. Check the starters to ascertain that the proper overload have been installed. Furnish and replace any improperly sized overload heaters in starters.
4. Check space heaters of motor for proper operation. Energize space heaters as soon as the motors with space heaters are received on the site.

D. Perform the following motor tests after start-up:

1. Check line current on each phase for motors.
2. Investigate and correct the cause where a motor draws more current than rated full load current. Do not change the overload heaters without the approval of the Contracting Officer.

3.7 TESTING LIGHTING (Section 16500)

A. Check lighting and receptacle circuits for proper operation. Check lighting controls for proper operation.

B. Whenever practicable, test lighting systems at the same time that the distribution panelboard or switchboard is tested.

C. Adjust floodlights in accordance with the aiming chart provided by the manufacturer. Make adjustments during darkness to obtain the optimum lighting levels throughout.

D. Check fixtures with standby batteries to confirm that transfer switch, battery, and charger operate properly.

E. Check fixtures on an emergency power circuit (generator or other central power source) by simulating a failure of normal power.

F. After adjustments have been completed, check light levels with a precision light meter to verify that the specified footcandle level has been achieved.

3.8 TESTING LIGHTING CONTROL AND FIRE AND INTRUSION ALARM SYSTEMS (Section 16721)

A. Check control and alarm systems for proper operation. Check individual alarms for proper function.

3.9 TESTING LIGHTNING PROTECTION SYSTEM (Section 16670)

A. Inspect components, materials and workmanship, and determine that they meet or exceed UL and NFPA requirements.

3.10 FIELD INSTALLATION AND TESTING

A. Contact the manufacturers of the equipment consisting of substation, switchboards and motor control centers, and make arrangements to have their representatives present at the Site to:

1. Supervise and instruct personnel in assembling the various components of the equipment.
2. Coordinate and adjust the settings of relays and devices.
3. Inspect and supervise the testing of the equipment after it is installed.

3.11 TESTING EMERGENCY POWER SYSTEMS

A. Test operation of emergency power supplies (generator, CELPS, UPS, or other central power source) by simulating a failure of normal power. Note that power source and transfer switches operate properly (including voltages, frequency, and time delays) and that emergency loads are supplied with correct power.

B. Test of the functions of the emergency power system, including (but not limited to): Re-transfer to normal power, battery charging, engine operation, and programmed exercising.

1. Testing of Emergency Lighting Units:

a. Testing: Furnish necessary personnel equipment and perform tests and adjustments in the presence of the Contracting Officer.

b. Test units for continuity and operation.

c. Check tightness of cable connections.

d. Aim and adjust heads or fixtures to provide distribution pattern approximately as shown and as approved.

e. Test lighting levels to assure they meet requirements of codes (especially NFPA 101) and applicable drawings and specifications.

1) Unit must operate properly within 10 seconds maximum.

2) Unit must operate for minimum of 90 minutes.

3) Units must provide a minimum of 1 fc at ground level along path of egress. Adjust heads to meet this requirement.
2. Testing of Central Emergency Lighting Power Supply:
   a. Operate the complete system and demonstrate that component work properly and as specified.
   b. Demonstrate with meters and oscilloscope that power characteristics, including voltages, frequency, and wave form, are in accordance with the Specifications.
   c. Simulate power failure to demonstrate proper transfer and re-transfer.
   d. Visual Inspection
      1) Inspect equipment for signs of shipping or installation damage
      2) Verify installation per manufacturer’s approved shop drawings
      3) Inspect cabinets for foreign objects and debris
      4) Verify the neutral and ground conductors are properly sized and configured
   e. Mechanical Inspection
      1) Check power modules are correctly fitted
      2) Check battery modules are correctly fitted
      3) Check terminal screws, nuts and lugs for tightness
   f. Electrical Inspection
      1) Confirm input voltages and phase rotation is correct
      2) Verify bypass voltage jumpers are correct for voltages being used.

3. Standby Power Systems:
   a. Test the engine generator set and the automatic transfer switch in the field to demonstrate that the system has been properly installed and that it meets the requirements of this Specification. Supply test equipment including load bank and materials to conduct full load test.
   b. Test SCADA dry contacts operation to demarcation panel.

C. Tests shall be conducted using a load bank. Field equipment shall be disconnected until such time that emergency power system passes full load test.

3.12 STATION DEMARCATION TERMINAL CABINET TESTING (Sections 16130 and 16135)
   A. Test operation of SCADA alarm contacts at the terminal blocks of the Station Demarcation Terminal Cabinet for each of the described SCADA alarm functions indicated. Verify and record continuity of the cables for voice, VMB signal and PA systems.
   B. Record and submit, in accordance with paragraph 1.3 of this Section, the results of these tests.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. In accordance with Section 16001, "Electrical Systems - General"
SECTION 16040
IDENTIFICATION OF ELECTRICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the furnishing and installing of nameplates on electrical equipment.

1.2 SUBMITTALS
A. Samples:
1. Two sample nameplates.
2. Samples of types of fasteners to be used.
3. Samples of adhesive materials (if used) with complete description and list of ingredients.

B. Identification List: Submit complete listing of nameplate identification system for approval, following guidelines to be developed by the Contracting Officer.

C. Material list showing composition of nameplate elements.

PART 2 - PRODUCTS

2.1 NAMEPLATES
A. Provide nameplates consisting of three-ply, laminated phenolic plates, approximately 1/8 inch thick with beveled edges, engraved through black face to white core and attached by four stainless steel rivets, drive screws, or sheet metal screws. Where it is not practical to drill holes in the item to be identified, an approved adhesive may be used in lieu of screws or rivets.

B. For letter size of nameplates conform to ANSI requirements.

C. Provide vertical gothic lettering using round or square cutter. V-shape groove is not acceptable.

D. Provide nameplates 1 inch high by 3 inches wide or as shown.

E. Where equipment nomenclature requires additional space, provide nameplates of such size as required.

F. Standard abbreviations may be used as required.

G. Obtain approval by the Contracting Officer of identification system before fabrication of nameplates.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Place nameplates on each remote motor starter, motor operated damper, push button station, pilot light, alarm bell, and control device.

B. Place nameplates on each starter and circuit breaker in motor control centers.

C. Place nameplates on each transformer, CELPS, UPS, disconnect switch, generator, fire alarm panel, intrusion alarm panel, switchboard, panelboard, contactor, and time clock; and on each cabinet or panel containing control devices.

D. Install in accordance with nameplate manufacturer’s instructions.

E. Label pullboxes and junction boxes with circuit numbers identified with permanent marker or adhesive label.

F. Label switch and receptacle devices with circuit numbers identified with permanent marker on backside of cover plates.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16040
PART 1 - GENERAL

1.1 DESCRIPTION

A. An Engineering Analysis and Coordination Study (Power Study) shall be performed for each Traction Power Substation (TPSS) and the associated electrical distribution system. This Specification Section contains the requirements for this Power Study. The study shall be performed utilizing the current ANSI/IEEE standards referenced herein. The intent of this study is to verify that the specified and supplied equipment is properly rated, correctly applied, and within industry and manufacturer’s tolerances.

B. Contractor shall prepare and submit a “Power Study” for approval by the Authority, the study shall consist of the following:

1. Short Circuit Analysis with Protective Device Evaluation: Evaluate the power system design to withstand fault currents and avoid resultant fires and equipment damage.

2. Protective Device Coordination Study: Prepare coordination time-current characteristic curves to determine the required setting and ratings for all the protective devices from the Utility fuse to the DC Breaker.

3. Arc Flash Evaluation: An arc-flash hazard analysis should be performed in association with or as a continuation of the short-circuit study and protective-device coordination study.

4. Harmonics Study:
   a. Perform harmonic analysis to determine the paths and harmonics that may flow into the Utility system. Include the
   b. Harmonic current magnitudes and voltage magnitudes.

C. Qualifications:

1. Contractor shall have the “Power Study” prepared by a qualified engineer of an independent consultant registered in the State of Texas who has at least 10 years of experience and specializes in performing power system studies.

2. Perform the study using a computer software package. Submit a complete description of the analysis program being used; include the version of software and any accessory software including database type libraries. Include sample copies of input and output screens and exact method of calculations.

3. If the Engineer makes self-generated type calculations, a copy of all the calculations shall be included.

1.2 REFERENCED STANDARDS

A. American National Standards Insitute (ANSI)


2. ANSI/IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.


4. ANSI C37.5 - Calculation of Fault Currents for Application of AC High-Voltage circuit breakers rated on a total current Bases.


B. Institute of Electrical and Electronics Engineers (IEEE)


2. IEEE 519 - Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems.

C. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC) requirements for warning labels

D. Occupational Safety and Hazard Administration (OSHA)

1. 29 CFR Part 1910 – Occupational Safety and Health Standards

2. 29 CFR Part 1926 – Safety and Regulations for Construction
E. International Cable Engineers Association (ICEA)

1. ICEA P-45-482 - Short Circuit Performance of Metallic Shields and Sheaths on Insulated Cable.

1.3 SUBMITTALS

A. NLT 30 days prior to shipment, submit for each Substation a complete coordination study for approval by the Authority.

B. Study shall include a one-line impedance diagram which shall include all pertinent equipment data, identify all busses, and shall include:
   1. A list of all fault contributors.
   2. A list of fault levels at each bus for 3-phase bolted faults and ground faults.
   3. Transformer KVA and voltage ratings, percent impedance, X/R ratios.
   4. Voltage at each bus.
   5. Identifications of each bus.
   6. Equipment data including feeder circuit sizes, conduit material and lengths.
   7. Equipment interrupting ratings.
   8. Time current plots which graphically illustrate performance.
   9. Equipment operating characteristics.
   10. A completely separate list of protective device settings.

C. Final report shall be bound in a 3-ring binder.

D. Submit for approval a short circuit study and coordination study for each Substation Site.

E. Submit for approval 1 equipment arc study for each type of TPSS.

1.4 QUALITY ASSURANCE

Not Used.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 GENERAL

A. Contractor shall coordinate with the TPSS Installation Contractor in obtaining the wire sizes, insulation types, conduit types and circuit lengths for use in the “Power Study”.

B. Primary service power for each Substation site shall be provided from an underground 3-phase utility feeder provided by the local utility. The Point of Service (POS) shall be at the utility service pole at the bottom of the utility fused cutout. Contractor shall coordinate with the Line Section Contractor to obtain the available short circuit power from the local utility for each site.

3.2 IMPEDANCE ONE-LINE DIAGRAM

A. Create an impedance one-line diagram. All electrical equipment wiring to be protected by the devices installed under this contract and each location where the fault current will be calculated shall be shown. Clearly show, on the one-line, the schematic wiring of the electrical distribution system, include:
   1. List of all fault contributors.
   2. List of fault levels at each bus for 3-phase bolted faults and ground faults. Include bolted faults and ground faults on the DC Bus.
   3. Transformer KVA and voltage ratings, percent impedance, X/R ratios.
   4. Voltage at each bus.
   5. Identifications of each bus.
   6. Equipment data including feeder circuit sizes, conduit material and lengths.
   7. Equipment interrupting ratings.
   8. Time current plots which graphically illustrate performance.
   9. Equipment operating characteristics.
   10. Separate list of protective device settings.

3.3 SHORT-CIRCUIT ANALYSIS WITH PROTECTIVE DEVICE EVALUATION

A. Systematically calculate fault currents based on the available fault current at the facility POS. The power study preparer shall coordinate with each Line Section Contractor to obtain the available fault current from the local utility. This Study shall recommend and coordinate the proper primary fuse size for the Utility.

B. The short circuit analysis shall terminate at each branch bus at the lowest utilization voltage secondary bus where the symmetrical short circuit RMS ampere is less than 10,000 amperes. It is the intent of these specifications to determine all
locations in the entire electrical system where the symmetrical short circuit amperes meets or exceeds 10,000 amperes.

C. Short circuit analysis shall compare interrupting ratings of all electrical protective devices connected to each bus with that of the available fault current at the load terminals of each protective device.

D. Short-circuit calculations shall be prepared by hand calculations or by means of a digital computer utilizing a commercially available software package.

E. Motor contribution shall be incorporated in determining fault levels. Results of short-circuit calculations shall be presented in tabular form and shall include momentary and interrupting fault values for 3-phase and phase-to-ground faults.

F. Analyze the short-circuit currents by preparing a tabulation comparing the fault levels to the device interrupting ratings. Indicate areas in which integrated/series ratings are utilized. The following information shall be included in the tabulation:

1. Bus identification number.
2. Location identification.
3. Voltage.
4. Manufacturer and type of equipment.
5. Device rating.

3.4 PROTECTIVE DEVICE COORDINATION STUDY

A. A Protective Device Evaluation Study shall be performed to determine the adequacy of circuit breakers, molded case switches and fuses. Any problems areas or inadequacies in the equipment due to prospective short-circuit currents shall be brought to the attention of the Authority.

B. A Protective Device Coordination Study shall be performed including calculations required to review the selection of power fuse ratings, protective relay characteristics and settings, ratios and characteristics of associated current transformers, and low-voltage breaker trip characteristic and settings.

C. Prepare coordination time-current characteristic curves to determine the required settings/sizes of the protective devices to maximize selectivity and backup tripping. The utility upstream protective device feeding the facility shall be maintained as the upper limit for coordination. These settings shall be obtained by the preparer, along with any other protective device setting requirements. The coordination curves shall be prepared on log-log paper and illustrate adequate clearing times between series devices. The curves shall be created using the study software package, but must reflect actual protective devices to be installed. Adequate time-current curves shall be generated to depict coordination. In addition, protective device characteristics shall be suitably determined to reflect calculated short-circuit levels at the location.

D. A narrative analysis shall accompany each coordination curve sheet and describe the coordination and protection in explicit detail. All curve sheets shall be multi-color for improved clarity. Areas lacking complete coordination shall be highlighted and reasons provided for allowing condition to remain or provide solution to resolve situation.

E. The following information shall be provided on all curve sheets.

2. Voltage at which curves are plotted.
4. ANSI frequent fault damage curve.
5. Cable insulation damage curves.
6. Transformer inrush point and Transformer Damage Curve.
7. Single-line for the portion of the system.
8. Fuse melting and clearing curves
9. Full load curves and overload curves

F. A summary tabulation shall be included in the study listing all adjustable protective devices with all recommended settings and each adjustable band included in each device.

G. Coordination study shall include ground-fault coordination inclusive of the medium voltage service cable shielding. The study shall verify that the service cable shielding and ground connections are adequate for the available fault current.

3.5 ARC FLASH CALCULATIONS

A. Contractor shall perform a system analysis of the equipment furnished by this Contract for determining the flash protection boundary and the requirements for Personnel Protective Equipment (PPE), Provide:
1. Calculations for the degree of arc flash hazard.

2. Warning labels on equipment containing the equipment’s flash protection boundary, its incident energy level, and the required personal protective equipment.

3. A list of appropriate tools and PPE required for safe working requirements. Note: the Contractor shall furnish any PPE determined to be required by these calculations.

4. A summary of any safety requirements for safe operation of this equipment for inclusion in the Authority’s Safety Program.

3.6 HARMONICS STUDY

A. A harmonic study shall be performed for each type of transformer in accordance with the recommendations in the Reference Standards and as specified herein.

B. Harmonic study shall verify that the voltage harmonics produced on the utility service connection feeder does not exceed the voltage harmonic limitations specified by the local utility.

3.7 ANALYSIS

A. In the final report, prepare an analysis of the short circuit calculations, coordination study, arc-fault calculations and harmonic study. Highlight any equipment that is determined to be underrated, propose approaches to effectively protect the underrated equipment.

B. After developing the coordination curves, highlight areas lacking coordination. Present a technical evaluation with a discussion of the logical compromises for best coordination.

3.8 ADJUSTMENTS, SETTINGS AND MODIFICATIONS

A. Necessary final field adjustments, settings and minor modifications shall be made to conform to the protective device study.

B. All final circuit breaker and relay settings and fuse sizes shall be made in accordance with the recommendations of the protective device study.

3.9 FINAL REPORT

A. Results of the “Power Study” shall be summarized in a final report. The report shall include the following sections:

1. Introduction, executive summary and recommendations, assumptions, impedance one line drawing, and copies of the project one-line drawing.

2. Tabulations of equipment ratings versus calculated short circuit values and X/R ratios, and commentary regarding same.

3. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selection and commentary regarding same.

4. Copies of the manufacturer’s time current curves for the devices studied and plotted on the time current curves.

PART 4 MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Work specified in this section will not be measured separately for payment, all costs in connection with this Section will be considered incidental to the furnishing and delivery of the TPSS units.

4.2 PAYMENT

A. Payment for the work specified in this section is considered as part of the project management of this Contract and shall be included in the Payment Schedule as a representative portion of each bid item value, which price will be full compensation for the performance of all requirements as described in this section including all materials, labor, transportation, handling, storage, tools, computer equipment, test equipment, rental equipment, printing services and incidentals necessary to complete the work as specified in this section, and all other related sections of the Specifications and the Drawings.
3. ANSI C37.58 - Rating Structure for AC Low-Voltage Circuit Breakers
4. ANSI C37.60 - Test Procedure for AC Low-Voltage Circuit Breakers
5. ANSI C37.62 - Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
6. ANSI C37.64 - Insulated Wire, Cable, and Accessories
7. ANSI C37.66 - Wiring Devices
8. ANSI C37.68 - Warning Signs
9. ANSI C37.70 - AC Distribution Panelboards
10. ANSI C37.72 - Lighting Fixtures
11. ANSI C37.74 - Low-Voltage AC Manual Transfer Switch
12. ANSI C37.76 - Low-Voltage AC Power Receptacles

B. American National Standards Institute (ANSI)
1. ANSI C37.41 - Test Methods for Electric Insulators
2. ANSI C37.44 - Test Methods for Electric Insulators
20. ANSI C62.2 - Guide for Application of Valve Type Lightning Arresters for AC Systems

21. ANSI C78.1 - Fluorescent Lamps - Rapid Start Types - Dimensional and Electrical Characteristics

22. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated

23. ANSI C80.3 - Specifications for Electrical Metallic Tubing, Zinc Coated

24. ANSI C80.4 - Specification for Fittings for Rigid Metal Conduit and Electrical Metallic Tubing

25. ANSI C82.1 - Fluorescent Lamp Ballasts

26. ANSI C84.1 - Voltage Ratings for Electric Power System and Equipment

27. ANSI C92.1 - Voltage Values for Preferred Transient Insulation Levels

C. American Railway Engineering and Maintenance Right-of-Way Association (AREMA)

1. AREMA CH 33-7.0 - Rail Bonding (Manual of Railway Engineering, Volume II)

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

1. ASTM A108 - Steel Bars, Carbon, Cold-Finished, Standard Quality

2. ASTM A123 - Zinc (Hot-Dip Galvanized) Coatings for Iron and Steel Products

3. ASTM A153 - Zinc Coating (Hot-Dip) on Iron and Steel Hardware

4. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

5. ASTM A36 - Structural Steel

6. ASTM A48 - Gray Iron Castings

7. ASTM A569 - Steel, Carbon (0.15 Maximum, Percent) Hot Rolled Sheet and Strip Commercial Quality

8. ASTM A575 - Steel Bars, Carbon, Merchant Quality, M-Grades

9. ASTM A576 - Steel Bars, Carbon, Hot-Wrought, Special Quality

10. ASTM B173 - Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

11. ASTM B187 - Copper Bus Bar, Rod, and Shapes

12. ASTM B187 - Specification for Copper Busbar, Rod and Shapes

13. ASTM B189 - Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes

14. ASTM B3 - Soft or Annealed Copper Wire

15. ASTM B633 - Electrodeposited Coatings of Zinc on Iron and Steel

16. ASTM B8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

17. ASTM D149 - Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies


19. ASTM D2000 - Classification System for Rubber Products in Automotive Applications (SAE J200)

20. ASTM D2240 - Rubber Property - Durometer Hardness

21. ASTM D2802 - Ozone-Resistant Ethylene-Propylene Rubber Insulation for Wire and Cable

22. ASTM D570 - Water Absorption of Plastics

23. ASTM D635 - Rate of Burning and Extent and Time of Burning of Self-supporting Plastics in a Horizontal Position

24. ASTM D638 - Tensile Properties of Plastics

25. ASTM D695 - Compressive Properties of Rigid Plastics

26. ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
27. ASTM E84 - Surface Burning Characteristics of Building Materials

E. Federal Specification (FS)

1. FS FF-S-325 - Shield, Expansion; Nail Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
2. FS L-P-387 - Plastic Sheet, Laminated, Thermosetting (For Design Plates)
3. FS W-F-408 - Fittings for Conduit, Metal, Rigid (Thick Wall and Thin Wall) (EMT) Type

F. Insulated Cable Engineers Associations (ICEA)

1. ICEA S-19-81 - Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy
2. ICEA S-68-516 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy (NEMA WC8)
3. ICEA5-95-658 - Non-Shielded Power Cables rated 2000 volts or less for the Distribution of Electrical Energy (NEMA WC 70)

G. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 141 - Recommended Practice for Electric Power Distribution for Industrial Plants
2. IEEE 316 - Direct Current Instrument Shunts
3. IEEE 383- Class 1E Electrical Cables, Field Splices and Connections for Nuclear Power Generating Stations
4. IEEE 730 - Software Quality Assurance

H. National Electrical Manufacturers Association (NEMA)

1. NEMA AB 1 - Molded Case Circuit Breakers
2. NEMA BU 1 - Busways
3. NEMA EI 2 - Instrument Transformers
4. NEMA ICS 4 - Terminal Blocks for Industrial Use

5. NEMA PB 1 - Panelboards
6. NEMA RN 1 - Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit
7. NEMA SG 3 - Low-Voltage Power Circuit Breakers
8. NEMA SG 4 - AC High-Voltage Circuit Breakers
9. NEMA SG 5 - Power Switchgear Assemblies
10. NEMA SG 6 - Power Switching Equipment
11. NEMA TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)
12. NEMA TC 3 - PVC Fittings for use with Rigid PVC Conduit and Tubing
13. NEMA VE 1 - Metallic Cable Tray Systems
14. NEMA WC 5 - Thermoplastic-Insulated Wire and Cable
15. NEMA WC 57 - Standard for Control and Instrument Cable
16. NEMA WC 7 - Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable
17. NEMA WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable
18. NEMA WD 1 - General Purpose Wiring Devices
19. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

I. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)

J. Underwriters Laboratories, Inc. (UL)

1. UL 5 – UL Standard for Safety Surface Metal Raceways and Fittings
2. UL 6- UL Standard for Safety Electrical Rigid Metal Conduit - Steel
3. UL 20 - UL Standard for Safety General - Use Snap Switches
1.3 SUBMITTALS
A. NLT (60 days after NTP): Manufacturer’s Equipment Drawings and Installation Instructions

1.4 QUALITY ASSURANCE
A. Contractor shall perform the work included in this section in strict accordance with the requirements of the Contractor’s Quality Control Program as approved by the Authority and in compliance with the requirements of these Specifications. Contractor shall perform the following:

1. Material qualification testing and certification for acceptance of materials, components, assemblies and sub-assemblies.

2. Project control testing of in-progress work being performed in shops, factories, and on-site and off-site locations.

3. On-site inspection of specified work elements.

PART 2 - PRODUCTS

2.1 GENERAL
A. Contractor shall submit for approval, manufacturer’s descriptions, catalog data, shop drawings, run sheets, and product information, including cut sheets, etc. showing model numbers or item identification, for all the electrical equipment and products incorporated into the Substations.

B. All equipment and materials shall comply with these Specifications and the Referenced Standards.

2.2 TEST REPORTS
A. Provide certified test reports or manufacturer’s certification demonstrating that materials comply with the specified requirements and the referenced standards.

2.3 MATERIALS
A. Materials furnished shall be standard products of manufacturers regularly engaged in the production of materials specified.

B. Contractor shall provide materials and equipment that is readily available for replacement.
2.4 CONDUIT EXPANSION AND DEFLECTION FITTINGS

A. Provide fittings that are UL listed and shall consist of 2 threaded end couplings, bronze for dry locations. Either hot-dip galvanized malleable iron, or hot-dip galvanized ductile iron.

B. A neoprene sleeve attached to the end couplings by stainless steel bands. Sleeve shall accommodate the following movements without collapsing or fracturing the conduits and damaging the wiring:

1. Axial expansion or contraction from normal of 3/4-inch minimum in either direction.
2. Parallel misalignment of the axis of coupled conduit runs, in any direction, of 3/4-inch minimum.
3. Angular misalignment of the axis of coupled conduit runs, in any direction, of 30 degrees minimum.

C. Where applicable, a tinned flexible copper braid bonding jumper, integral with the expansion fitting, attached to the end couplings to provide electrical continuity.

2.5 STEEL CABLE TRAYS

A. Steel trays shall be ladder type or solid-bottom type as required or indicated and shall be hot-dip galvanized after fabrication in accordance with the Referenced Standards.

B. Ladder Type Cable Trays:

1. Dimensions: Inside clear width shall be as required. Inside usable depth shall be 4 inches minimum. Outside depth shall be 6 inches maximum.
2. Fitting Radius: As required to suit tray width and capacity.
3. Rung Spacing: Maximum 9 inches between centers.
4. Working Load: Provide 50 pounds per linear foot on a maximum span of 8 feet with a safety factor of 1.5.
5. Fabrication: Straight sections and fittings shall consist of rungs located between channel-shaped side rails.
6. Flame Spread Index: Per the Referenced Standards.
7. Smoke Density: Per the Referenced Standards.

2.6 FIBERGLASS CABLE TRAYS

A. Fiberglass trays shall be ladder type, manufactured from fiberglass-reinforced polyester resin, designed as follows:

1. Dimensions: Inside clear width shall be as required. Inside usable depth shall be 4 inches minimum. Outside depth shall be 6 inches maximum.
2. Fitting Radius: 24 inches.
3. Rung Spacing: Maximum 9 inches between centers.
4. Working Load: Provide 50 pounds per linear foot on a maximum span of 8 feet with a safety factor of 1.5.
5. Fabrication: Straight sections and fittings shall consist of rungs located between channel-shaped side rails.
6. Flame Spread Index: Per the Referenced Standards.
7. Smoke Density: Per the Referenced Standards.

2.7 METAL FRAMING AND WIREWAYS

A. Metal Framing (Continuous Slot Metal Channel System): Comply with the following requirements:

1. Channel: Steel, where used as a raceway and lighting fixture support, channel shall be listed by UL as complying with UL 5 for use as surface raceway and support for lighting fixtures with electric discharge lamps.
2. Configuration: Single channel or 2 single channels welded together. Channels shall accept spring-held steel nuts.

5. General Fittings Dimensions, for Flat, Angular and U Shapes: 1/4 inch thick by 1-5/8 inch wide, unless otherwise indicated.


7. Nuts, Bolts, and Screws Finish: Electro-deposited zinc coating, Class Fe/Zn 5, Type III.

8. Wire ways: Galvanized sheet steel with screw covers, complying with UL 870.

2.8 HANGERS AND SUPPORTS

A. Hanger Rods: Threaded, hot-rolled steel, 3/8 inch diameter minimum with electro-deposited zinc coating, Fe/Zn 5, Type III.

B. Trapeze, Multiple Conduit Hangers: Fabricated of 2 or more galvanized steel hanger rods, a steel channel horizontal member and U-bolts, clamps and other attachments necessary for securing hanger rods and conduits.

C. Horizontal Member: Continuous slot galvanized metal channel single or double, as required.

2.9 CONCRETE INSERTS

A. Continuous Insert: Steel single channel with concrete anchors and continuous slot to accept spring held steel nuts. Channel hot-dip galvanized and filled with expanded polystyrene. Nuts and springs electro-deposited zinc coating.

B. Expansion Anchors: Steel with electro-deposited zinc coating.

C. Equipment Anchorages: Steel leveling plates, angles, and studs.

2.10 OUTLET, JUNCTION, PULL, AND CORROSION CONTROL BOXES

A. Surface Mounted Outlet and Switch Boxes: Cast iron alloy, hub-type with cover gasket in wet locations, complete with painted steel cover plates.

B. Pull Junction Boxes:

1. Dry Locations: Galvanized, 16-gage minimum, sheet steel with welded seams and screw covers. Corrosion control boxes shall have a hinged cover.

2. Wet Location: NEMA Type 4X or 3R, hot-dip galvanized sheet metal, stainless steel or Aluminum.

2.11 GROUNDING AND BONDING MATERIALS

A. Ground Rods: Medium carbon steel core, copper-clad by the molten weld casting process and have a conductivity of not less than 27 percent of pure copper. Rods shall be not less than 3/4-inch diameter with lengths as indicated.

B. Ground Conductors: Class B stranded annealed copper and sizes as indicated.

C. Ground Test Station Bus: Provide 98 percent conductivity tinned copper. Bus size shall be not less than 2 inch by 1/4 inch. Bus shall be supported by standoff insulators having an insulation level of 2 KV.

D. Connectors:

1. Exposed ground connections shall be bolted type of high copper alloy. Terminal lugs on cable ends shall be compression or exothermic-weld type.

2. Buried ground connections shall be exothermic-weld type.

2.12 INSULATED WIRE, CABLE, AND ACCESSORIES

A. High-Voltage AC Power Cable:

1. Type: Cables shall be single-conductor, shielded, and appropriate for use on 13.2 KV or 12.47 KV, 3-phase, 60 Hz systems. Cables shall comply with the referenced standards, type MV-90, and shall be suitable for installation in conduit and ducts. Conductor size shall be as required, but not less than No. 2 AWG and the maximum continuous operating temperature rating shall be 194 degrees F.

2. Conductors: Shall be uncoated copper wire in compliance with ASTM B3 and Class B stranded conductor conforming to ASTM B8.

3. Strand Screen: Extruded semi conducting ethylene - propylene - rubber (EPR) thermosetting compound, which shall be clean stripping from the conductor and firmly bonded to the overlying insulation.

4. Insulation: Insulation shall be a flame-resistant, ethylene-propylene-rubber thermosetting compound with minimum average insulation thickness for 133
percent insulation level in accordance with the applicable standards.

5. Insulation Screen: An extruded semi-conducting, EPR cover shall be applied directly over the insulation. It shall be clearly identified as being conductive.

6. Insulation Shield:
   a. Bare 5 mils thick minimum, copper tape shall be helically applied over the insulation screen with a minimum overlap of 25 percent.
   b. Nonmetallic jacket shall consist of a durable black moisture-resisting heavy-duty vulcanized chlorosulphonated polyethylene compound, with a thickness of not less than 80 mils.

7. Cable Identification: The following information shall be printed on the jacket, in contrasting color, at approximately 2-foot intervals:
   a. Manufacturer's name.
   b. Year of manufacture.
   c. Conductor size.
   d. Voltage rating.
   e. Insulation type.
   f. Jacket type.

8. Warranty: Cable shall have a written warranty of not less than 40 years.

B. Low-Voltage Wire and Cable:

1. Shall be UL listed for the intended purpose.

2. Conductors: Soft or annealed copper complying with ASTM B3.

3. Power Circuits: Size No. 12 AWG, minimum, shall be ASTM B8, Class B stranded conductor.


5. Fixture wiring: Size No. 16 AWG, minimum, ASTM B8, Class C stranded.

6. Wire that crosses hinge points shall be flexible Class C stranded.

C. Insulation:

1. Power Circuits: Conductors shall be insulated with a flame retardant dielectric based on an ethylene - propylene type elastomer meeting UL1581. Jacket overall shall be mechanically rugged cross-linked polyolefin or thermoplastic compound to comply with UL1277.

2. Control Circuits (except panel wiring): Conductors shall be insulated with a flame retardant dielectric based on an ethylene - propylene type elastomer meeting UL1581. Jacket overall shall be mechanically rugged cross-linked polyolefin or thermoplastic compound to comply with UL1277.

3. Panel Wiring: NEC Type SIS or TBS. Comply with UL 83 flame-retardant properties test. Wiring in dc switchgear compartments subjected to 845 V DC nominal potential shall have a 2,000 V AC minimum insulation level. Each conductor shall be one continuous length from terminal to terminal with no splices or taps. Control wiring shall be so designed and installed that faults on power circuits cannot be communicated to the control wiring of that circuit or of another power circuit.

4. Fixture Wiring: NEC Type SFF-2 or PFF.

5. Non-metallic jacket for single-conductor cable and as overall covering on multiple-conductor cable. Jacket shall have the following physical requirements, properties and tested in accordance with the Referenced Standards.
   a. Tensile strength, minimum pounds per square inch: 1,800.
   b. Elongation at rupture, minimum percent: 150.
   c. Aging requirement: After 168 hours in air oven test at 212 degrees F within plus or minus 33.8 degrees F.
   d. Tensile strength, minimum percentage of un-aged value: 100.
   e. Elongation at rupture, minimum percentage of un-aged value: 80.
   f. Oil immersion: 18 hours at 249.8 degrees F, within plus or minus 33.8 degrees F, ASTM D470, Table 1, No. 2 Oil.
BASIC ELECTRICAL MATERIALS – TRACTION POWER SUBSTATIONS

g. Tensile strength, minimum percentage of un-aged value: 80.
h. Elongation at rupture, minimum percentage of un-aged value: 80.

D. Multiple-conductor cable: Type TC, 194 degrees F Wet and Dry, 266 degree F emergency overload rating, 482 degrees F short circuit rating, insulated to 600 Volt and 2000 Volt in accordance with application usage.

E. Applied voltage testing:
1. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied AC voltage dielectric strength test, i.e., 6-hour water-immersion tests.
2. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.

F. Test procedures:
1. In accordance with the Referenced Standards.

G. Color Coding of Conductors: Color code of single-conductor control wires shall be as follows:
1. 2000 V circuits: black
2. 480/277 V circuits: blue with yellow tracer
3. 208/120 V circuits: yellow with blue tracer
4. Color-coded with base colors and tracers per ICEA Method 1.
5. Color code of multiple conductor control cables shall conform to industrial standards and the referenced specifications.

H. Power Conductors: Color-code feeder and branch circuit conductors throughout the secondary alternating current wiring system as follows:

<table>
<thead>
<tr>
<th>Conductor</th>
<th>208/120V</th>
<th>480/277 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>B</td>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>C</td>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>(With Black or Gray Tracer)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>

I. Branch Circuit Phase Conductors No. 10 AWG and Smaller and Neutral and Equipment Ground Conductors: Solid color insulation or solid color coating.

J. Phase Conductors Having Colored Tracers: A strong adherent paint or dye not damaging to the insulation and which will not be obliterated by pulling into a conduit or raceway.

K. On-site coloring of ends of conductor may be permitted upon receipt of satisfactory evidence that the Contractor is unable to order color-coded wire and cable as specified.
1. Provide certification from the cable manufacturer that the paint or dye proposed for field application is non-damaging to the insulation.

L. Terminations for Low-Voltage Wire and Cable:
1. Terminal connections shall be UL listed and have capacity and insulation voltage ratings of not less than the ratings of the wire or cable terminated.
2. Terminals for No. 10 and smaller wire: Except as noted, vinyl-insulated, electro-tin-plated, electrolytic copper locking spade or ring type.
3. Terminals for No. 8 to No. 3/0 wire: Compression-type, tin-plated copper lug.
4. Terminals for No. 4/0 and larger wire: Long-barrel, tin-plated copper, compression-type, with 2 bolting holes in the pad.

M. At the Overhead Contact System (OCS) Poles: Termination furnished and installed by the Site Contractor.

N. Terminations for 2,000 V Cables:
1. Contractor shall provide TPSS terminations at the TPSS for installation by the Site Contractor.
2. Provide 3 (at each DC Power feeder) long-barrel, double-indentation, compression-type, tin-plated copper sleeve, with 2-hole lug.
3. Provide an equal number of terminations for the DC negative returns.
4. Terminal lugs shall be as specified for 2,000 Volt cables and shall be rated not less than 194 degree F.
BASIC ELECTRICAL MATERIALS – TRACTION POWER SUBSTATIONS

O. Wire Identification Markers:
   1. Feeder Identification Marker: Fungus and water-resistant, self-laminating vinyl, with opaque blank write-on section and transparent adhesive section to wrap around the cable and protect printing. Identify cable at both ends.
   2. Control Wire Identification Marker: Fungus and water-resistant, factory-printed, self-adhesive vinyl with printing protected by clear, permanent overcoat. Identify cable at both ends.
   3. Wire Tie Wraps: Stainless steel or nylon, with locking barb and taper, capable of supporting bundled conductors and insulated cables.

P. Factory Testing:
   1. All UL and ICEA production tests including standard dielectric withstand tests shall be performed on each reel supplied by this Contract.
   2. Contractor shall furnish a certified copy of the test results for each reel as tested.

2.13 WIRING DEVICES AND PARTS

A. Terminal Blocks:
   1. Except where noted, blocks shall be of the screw type with washer style head to accommodate terminals specified.
   2. Base and inter-terminal barriers shall accommodate terminals for No. 8 AWG and smaller stranded copper wire connectors.
   3. Metallic parts shall be nonferrous and corrosion-resistant.
   4. The 845 V DC control, sensing or logic circuit shall be brought out to separate terminal blocks and identified with permanent labels.
   5. Terminal blocks shall be identified and provided with 2 spare terminals, over those required for circuit wiring.

B. Receptacles: Provide heavy-duty, general-purpose, with fire-resistant, non-absorptive, hot-molded phenolic composition bodies and bases, with metal ears suitable for mounting in specified metal outlet box.

C. Switches:
   1. Provide heavy-duty, AC general use, snap type, toggle-operated and rated 20 amp, 120-277 V.
   2. Switches shall be single-pole, double-pole, 1-way or 3-way, as indicated.
   3. Provide hot-molded phenolic composition bodies and bases with metal ears for mounting in specified metal outlet box.

D. Identification of Parts:
   1. Electrical components shall be permanently marked to the lowest level of repair and replacement with part number identification, which coincides in all cases with the latest manufacturer's data.
   2. Nameplates shall be provided on major equipment items with adequate space for the addition of the Authority identification numbers by the Contractor as directed by the Authority.

E. Equipment Identification Nameplates: Nameplates shall be attached at the center or center middle of the equipment, in a neat manner, depending on the space available, or as specified, using screws.

2.14 HIGH VOLTAGE WARNING SIGNS

A. Shall be made from stainless steel plate with red background and engraved white lettering of 2 inches minimum height. The plate shall be 10 inches high by 14 inches wide and 1/8-inch thick minimum, machine drilled to accept 6 stainless steel machine screws, included, for attachment to vertical surface. Inscription shall read:

   WARNING
   HIGH-VOLTAGE
   KEEP OUT

2.15 STANDARD NAMEPLATES

A. Equipment standard nameplates shall comply with the references of the cited references given in the Specifications.

B. Each Substation equipment and associated control and metering devices shall be assigned an identification nameplate.

C. Nameplates shall be opaque, white over black laminated melamine, not less than 3/32 inches thick. They shall have black engraved letters and comply with FS L-P-387, Type NDP. Equipment nameplates shall have 1-5/8 inch high plates with 7/8-inch high characters.
D. Device nameplates shall have 5/8-inch high plates and 1/4 inch high characters.

E. Nameplates shall be fastened to the equipment or device compartment door with machine screws.

2.16 SEALING COMPOUND

A. Sealing compound shall be 2-part silicone foam used to prevent passage of fire, smoke toxic gases and water.

B. Sealing compound shall be rated for 2 hours and UL 1479 listed.

C. Approved products include or an Authority approved equal:
   1. Dow Corning 3-6548 Silicone RTV Foam, as manufactured by Dow Corning Corporation, Midland, Michigan 48640; or
   2. Chase-Foam, CTC PR-855, as manufactured by Chase Technology Corporation, 168 Railroad Street, Huntington Station, New York 11746.

D. Sealing compound shall be installed in accordance with the manufacturer's written instructions.

2.17 LIGHTING FIXTURES

A. The following requirements shall apply to all Traction Power Substations.

B. Substation Interior Fluorescent Lighting:
   1. Luminaries for interior 120 VAC lighting system shall comply with the Referenced Standards and be UL listed or as required by the final design.
   2. Luminaries shall be standard suspended type industrial 4-foot fluorescent lamp fixtures.
   3. Product shall have porcelain coated steel self-ventilated reflector with apertures for 10 percent up light.
   4. Lamp ballasts shall comply with ANSI C82.1 and UL 935 and shall be UL listed, Class P, with integral protection set to limit case temperature. Product shall be suitable for use at 120 VAC and coordinated with the luminaries furnished.
   5. Fluorescent lamps shall be rapid start, cool white, and shall comply with ANSI C78.1.

C. Substation Interior Emergency Lighting:
   1. Emergency lighting assemblies shall be self-contained units, complete with 2 adjustable, prismatic lens fixtures and high intensity tungsten (HIT) lamps, battery, and battery charger, suitable for 120 V ac power supply.
   2. Battery shall be sealed, maintenance-free, lead-acid type, suitable for float service with 15-year life expectancy and extended warranty. Battery shall have 1-1/2 hour minimum cut-off capacity from fully charged state.
   3. Assembly shall be provided with the following accessories:
      a. Operation test switch, with spring return.
      b. AC supply healthy pilot lamp.
      c. High-charge supervision lamp.
      d. Battery low-voltage load cut-off protection.
      e. Automatic connection of lamp load upon failure of ac supply, and automatic disconnection following restoration of supply.

D. Substation Exterior Lighting Fixtures:
   1. Luminaries shall be mounted at a height of not less than 10 feet, on the exterior surface of each side of the Substation enclosure. Luminaire spacing shall produce a uniformity ratio of 6:1 average/minimum and 15:1 maximum/minimum, and provide a minimum illumination level of 1 foot-candle at ground level within a radius of 20 feet from each luminaire.
   2. Luminaries shall be UL listed as suitable for wet locations.
   3. Housing shall be one-piece hot-galvanized steel, or die-cast aluminum with anodized finish. Housing shall be provided with knockouts or lugs for 2-bolt attachment to wall, and 2 threaded and plugged conduit hubs.
   4. Housing shall be furnished with inset extruded silicone gasket for door seal, and integral hinge pins to mount the door. Front access door and prismatic lens shall be of integrated, vandal-resistant design. Door shall be hinged at
bottom, allow full front access, and be retained in closed position by 2 captive stainless steel tamperproof screws.

5. Luminaries shall be furnished with 150 watt high pressure sodium lamps, and class H insulated regulated high power factor type ballast complying with ANSI C82.1, UL 935 listed, and suitable for 120 VAC supply. Lamp holder shall be heavy-duty glazed porcelain, under hung mounted and tilted from vertical to provide optimum light transmission. Luminaire shall be provided with built-in photocell control, with door-mounted prismatic window designed to prevent operation by light from below.

6. Lamp reflector shall be high quality finish coated aluminum or glass.

2.18 METAL-ENCLOSED BUS AND BUSWAYS

A. Work in this Article consists of providing AC and DC metal-enclosed bus assemblies and accessories for power interconnections between Substation components, assemblies and sub-assemblies.

B. Bus assemblies shall comply with the applicable requirements given in ANSI C37.20 and NEMA BU 1 for self-cooled, metal-enclosed bus.

C. Bus conductors shall be high conductivity electrical grade copper. Bus conductors, splices, and fittings shall be insulated within each bus enclosure. Insulation shall be flame-retardant and nonhygroscopic. Bus joints and terminations shall be silver-plated.

D. Bus conductors shall be electrically connected to equipment terminals by means of flexible braid or laminations. Bus enclosures shall be furnished with removable gasketed covers at bus connections for ease of installation and maintenance.

E. Low-voltage AC bus enclosures for AC-to-DC conversion assemblies shall be electrically insulated from the rectifier enclosures, and connected to the transformer enclosure ground circuit only.

F. AC bus shall be non-segregated type as follows:

1. Ratings: Rectifier transformer low-voltage AC bus continuous current rating shall match the specified 2-hour load rating of the associated rectifier transformer output windings. Momentary current rating, KA asymmetrical, shall be not less than the theoretical maximum value of bolted short-circuit current at the output winding terminals of the transformer.

2. Insulation Level: Bus insulation level shall be coordinated with that for the transformer output windings.

G. DC busses shall be segregated type as follows:

1. Current Ratings: Rectifier DC bus circuits to cathode circuit breaker shall have a continuous current rating not less than the circuit breaker rating. Momentary current rating shall be not less than 100 KA asymmetrical.

2. Voltage Ratings: Busses shall have a rated voltage of 2000 VDC. Insulation level shall be not less than 4.6 KV rms.

2.19 CABLE SEALS

A. Provide watertight seal as required by the final design.

2.20 AC CIRCUIT BREAKER & PANELBOARDS:

A. General Requirements:

1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.

2. Finish for enclosures for panelboards.
   a. Clean and degrease metallic surfaces.
   b. Prime with zinc primer. Finish with 1 coat of light gray enamel per the Referenced standards.

B. Circuit Breaker:

1. NEMA AB1, UL489, molded-case, bolt-on, quick-make/quick-break, mechanically trip-free, switching mechanism, with thermal trip for inverse time delay overcurrent protection and magnetic trip for instantaneous short-circuit protection.

2. Main frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic trip unit.

3. Designed to carry continuous rating in ambient temperature of 104 degrees F.

C. Panelboards:

1. NEMA PB1, UL 67 with main breaker.

2. Enclosure:
   a. UL 50.
b. Galvanized steel, surface mounted unless otherwise shown.

c. NEMA 250, Type 1.

d. Interior components mounted on back plate of reinforced steel for rigid support and accurate alignment.

e. One-piece sheet steel front panels with hinged door and lock so constructed that when panel board door is locked the front cannot be removed.

f. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.

g. Provide provision for enclosure grounding.

3. Bus bars:

a. ASTM B187.

b. 98 percent conductivity copper.

c. Contact surface silver-plated or tin-plated.

d. Rating of neutral and ground bus: Equal to that of phase bus.

e. Neutral bus mounted on insulating block.

f. Neutral and ground bus equipped with integral mechanical connectors.

4. Circuit Directory:

a. Neatly typed to identify the load fed by each circuit by number.

b. Mounted on a metal frame with clear plastic cover inside cabinet door.

2.21 SURGE PROTECTIVE DEVICES (SPD)

A. General:

1. Surge Protective Device (SPD) shall provide for the protection of all AC and DC electrical circuits and equipment from the effects of lightning induced voltages, external switching transients, and internally generated switching transients resulting from inductive and or capacitive load switching.

2. Surge protection devices shall be provided for all distribution panels, feeding external circuits such as catenary motorized disconnect switch power units, Signal Service Panel, Communication Station Service Panel’s and DC data circuits which enter or exit the TPSS.

B. Acceptable Manufacturers:

1. AC Panels: APEX Series manufactured by Transtector Systems, Inc, Hayden Lake, ID or an Authority approved equal.

2. AC Circuits (external): HPS Series manufactured by Transtector Systems, Inc, Hayden Lake, ID or an Authority approved equal.

3. DC Circuits: TSP, FSP, or DR DIN Rail Protectors, manufactured by Transtector Systems, Inc, Hayden Lake, ID or an Authority approved equal.

C. General Material Requirements: Furnish all equipment specified herein and as required by the Referenced Standards.

1. As required by the final design the SPD System shall consist of a Service Protection Panel for each service rated 600 volts or less.

2. All SPD’s shall operate as a total coordinated and engineered system.

3. Surge protections shall be engineered as a system by the manufacturer.

4. Maximum continuous operating voltages of any system component shall not be less than 115 percent of the nominal system operating voltage.

5. All SPD components shall be rated with an operating temperature range of negative 20 to 120 degrees F, and from 1 to 85 percent humidity with no condensing.

6. SPD components shall operate in altitudes up to 2,000 feet above sea level.

7. No system component shall generate appreciable magnetic fields, i.e. sufficient fields to damage stored magnetic data.

8. Average power consumption of any single SPD system shall be 1 watt per phase or less with zero percent total harmonic distortion.

9. Nominal system frequency is 60 Hertz, operating frequency range of the SPD system shall be 0 to 400 Hertz.
10. All SPD’s shall be connected in parallel with the power system they are protecting.
   a. Series connected components shall not be used.

D. SPD Panel:

1. SPD Service Protection Panel enclosure shall be as a minimum:
   a. NEMA 12 construction.
   b. Factory primed and painted.
   c. Wall or floor mounted.
   d. Provide visual indication on the cover of the enclosure to identify system and indicate systems operation.
   e. The Service Panel SPD must be furnished with terminal connections capable for accepting up to No. 1/0 conductors.

2. Service Panel SPD, as a minimum must be UL listed for Permanently Connected Products.

3. Service Panel Protectors shall be installed parallel to the disconnect switch or circuit breaker and rated for the interrupting current of the panel protected panel.

4. During normal suppression cooperation, the units shall not short circuit or crowbar the power flow that would result in an interruption to the load.

5. Unit shall not require interruption of service power for maintenance.

6. Hybrid designs are not allowed.

7. Primary and back-up suppression components must not employ a degrading technology.

8. SPD must not experience degradation from published specifications for a minimum of 10 years, as long as system performance parameters are not exceeded.

9. Surge Voltage Rating (SVR), and protection level (clamping voltage) shall be per the Referenced Standard’s for each service voltage.

<table>
<thead>
<tr>
<th>Voltage Configuration</th>
<th>SVR Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 Volts, Single Phase</td>
<td>330 Vpk (L-N, L-G)</td>
</tr>
<tr>
<td>240/120 Volt, Single Phase</td>
<td>330 Vpk (L-N, L-G)</td>
</tr>
<tr>
<td>208/120 Volt, Three Phase Wye</td>
<td>330 Vpk (L-N, L-G)</td>
</tr>
<tr>
<td>240 Volt, Single Phase Delta</td>
<td>600 Vpk (L-L)</td>
</tr>
<tr>
<td>240 Volt, Three Phase Delta</td>
<td>600 Vpk (L-L)</td>
</tr>
<tr>
<td>380/220 Volt, Three Phase Wye</td>
<td>600 Vpk (L-N, L-G)</td>
</tr>
<tr>
<td>480/277 Volt, Three Phase Wye</td>
<td>800 Vpk (L-N, L-G)</td>
</tr>
<tr>
<td>480 Volt, Three Phase Delta</td>
<td>1000 Vpk (L-L)</td>
</tr>
</tbody>
</table>

   a. This remote will consist of a normally open and normally closed (single pole, double throw) dry contact.
   b. It shall provide status information on whether the suppression system is on line.

E. DC Data Line Circuits:

1. Furnish all equipment specified herein and as required by the Referenced Standards.

2. Data Line Protector (DLP) shall consist of a single line or Rail type line surge protectors, which stop damage and downtime caused by Voltage transients.

3. All surge protective devices shall operate as a total coordinated and engineered system, as well as be engineered as a system by the manufacturer.

4. Maximum continuous operating voltages of any system component shall not be less than 115 percent of the nominal system operating voltage.

5. All DLP components shall be rated with an operating temperature range of negative 20 to 120 degrees F, and from 1 to 85 percent humidity with no condensing.
   a. DLP components shall operate in altitudes up to 2,000 feet above sea level.
b. No system component shall generate appreciable magnetic fields, i.e. sufficient fields to damage stored magnetic data.

c. Average power consumption of any single SPD system shall be 1 watt per phase or less with zero percent total harmonic distortion.

6. All DLP’s shall be connected in parallel with the power system they are protecting.

a. Series connected components shall not be used.

b. Suppression paths shall not be grounded.

c. During normal suppression cooperation, the units shall not short circuit or crowbar the power flow that would result in an interruption to the load.

d. Hybrid designs are not allowed.

e. Primary and back-up suppression components must not employ a degrading technology.

f. DLP must not experience degradation from published specifications for a minimum of 10 years, as long as system performance parameters are not exceeded.

7. Performance Specifications:

a. L-L Leakage at max line-to-line voltage: 5 micro amps.

b. L-L Leakage at max line to ground voltage: 5 micro amps

c. Power Dissipation:

1) 24 VDC: 15,000 Watts

2) 125 VDC: 30,000 Watts Voltage protection Level

3) 125 VDC: 150V, L-L and L-G

4) 24 VDC: 33V, L-L and L-G

2.22 WORKMANSHIP

A. All equipment surfaces shall be smooth and free of defects, which detract from safe performance and neat appearance. Such defects include, but are not limited to gaps, burrs, sharp edges, wrinkles, waves, and blemishes. Enclosing structures shall possess sufficient reinforcement to maintain structural integrity as well as the safety of their contents through transport, handling, installation and operation.

B. Equipment Metal Enclosures: Enclosures shall be fabricated according to the requirements of the cited references listed in the Specifications.

C. Threaded Fasteners:

1. Fasteners shall be Unified-type screw threads with dimensions in inches.

2. When specifically approved by the Authority, the Contractor may use metric fasteners for internal assemblies, or components.

3. Each assembly or component containing ISO-metric threaded fasteners shall be indelibly identified in a manner approved by the Authority.

4. Additionally, all maintenance manuals shall be conspicuously marked on each page where metric threaded fasteners are used to assemble the component.

5. Spare parts shall contain all necessary replacement ISO-metric fasteners of the correct size and grade.

D. Surface Treatment:

1. Exposed non-wearing metal surfaces shall be painted.

2. Surface shall first be thoroughly cleaned and treated with an anti-rust coating.

3. Metal finish shall be a semi-gloss paint system that is the manufacturer's standard for the service specified.

4. Unfinished metal surfaces shall be coated with a layer of grease. The grease shall be removable by a petroleum-derived solvent.

E. Finish Color:

1. Enclosures shall have an exterior finish of light gray color No. 61 in accordance with Referenced Standards.
2. Interior colors of enclosures shall be the manufacturer’s standard for the intended service.

3. Touchup:
   a. Provide touchup paint for each color furnished.
   b. Each set of substation equipment shall be furnished with sufficient finish coat touchup paint to cover 5 percent of the metal surfaces.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Installation work shall be in accordance with applicable requirements of the NEC and the Referenced Standards and shall comply with the regulations of the Authority Having Jurisdiction (AHJ) in all cases.

B. Materials and equipment shall be applied, installed, and connected as recommended by the manufacturer.

C. External wiring between major electrical equipment shall be accomplished with cable trays, conduit or wireways. The interface wiring shall be readily accessible for future additions/modifications.

3.2 CABLE TRAYS, METAL FRAMING, AND WIREWAYS

A. Trays and wireways shall be supported by cantilever type metal frame support or hangers of sufficient strength to carry combined weights of tray and cable and the dynamic loads imposed during cable pulling.

1. Provide load calculations for all cable tray installations.

B. Electrical continuity shall be maintained between sections of steel tray by bolted copper braid and the steel tray connected to local grounding system by green colored insulated wire.

C. Trays shall have tray number stenciled in red on the side rails at each end of the tray run.

D. Anchors used to fasten DC switchgear to the floor shall be duly insulated to ensure integrity of high resistance grounding floor insulation.

3.3 OUTLET, JUNCTION, PULL, AND CORROSION CONTROL BOXES

A. Mount boxes on enclosure columns with machine screws.

B. Install switch and outlet boxes on lock side of entry doors and 48 inches above floor level.

C. Install junction, pull, and control boxes so that covers are accessible after completion of the installation.

D. Install blank cover plates on unused openings in boxes after completion of installation.

3.4 GROUNDING

A. General:

1. Except for insulated DC equipment, all Substation equipment metal enclosures, equipment ground bus, and exposed non-current carrying metallic parts shall be solidly connected to the substation ground bus bar or ground mat.

2. Design and installation of each Substation ground grid shall be by the Site Contractor, this Contract shall provide ground connections for connection to the substation enclosure, and the substation equipment grounding bus, AC lightning arresters, transformer ground pads and to high resistance equipment grounding points.

3.5 INSULATED WIRE, CABLE, AND ACCESSORIES

A. General:

1. Wire and cable shall be installed by means of equipment, devices, and methods recommended by manufacturer.

2. High-voltage cable terminations shall be performed by qualified personnel only.

3. External wiring and cabling to the substations, remote mounted traction power equipment, and other facilities shall be provided as indicated.

4. Wiring and cabling shall be terminated and connected, except as indicated, by means of connectors, lugs, and other methods specified.

5. Wire and cable shall be installed, supported and segregated in cable tray, raceway or conduit within the substation enclosure.

6. Wiring and cabling shall be run end to end without splices, except where indicated otherwise on the Contract Drawings. Each cable shall be identified at each end, and at any intermediate pull.
box, by markers as specified in these specifications.

7. Interconnecting circuit wiring between equipment panels and cubicles shall be terminated at terminal blocks.

8. Suitable installation equipment shall be provided, to prevent cutting and abrasion of conduit and wire during the pulling of feeders, power cables and control cables.

9. Masking or other means shall be used to prevent obliteration of cable identifications when solid-color coating or colored tracers are used.

10. Cables to be installed in a single conduit shall be pulled together.

11. Manufacturer's recommended pulling tension or sidewall pressure shall not be exceeded.

B. Power Cabling:

1. AC and DC circuits consisting of multiple single conductors shall be grouped and pulled together in the designated raceway. Conductors shall be continuous from end to end without splices, except as approved by the Authority. Adequate slack shall be provided at terminations and in pull boxes.

2. Bundle circuit conductors neatly and securely to cable trays with specified strap. Cables entering equipment panels and cubicles shall be spaced and tied to supports provided.

3. Cables shall also be identified at 10 feet intervals in cable trays and at each termination point.

C. Control Wiring:

1. Unless otherwise specified, multi-conductor control wiring with 600 V or 2000 V insulation between equipment panels and cubicles shall be installed in designated conduits and raceways separate from those used for power cables. Multi-conductor cables installed in the same conduit shall be pulled together.

2. Control wiring shall be run from end to end without splices. Each multi-conductor cable shall be identified at each end and at any intermediate pull box by specified markers. Control wiring shall be identified at 10 feet intervals in cable trays.

3. Control cable shall be neatly laid and grouped in cable tray and secured by specified straps. Cable entering equipment panels or cubicles shall be supported and secured to prevent tension on terminations. Adequate slack cable shall be provided and each wire terminated shall be double looped.

4. Interconnecting circuit wiring between equipment panels and cubicles shall be terminated at terminal blocks. Substation interior wiring across shipping sections shall be neatly coiled and secured before shipment and each wire identified by specified marker.

5. Equipment panel and cubicle wiring shall be run in wireways and each conductor shall be continuous without splices or taps from terminal to terminal.

6. Wiring within DC switchgear and disconnecting switch compartments and cubicles shall be shielded from primary current conductors by flame-resistant insulating barriers.

7. Wiring within high-voltage AC equipment compartments shall be shielded by a grounded metal screen.

8. Interior wiring within equipment panels and cubicles shall be identified at each termination with the equipment manufacturer's wire number by a marker as specified with imprinted identification.

3.6 WIRING DEVICES

A. Device Mounting: Convenience power receptacles and lighting switches shall be rigidly attached to outlet boxes by 2 machine screws.

B. Wire Termination: Power wiring shall be terminated with specified connector. Provide adequate slack wire, 1 loop minimum, to prevent strain on termination.

3.7 WARNING SIGNS

A. Attach specified warning signs to exterior surface of Substation Enclosure, and enclosure access doors with tamper proof mechanical fasteners.

3.8 FIELD TOUCH-UP

A. Galvanized Metal Surfaces: Coat damaged surfaces, to the strength and finish of the original coating, with polystyrene organic rich compound
containing not less than 91 percent by weight metallic zinc powder in dried film.

B. Painted Metal Surfaces: Clean, treat, and coat damaged surfaces with required rust inhibiting undercoating and finish coat paint system in accordance with manufacturer's instructions.

C. Fiberglass: Reinforced Polyester Enclosures: Repair damage surface with materials and methods recommended by manufacturer.

3.9 SURGE PROTECTIVE DEVICES

A. Installation - Service Panel Protection and Data Line Protectors:

1. Installation shall comply with the manufacturer's printed instructions, the NEC, and local wiring codes.

2. Equipment Identification:

   a. SPD and DLP system components shall be identified.

   b. Refer to the electrical identification section of these specifications for identification requirements.

B. Field Quality Control:

1. SPD System and DLP shall be installed in accordance with the manufacturer’s printed instructions to maintain warranty.

2. All local and national codes shall be observed.

3. Upon completion of installation, the SPD and DLP shall not require testing of any kind.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Work specified in this section will not be measured separately for payment, all costs in connection with this Section will be considered incidental to the furnishing and delivery of the TPSS units.

4.2 PAYMENT

A. Payment for the work specified in this section is considered as part of the project management of this Contract and shall be included in the Payment Schedule as a representative portion of each bid item value, which price will be full compensation for the performance of all requirements as described in this section including all materials, labor, transportation, handling, storage, tools, computer equipment, test equipment, rental equipment, printing services and incidentals necessary to complete the work as specified in this section, and all other related sections of the Specifications and the Drawings.

END OF SECTION 16050
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PART 1 - GENERAL

1.1 DESCRIPTION

A. This Work includes complete conduit and raceways for above ground Systems Work. Reference Section 02780, “Underground Electrical and Communications Distribution Systems”, for underground electrical and distribution systems. Reference Section 16111, “Conduits”, for above ground non-systems related conduits.

B. This Section specifies the requirements for coating of metallic conduits.

C. Conduits assembled into systems concrete encased duct banks, stub-ups and stub-outs shall meet the requirements of Specification Section 02780, “Underground Electrical and Communications Distribution Systems”.

1.2 DEFINITIONS

A. Conduit: Individual electrical raceway.

B. Duct: Assembly of conduit in configurations shown, either concrete encased or not, with or without reinforcement.

C. Raceway: An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars.

1.3 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM A36/A36 M - Standard Specification for Carbon Structural Steel
   4. ASTM A153/A153 M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   5. ASTM A615/ A615 M Rev B - Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement
   6. ASTM C33 - Standard Specification for Concrete Aggregates

B. National Electrical Manufactures Association (NEMA)
   1. NEMA C80.1 - Rigid Steel Conduit, Zinc Coated Specification for
   2. NEMA ANSI C80.3 – American National Standard for Electrical Metallic Tubing (EMT)
   3. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit
   4. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing
   5. NEMA TC 6 & 8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations

C. Nation Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

1.4 SUBMITTALS

A. Submit the following for Authority approval in accordance with these Specifications and with the additional requirements as specified for each.

B. Submit product data 30 days to any conduit or raceway installation, on the following items unless noted otherwise:
   1. Raceways
   2. Fittings
   3. Metallic joint compounds, caulking and sealing compounds
   4. Pull cords
   5. Raceway tags and labels
   6. Conduit mandrels and brushes
   7. Warning tape
   8. PVC Conduit joint cleaning solvent and cement
   9. Conduit Numbering Schedule/Tabulation

C. Mandrel log sheets shall be submitted 7 days after completion.
D. All submittals shall be submitted at least 21 days prior to installation.

E. Submittals for concrete encased conduits (CENC) conduits, duct banks and manholes shall be in accordance with Specification Section 02780, “Underground Electrical and Communications Distributions Systems”.

1.5 QUALITY ASSURANCE

A. Contractor shall perform the Work included in this Section in strict accordance with the requirements of the Contractor’s Quality Control Program as approved by the Authority and in compliance with the requirements of these Specifications.

B. Contractor shall perform the following in accordance with Contractor’s Quality Control Program specified in these Specifications.

1. Material qualification testing and certification for acceptance of materials, components, and assemblies.

2. Job control testing of in-progress Work being performed in shops, factories, and on-site.

3. On-site inspection of specified Work elements.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Receive, transport and store until use.

1. Area for storage of those materials provided by other contractors or utilities.

PART 2 - PRODUCTS

2.1 GALVANIZED RIGID STEEL CONDUIT (GRSC)

A. Conduit shall comply with NEMA C80.1 and shall be hot-dip galvanized inside and out. Threaded ends shall be galvanized using a zinc metallizing process, which sprays or blasts molten or semi-molten zinc on the threaded area. Minimum size shall be 3/4 inch.

B. Approved manufacturers: LTC, Triangle, Allied or Authority approved equal.

2.2 PVC SCHEDULE 40 CONDUIT (PVC)

A. Conduit shall comply with NEMA TC 2, rigid polyvinyl chloride, Schedule 40. Conduit shall be sunlight resistant and suitable for 194 degrees F conductors and exposed locations.

B. Approved manufacturers: Carlon, PW Pipe, Western Plastics or Authority approved equal.

2.3 PVC SCHEDULE 80 CONDUIT (PVC 80)

A. Conduit shall comply with NEMA TC 2, rigid polyvinyl chloride, Schedule 80. Conduit shall be sunlight resistant and suitable for 194 degrees F conductors and exposed locations.

B. Approved manufacturers: Carlon, PW Pipe, Western Plastics or Authority approved equal.

2.4 ELECTRICAL METALLIC TUBING (EMT)

A. Conduit shall comply with NEMA ANSI C80.3.

B. Interior exposed, dry locations only, not subject to damage

2.5 FLEXIBLE METAL CONDUIT

A. Galvanized flexible steel, listed for dry locations. Minimum size shall be 1/2 inch.

B. Liquid tight: Polyvinyl chloride (PVC) weatherproof cover over galvanized flexible steel conduit, listed for damp and wet locations. Minimum size shall be 1/2 inch.

2.6 GRSC CONDUIT FITTINGS

A. Conduit fittings shall be steel or cast malleable iron and shall be hot-dip or mechanically galvanized. Die-cast zinc fittings shall not be used.

B. Bushings and grounding bushings shall have molded phenolic or “Nylon” insulating collars. Grounding bushings shall have a “lay-in” tinned copper lug.

C. Expansion fittings for exposed conduit runs shall be weatherproof with external bonding jumper, providing up to 4 inches longitudinal movement with bushed conduit ends. Manufacturers shall reference the product to ANSI, IEEE, UL, NEMA or any other recognized standards or code.

D. Watertight split couplings or 3-piece (“Ericson”) couplings shall be O-Z/Gedney, or Authority approved equal.

E. Running thread or set screw type fittings shall not be used.

F. Lock nuts 2 inches and smaller shall be heavy galvanized steel. Lock nuts larger than 2 inches shall be galvanized malleable iron.

G. Hubs shall be galvanized steel or galvanized malleable iron, with insulating inserts and sealing rings. Hubs shall provide watertight conduit connections to boxes and enclosures.
H. Conduit outlet bodies shall be cast ferrous alloy, with gasketed ferrous alloy cover, hot-dip or mechanically galvanized. Aluminum alloy conduit bodies shall not be acceptable. “Short” conduit bodies such as SLBs shall not be acceptable. Acceptable manufacturers: O-Z/Gedney, Crouse-Hinds, Appleton, or Authority approved equal.

2.7 PVC CONDUIT FITTINGS
A. Fittings for PVC conduit shall comply with NEMA TC 3. PVC conduit fittings shall be of the same manufacturer and type as the conduit.

B. Expansion fittings shall allow expansion, with the same characteristics as the PVC conduit and be of the same manufacturer. Manufacturers shall reference the product to ANSI, IEEE, UL, NEMA or any other recognized standards or code.

2.8 EMT FITTINGS
A. Fittings for EMT shall be by the same manufacturer and specifications as for EMT conduit.

B. Fittings shall comply with NEMA ANSI C80.3.

2.9 FLEXIBLE METAL CONDUIT FITTINGS
A. Flexible Metal Conduit Fittings: Galvanized malleable iron or steel squeeze-type, setscrew fittings with insulated throat. Acceptable manufacturer: O-Z/Gedney C-8T Series, Thomas and Betts 3112 Series, or Authority approved equal.

B. Liquid Tight Flexible Metal Conduit Fittings: All fittings shall be galvanized steel compression fittings, with O-rings, conduit ferrule and insulated throat, and shall be oil-tight and water tight. Manufacturers shall reference the product to ANSI, IEEE, UL, NEMA or any other recognized standards or code.

2.10 RACEWAY TAGS AND LABELS
A. Tags and labels shall be made from nonferrous metals with raceway designations shown on the Drawings stamped by steel dies.

2.11 CONDUIT MANDRELS AND BRUSHES
A. Conduit brushes shall utilize round wire bristles for maximum cleaning of sand, grit, and obstructions from the conduit. They shall have a pulling eye on one end, and a smaller twisted eye on the other end, which shall allow for bi-directional pulling. Conduit brushes shall be sized as shown in Table 2.16A, Conduit Brush Sizes.

B. Conduit mandrels shall be flexible, and manufactured for cleaning out mud, dirt, and light obstacles from ducts before the installation of cable. Mandrels shall be suitable for pulling around tight bends, and use a tapered profile that allows pulling in either direction. Pulling eyes shall be provided on each end. The mandrel shall be fabricated from polyurethane, or an Authority approved equal material, and shall not damage conduit inner walls. Conduit mandrels shall be sized per Table 2.16B, Conduit Mandrel Sizes.

C. Conduit mandrels and brushes shall not damage any conduit interior coating.

D. Conduit brushes and mandrels shall be manufactured for the purpose by a company regularly engaged in the production of electrical equipment, such as Greenlee Textron, Inc., or Authority approved equal. Mandrels shall not be fabricated by the Contractor in the shop or field.

2.12 WARNING TAPE
A. Tape shall be installed in accordance with Specification Section 02780, “Underground Electrical and Communications Distribution Systems”, and Systems Elements Standard Drawings.

2.13 PULL CORD
A. Pull cord shall be twisted or braided nylon cordage with a minimum tensile strength of 1,000 pounds.

PART 3 - EXECUTION
3.1 GENERAL INSTALLATION REQUIREMENTS
A. Many raceways shall remain empty, with conductors installed in the future. All raceways installed for future use shall have a nylon pull-cord installed and secured at each end, with tags referenced the same at both ends on the pull-cord.

B. Install raceways with not more than 270 degrees of bend, total, in each raceway run between boxes, manholes, handholes, and raceway terminations.

C. Unless otherwise noted, minimum raceway size shall be 3/4 inch for inside buildings or in a building slab, and one inch for underground raceways governed by this specification section.

D. Install raceways concealed in construction unless shown otherwise on the Contract Drawings.

E. Cut raceway ends square, ream, and extend maximum distance into all couplings and connectors. Tighten all fittings securely.

F. Field-cut threads and reamed ends in metallic conduit shall be protected from corrosion immediately after cutting, reaming and cleaning by application of a zinc-rich coating.
G. Use conductive joint compounds to insure electrical continuity of metallic raceway joints. Manufacturers shall reference the product to ANSI, IEEE, UL, NEMA or any other recognized standards or code.

H. Install manufactured end caps or plugs on all raceway ends immediately after installation to prevent the entrance of liquids or foreign materials.

I. Bends in GRSC shall be factory ells or field bends. Field bending shall be done using one-shot or segment benders which do not decrease the raceway cross-section. Bending shall be done in accordance with manufacturer's instructions.

1. Unless otherwise indicated, minimum bend radius for raceways within structures shall be in accordance with the NEC. Exceptions to the NEC shall not be used to determine conduit bend radius, even if permitted by the NEC, for any part of this Contract unless Authority approved. Minimum bend radius for raceways installed underground shall be as shown in Table 3.1, Underground Conduit Minimum Bending Radius, except where otherwise indicated.

J. Route raceways to avoid structural obstructions and to minimize crossovers. Should any core drilling or installation of sleeves not shown on drawings be desired by the Contractor, such proposed concrete penetrations shall be submitted to the Authority for structural review prior to any core drilling or sleeving.

K. Install expansion fittings complete with grounding jumpers where raceways cross expansion joints, construction joints, sawn joints, and where shown.

L. All connections shall be watertight, except for non-liquid tight flexible metal conduit.

M. Install PVC conduit in accordance with manufacturer's instructions. Cut the conduit ends square, deburr, and apply an Authority approved solvent to clean the joint. Apply Authority approved cement and allow to set 24 hours before mandrelling, brushing, and installing conductors. Joint cleaning solvent and cement shall be approved by the conduit manufacturer and the Authority.

N. This Clause covers bends in PVC conduit runs underground but not in duct banks as governed by this specification section. Minimum bend radius for conduits/raceways installed underground shall be as shown in Table 3.1, Underground Conduit Minimum Bending Radius, except where otherwise indicated. Refer to Specification Section 02780, “Underground Electrical and Communications Distribution Systems”, for bends in PVC conduit runs in CENC duct banks, stub-ups and stub-outs. PVC/GRSC shall be used for conduit bends 30 degrees or greater in PVC conduit runs underground but not in duct banks. Bends in PVC conduit runs underground but not in duct banks that are less than 30 degrees shall be factory PVC ells or field bend PVC conduit. Use of 2 PVC ells of less than 30 degrees with short, straight lengths of PVC between ells to make up a bend 30 degrees or greater is not acceptable. Field bends in PVC conduit with a radius of 100 feet or less shall be formed hot using only a heater recommended by the conduit manufacturer. Use conduit plugs during bending for conduit 2 inches and larger. Remove plugs only after conduit has cooled. Field bends (sweeps) with radius greater than 100 feet may be formed cold.

O. Route all exposed raceways installed in a building parallel or perpendicular to building lines except where otherwise shown. Form bends in adjacent raceways to match radius and center of bend.

P. Install all ground bushings, and incidentals.

Q. All PVC conduits entering concrete manholes, handholes, or pullboxes shall be terminated with bell-end fittings.

R. End Bells: Flared, smooth surfaced fittings of same material as conduit.

3.2 REQUIREMENTS FOR RACEWAY TYPES

A. General

1. Raceway types for specific locations shall be as shown on the drawings. Where conduit types are not called out on the drawings, or specified elsewhere in this Section, the conduit type shall be as specified herein. See Tables 3.3-1, Summary of Conduit Types by Specific Location and 3.3-2, Summary of Conduit Types by Application.

2. For the purpose of this Specification raceways are considered 'subject to damage' in any of the following locations:

a. Exposed installations within 48 inches of finished floor or final grade.

b. Exposed installations where the area is subject to vehicular traffic, within 4 feet of established drive lanes or parking areas unless the area is protected by bollards or other structure. Height of affected area shall be 8 feet or maximum height of vehicles whichever is greater.

c. Exposed installations where the area is subject to maintenance activity, including electrical and
CONDUIT AND RACEWAYS

mechanical equipment rooms. Height of affected area shall be 8 feet above finished floor.

B. For interior and exterior installations above ground, exposed or concealed in construction, not embedded in concrete or masonry, or not subject to damage, provide uncoated galvanized rigid steel conduit. For equipment requiring flexible connections, provide flexible metal conduit.

C. For concrete encased conduits in underground duct banks, provide raceway types specified in Specification Section 02780, “Underground Electrical and Communications Distribution Systems”.

D. For direct buried underground conduit, provide PVC Schedule 80 or raceway type DB-120 specified in Specification Section 02780, “Underground Electrical and Communications Distribution Systems”. Conduit shall be encased and embedded in 4 inches of Authority approved cement based soil stabilizer/flowable fill or clean sharp sand on all sides of the raceway, as indicated on the drawings.

E. For concrete embedded conduit, such as conduit embedded in concrete building or structure walls, or where the conduit is fully encased in concrete not in a duct bank, where used in formed concrete, provide uncoated galvanized rigid steel conduit. PVC conduit shall not be used, unless otherwise indicated.

F. For conduits installed in pole foundations, in roadways, and all track crossings, not in duct banks, provide GRSC. PVC conduit shall not be used unless otherwise indicated.

G. For direct buried raceway not in a roadway, for crossing lighting, roadway lighting, pathway lighting, or site lighting, or under station platforms provide schedule 40 PVC conduit, except where schedule 80 PVC conduit is indicated. Conduit shall be encased and embedded in 4 inches of Authority approved cement based soil stabilizer/flowable fill on all sides of the raceway. PVC raceway is not permitted at burial depths less than 36 inches.

H. For conduit risers on catenary poles, provide GRSC type conduit, ells and fittings unless otherwise indicated.

I. For bridge abutment conduit risers, use GRSC type conduit unless otherwise indicated.

3.3 RACEWAYS INSTALLED UNDERGROUND

A. Install underground raceways in accordance with Specification Section 02780, “Underground Electrical and Communications Distribution Systems”.

3.4 SLEEVES

A. All sleeves shall be GRSC unless otherwise indicated.

B. Install, in advance of pouring concrete, all sleeves where shown. Sleeves shall terminate flush with the surface of the concrete with a coupling.

3.5 RACEWAYS Stubbed UP Through FLOORS, WALLS, FOOTINGS OR FOUNDATIONS

A. Install at such depth that the exposed raceway is vertical and no curved section of the elbow is visible. End of conduit stub-ups or stub ups shall terminate 3 inches above finished floor or vertical services, unless indicated otherwise.

B. GRSC shall be provided for all raceways installed through floors, walls, footings, or foundations. PVC conduit shall not be stubbed-up through floors, walls, footings, or foundations. PVC conduit may be terminated in vault walls as shown on the drawings.

3.6 CONDUIT MANDRELLING AND CLEANING

A. A log shall be kept for all conduits mandrelled. The mandrel log shall contain the following information in tabular format for each conduit mandrelled:

1. Conduit designation
2. Conduit endpoints
3. Conduit size
4. Date mandrelled
5. Pass/fail for specified mandrel
6. Install pull cord

B. After final assembly is in place, all conduit 2 inches and larger shall be thoroughly cleaned and mandrelled prior to installing wires or pull cords. Each conduit shall be mandrelled by pulling a mandrel sized in accordance with these Specifications through the conduits, followed by a steel bristle brush to clean the conduit. At the completion of cleaning and mandrelling, and before final acceptance, a “Nylon” pull cord shall be installed in each empty conduit. The pull cord shall remain accessible from each end at all times.

C. After final assembly is in place, all conduits smaller than 2 inches shall be thoroughly cleaned and mandrelled by one of the following methods:

1. Pulling through the conduits a wire brush and mandrel sized 1/4 inch maximum less than the inside diameter of the conduit for
CONDUIT AND RACEWAYS

1. 1-1/2 and 1-1/4 inch conduits, and 1/8 inch maximum less than the inside diameter of the conduit for 1 inch and smaller conduits.

2. Pulling through the conduits a cloth rag or conductor bundle sized 1/4 inch maximum less than the inside diameter of the conduit for 1-1/2 and 1-1/4 inch conduits, and 1/8 inch maximum less than the inside diameter of the conduit for 1 inch and smaller conduits.

3. At the completion of cleaning and mandrelling, and before final acceptance, a "Nylon" pull cord shall be installed in each empty conduit. The pull cord shall remain accessible from each end at all times.

D. If requested by the Authority, cleaning and mandrelling shall be done in the presence of the Authority. Notify the Authority 7 days in advance of mandrelling.

E. Where raceways are stubbed and capped, the pull cord shall extend through a drilled hole in the cap.

F. Raceways that cannot meet the requirements for mandrelling, shall be deemed defective, and shall be replaced as Authority approved.

3.7 RACEWAY LABELING

A. Identify each exposed raceway conduit at each end with tags as described below. Tags shall always designate location conduit ends. Tags and labels shall be made from nonferrous metals with raceway designations stamped by steel dies.

B. Conduit numbering shall be decided by the Contractor at time of construction. Use a left to right convention for numbering all conduits.

C. Fasten tags above raceway in manholes using a stainless steel anchor screw. At stub-up locations, band tag to rim of conduit using a stainless steel tie wrap band.

1. MH (manhole no.) - (conduit no.) - (chain marker)
a. MH 110B - 08 - 552+28

2. POS - (conduit number) - (chain marker)
a. POS - 08 - 552+81

3. NEG - (conduit number) - (chain marker)
a. NEG - 06 -552+90

4. TPSS - (conduit number)- (conduit type)
a. TPSS - 08 – POS
b. TPSS - 06 – NEG
c. TPSS - 02 – COMM
d. TPSS - 02 - SIG

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs will be considered incidental to the Work specified under Section 16312 “Traction Power System Substation Installation.”

END OF SECTION 16110
### TABLE 2.16A
**CONDUIT BRUSH SIZES**

<table>
<thead>
<tr>
<th>Duct Size (in)</th>
<th>Diameter (in)</th>
<th>Working Load (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>1.87</td>
<td>200</td>
</tr>
<tr>
<td>2.5</td>
<td>2.38</td>
<td>200</td>
</tr>
<tr>
<td>3.0</td>
<td>2.87</td>
<td>200</td>
</tr>
<tr>
<td>3.5</td>
<td>3.38</td>
<td>200</td>
</tr>
<tr>
<td>4.0</td>
<td>3.87</td>
<td>200</td>
</tr>
<tr>
<td>5.0</td>
<td>4.87</td>
<td>200</td>
</tr>
<tr>
<td>6.0</td>
<td>5.87</td>
<td>200</td>
</tr>
</tbody>
</table>

### TABLE 2.16B
**CONDUIT MANDREL SIZES**

<table>
<thead>
<tr>
<th>Duct Size (in)</th>
<th>Diameter (in)</th>
<th>Working Load (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>1.88</td>
<td>2330</td>
</tr>
<tr>
<td>2.5</td>
<td>2.19</td>
<td>2330</td>
</tr>
<tr>
<td>3.0</td>
<td>2.81</td>
<td>2330</td>
</tr>
<tr>
<td>3.5</td>
<td>3.25</td>
<td>4800</td>
</tr>
<tr>
<td>4.0</td>
<td>3.75</td>
<td>4800</td>
</tr>
<tr>
<td>5.0</td>
<td>4.69</td>
<td>4800</td>
</tr>
<tr>
<td>6.0</td>
<td>5.81</td>
<td>4800</td>
</tr>
</tbody>
</table>

### TABLE 3.1
**UNDERGROUND CONDUIT MINIMUM BENDING RADIUS**

<table>
<thead>
<tr>
<th>Conduit Size (in)</th>
<th>Conduit Radius (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>1-1/4</td>
<td>18</td>
</tr>
<tr>
<td>1-1/2</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>2-1/2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>3-1/2</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>42</td>
</tr>
<tr>
<td>6</td>
<td>48</td>
</tr>
</tbody>
</table>
# TABLE 3.3-1
**SUMMARY OF CONDUIT TYPES BY SPECIFIC LOCATION**

<table>
<thead>
<tr>
<th>Location</th>
<th>Uncoated GRSC</th>
<th>EMT</th>
<th>PVC 40</th>
<th>PVC 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground ductbanks</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Underground direct buried, including under building slabs</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Underground direct buried lighting only, not in a roadway</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stub-ups through concrete slabs</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded in concrete building walls, or in formed concrete</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior exposed or concealed in construction, dry locations only, not subject to damage</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Interior exposed or concealed in construction, dry locations only, subject to damage</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior exposed or concealed in construction, wet, or damp locations</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exterior exposed above ground in construction, wet, damp, or dry locations, whether, or not subject to damage</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeves</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Under station platforms direct buried, not in a roadway</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Under-track crossings</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catenary pole risers</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct buried in a roadway</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

# TABLE 3.3-2
**SUMMARY OF CONDUIT TYPES BY APPLICATION**

<table>
<thead>
<tr>
<th>Application</th>
<th>Conduit Type</th>
<th>Number* (Size)</th>
<th>Installation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication System Station – VMB</td>
<td>Liquid-tight Flexible Metal</td>
<td>As required, ((2 conduits) 1 inch per stanchion)</td>
<td>As Required</td>
</tr>
<tr>
<td>Junction Boxes to VMB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication System Station – Mounting column/pole to PA Speaker</td>
<td>Liquid-tight Flexible Metal</td>
<td>As required</td>
<td>As Required</td>
</tr>
<tr>
<td>Communication System – Interior House</td>
<td>EMT</td>
<td>As required</td>
<td>Surface Mounted</td>
</tr>
</tbody>
</table>

For CENC duct banks, stub-ups and stub-outs refer to the requirements of Specification Section 02780, "Underground Electrical And Communications Distribution Systems", for conduit type applications.

* If cable fill is greater than 40 percent, add another conduit.

Note: These tables do not address all situations or locations. Conduit types shall meet all the requirements of these Specifications and Contract Drawings.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Work includes conduits for above ground non-systems related conduits. Reference Section 02780, "Underground Electrical and Communications Distribution Systems", for underground electrical and distribution systems. Reference Section 16110, "Conduits and Raceways", for above ground conduit and raceways for Systems Work.

1.2 REFERENCED STANDARDS

A. American National Standards Institute (ANSI):
   1. ANSI C80.1 - Rigid Steel Conduit - Zinc Coated (GRC)
   2. ANSI/NEMA C80.3 - Electrical Metallic Tubing - Zinc Coated

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   2. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
   2. NEMA TC 6 & 8 - PVC Plastic Utilities Duct for Underground Installations

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)
   2. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

E. Underwriters Laboratories, Inc. (UL):
   1. UL 1 - UL Standard for Safety Flexible Metal Conduit
   2. UL 6 - UL Standard for Safety Rigid Metal Conduit - Steel
   3. UL 514B - UL Standard for Safety Fittings for Cable and Conduit
   4. UL 651 - UL Standard for Safety Schedule 40 and 80 Rigid PVC Conduit

1.3 SUBMITTALS

A. Product data or certification indicating compliance with the requirements listed.
B. Provide certification that galvanized rigid steel conduit and fittings comply with NFPA 130.

1.4 QUALITY ASSURANCE

A. Manufacturer: Select a firm regularly engaged in the manufacture of conduit, conduit fittings, connectors, and accessories of the type specified herein indicating conformance and compliance with specifications indicated herein.

PART 2 - PRODUCTS

2.1 GENERAL

A. Do not use conduit smaller than 3/4 inch in diameter for interior work and not smaller than 1 inch in diameter for exterior work, unless shown otherwise on the drawings.
B. Do not use polyvinyl chloride materials in tunnels or in stations below grade.

2.2 GALVANIZED RIGID STEEL CONDUIT AND FITTINGS

A. Manufacture galvanized rigid steel conduit in accordance with UL 6.
B. Apply protective coating and threading complying with ANSI C80.1. Hot-dip galvanize externally and internally after fabrication in accordance with ASTM A123.
C. Hot dip galvanize the male threads of conduit and fittings in a manner to keep the threads clear of excess zinc. Female threads may be electrogalvanized instead of hot dipped. Provide zinc coating for conduit accessories such as lock nuts, bushings and connectors.
D. Touch up galvanized coating with cold galvanizing compounds for all ferrous and non-ferrous surfaces; ASTM A780 where the original galvanized coating on conduit or galvanized steel has been damaged.

2.3 RIGID STEEL PLASTIC COATED CONDUIT AND FITTINGS

A. Use galvanized rigid steel conduit (GRSC) as specified in Article 2.2. Apply external coating of polyvinyl chloride (PVC), 40 mils (0.040 inch) thick, minimum. Apply internal coating of either urethan, 2 mils (0.002 inch) thick, minimum; or epoxy, 5 mils (0.005 inch) thick, minimum. Apply coatings under factory conditions, using heat and other environmental conditions as required for optimum quality of finished product. Apply these coatings to conduit and also to couplings, fittings, and conduit bodies that are parts of the conduit system. At female threaded areas of fittings - including both ends of couplings - provide a skirt of PVC (40 mils minimum thickness) extending far enough to cover the exposed male threads of the mating conduit section and overlap the PVC coating sufficiently to provide a seal.

B. Liquid PVC compound shall not be used as a substitute for factory applied PVC coating. The liquid compound shall be used only for touch-up and bonding in the field, as described in "Installation of Conduit" below.

2.4 NON-METALLIC RIGID CONDUIT AND FITTINGS

A. Furnish non-metallic rigid conduit and fittings fabricated from polyvinyl chloride (PVC). Provide sunlight-resistant, PVC, with impact strength conforming to the requirements of ASTM D256 and also NEMA TC 6 & 8 and ASTM F512.

B. Fabricate rigid, non-metallic, fiberglass reinforced epoxy (FRE) type conduit as indicated. Provide each conduit length with an expanded coupling with integral gaskets for a watertight seal when the coupling is mated to the joining conduit end. Make watertight joint without the use of lubricants or adhesives.

C. Provide non-metallic rigid conduit and fittings conforming to UL 514B and UL 651.

D. Provide end bells, flexible couplings, and expansion joints as necessary.

E. Use fitted plastic couplings to ensure a watertight joint.

2.5 ELECTRICAL METALLIC TUBING AND FITTINGS

A. Manufacture electrical metallic tubing from galvanized steel in accordance with ANSI C80.3.

B. Fittings and conduit bodies shall be steel compression type in accordance with NEMA FB 1. Do not use set screw type fittings.

2.6 LIQUID-TIGHT FLEXIBLE STEEL CONDUIT AND FITTINGS

A. Provide liquid-tight flexible conduit UL listed with galvanized steel core and thermoplastic cover conforming to UL 1 and being UL listed, where indicated. Do not use flexible steel conduit other than watertight type.

B. Provide fittings and conduit bodies suitable for watertight flexible steel conduit and in accordance with NEMA FB 1.

2.7 CONDUIT FITTINGS AND ACCESSORIES

A. Provide conduit connector fittings which conform to ULB 514, material similar to that of conduit with which they are to be used with the following additional requirements:

1. For enclosures, cabinets, boxes, and gutters which are subject to moisture or dirt: Tapped conduit hub.

2. For enclosures having punched or formed knockout for conduit entry: Watertight hub fitting with gasket, nylon insulated throat, and locknut.

B. Thread conduit couplings on both ends. Do not use slip-on couplings.

C. Provide malleable iron union couplings for joining rigid conduit at intermediate runs, threaded watertight to permit completing conduit run when neither conduit can be turned and to permit breaking the conduit run at the union.

D. Fabricate bushings of the same material with which the bushings are to be used. Provide insulated bushings 1-1/4 inches and larger with 300 degrees F temperature rating. Install insulated grounding bushings in conduits to protect wires inside boxes except where the protective shoulder is provided as part of the conduit thread connection.

E. Equip metal fittings with bonding jumper cable where required to provide electrical continuity.

F. Provide expansion fittings with both expansion and deflection types on conduits crossing expansion joints. Fabricate conduit expansion fittings from material similar to that of conduit with which coupling is to be used, having factory installed packing ring and pressure ring to prevent entrance of moisture. Equip metallic couplings with grounding ring.

G. Provide sealing fittings watertight, malleable iron cadmium plated with pouring spout perpendicular to the conduit. Provide vertical seals complete with drain seals.
PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUIT

A. Provide conduit of size and type approved for use in accordance with NEC and as indicated on drawings.

B. Provide conduit concealed, where possible, within finished walls, ceilings, and floors. Install exposed conduit parallel with or at right angles to the building walls in accordance with the NEC.

C. Use galvanized rigid steel conduit for all exposed installations.

D. Use flexible metal conduit for final connection to rotating and/or vibrating equipment and as permitted by NEC. Install a green insulated wire in flexible conduits for grounding purposes. Use liquid-tight flexible conduit in wet and damp locations. Provide flexible conduit no longer than 36 inches, except from outlet box to recessed lighting fixtures, provide flexible conduit no longer than 6 feet from outlet box to recessed lighting fixture. Do not use flexible conduit to aid in the final positioning of panels, back boxes and terminal cabinets.

E. Make all conduit bends in accordance with NEC with not more than three 90 degree bends between conduit ends or pull boxes. 90 degree bends for conduit sizes 4 inches or greater shall not be made in the field. Provide conduit manufacturer’s factory elbows for conduit sizes 4 inches or greater.

F. For all installations of metal conduit that will be in direct contact with earth, use only galvanized rigid steel conduit and fittings with factory-applied exterior PVC coating as described above. After installation, touch-up any areas where the external coating has been damaged, using liquid PVC compound. Apply as many coats as required to assure that damaged area has been covered with at least 40 mils of PVC. If any damaged area is so large that liquid PVC will not make a permanent bond, remove the damaged pieces and provide new ones. Before connecting a coupling to a section of conduit, apply liquid PVC compound liberally to the conduit near the threads so it will form a seal between the PVC coating of the conduit and the PVC skirt on the coupling. Provide a finished system of conduits that is completely covered inside with urethane or epoxy - all at the specified thicknesses.

G. Cut off square all field-cut conduit without restriction to the conduit openings. After conduit is cut and threaded, ream conduit to remove all burrs and sharp edges and then clean thoroughly. Make all joints waterproof by the application of a suitable corrosion-resistant sealer to the threads immediately before assembly.

H. Cut off square non-metallic conduit without restriction to the conduit openings. Trim all cut ends inside and out to remove rough edges and then clean thoroughly. Install all joints completely sealed and watertight.

I. For each completed run of conduit, pull a flexible mandrel through the conduit at a speed not greater than 1-1/2 feet per minute prior to installation of cable. Use mandrel size not less than shown below. If the mandrel does not pass through the conduit, remove the obstruction or replace the clogged conduit with new conduit.

<table>
<thead>
<tr>
<th>CONDUIT SIZE DIAMETER SIZE</th>
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<tbody>
<tr>
<td>(inches)</td>
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<tr>
<td>3/4</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1-1/4</td>
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<td>1-1/2</td>
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<tr>
<td>2</td>
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<td>3</td>
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<td>4</td>
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</tbody>
</table>

J. Where non-metallic conduit is installed in concrete, use adapters used for transition from non-metallic conduit to galvanized rigid steel conduit before leaving concrete enclosure. Do not install non-metallic conduit exposed.

K. After the conduit has been rodded and swabbed, repack boxes and protect conduit ends to prevent any foreign material from entering the conduit.

L. Install conduits in tiers under the slab with a minimum of 6 inches between rows where indicated. Set conduits so as not to interfere with reinforcing bars.

M. Provide metallic numbering tags (brass or aluminum) indicating the conduit number on the ends of conduit. Identify signal and communication conduit as indicated.

N. Securely fasten each conduit entering a non-threaded metal box with two locknuts and a bushing. Retain bushing caps, where required, in place until just before conductors are installed. Secure continuous ground by bonding as required. Thread free ends of spare conduits and install couplings and plugs.

O. Install bell ends on conduits terminating in manholes, hand holes, building walls, or floors.

P. Install a pull rope or cable in each conduit having a minimum tensile strength of 600 pounds. Double back 2 feet of pull rope at each termination. Do not use nylon rope for pulling wires.

Q. Mechanically connect together metal conduits, fittings, boxes, cabinets, and raceways to form an effective continuous electrical path for grounding purposes.

R. Examine carefully conduits and fittings before installing. Set aside pieces having splits, breaks, blisters, or defects and remove from the Worksite.
S. Install expansion and deflection fittings as required on all conduits crossing expansion and contraction joints.

T. Install sealing fittings on conduits and cables penetrating fire rated walls, floors, partitions, and ceilings to insure that the fire rating is maintained.

U. After sanding, apply joint solvent cement to the male end of all PVC conduit prior to inserting in coupling. Furnish solvent cement of type as recommended by the conduit manufacturer.

V. Apply electrically conductive pipe joint compound to male threads prior to assembly of metallic conduits.

W. Install conduit spacers for buried conduit and duct banks before placing concrete.

X. Prime coat and paint galvanized rigid steel where shown on drawings and as specified in Section 09920, “Interior Painting” for interior locations and Section 09970, “Coatings for Steel” for exterior locations.

Y. Where metal conduit runs exceed 500 feet, provide insulated couplings at intervals of 500 feet or less, to minimize stray current effects.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16111
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing of cable trays complete with accessories as shown.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
2. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
3. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

B. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
2. NFPA 70B - Recommended Practice for Electrical Equipment Maintenance

C. National Electrical Manufacturers Association (NEMA):
1. NEMA VE 1 - Metal Cable Tray Systems
2. NEMA VE 2 - Cable Tray Installation Guidelines

1.3 SUBMITTALS

A. Submittal Drawings: Submit drawings of cable tray and accessories including clamps, brackets, hanger rods, splice plate connectors, expansion joint assemblies, and fittings, showing accurately scaled components.

B. Product Data: Submit manufacturer's data on cable tray including, but not limited to, types, materials, finishes, rung spacings, inside depths and fitting radii. For side rails and rungs, submit cross sectional properties including Section Modulus (Sx) and Moment of Inertia (Ix).

1.4 QUALITY ASSURANCE

A. Experience:
1. Manufacturer: Select a firm regularly engaged in the manufacture of cable trays of the type specified.
2. Incorporate equipment into this work which essentially duplicate equipment that has been in satisfactory use for a period of 5 years prior to the bid opening of this Project.

PART 2 - PRODUCTS

2.1 CABLE TRAY - GENERAL USE

A. Provide steel ladder type cable tray in accordance with NEMA VE 1 in 12 foot or 24 foot lengths with rung spacing as shown on the drawings. If no spacing is shown, provide tray with 9 inch rung spacing. Width as indicated on the drawings.

B. Fabricate tray from steel conforming to ASTM A1008/A1008M, Grade C, hot dipped galvanized after fabrication, conforming to ASTM A1011/A1011M or ASTM A123. Side rails: reinforced I-beams with nominal inside loading depth of 3, 4, 5, or 6 inches, as required. Rungs: reinforced channels, with minimum depth of 1 inch and minimum width of 1 inch, or 1 inch diameter tubes, which may be flattened on top.

C. Tray capacity: Provide for a working load of 40 pounds per linear foot with a deflection not enough to cause permanent deformation of any part of the tray system. Design tray with a safety factor of 2. In addition, provide tray to support, without failure, or permanent deformation, a 200 pound concentrated load applied on the rungs or side rails anywhere in the span. Design for a NEMA Class 16A system.

D. Connect splice plates in the field with 3/8 inch by 1-1/2 inch stainless steel carriage bolts, lock washers, and nuts.

E. Connect ground jumpers in the field with 3/8 inch by 1-1/2 inch hexagon head stainless steel bolts, lock washers, and double hexagon head nuts.

F. Locate cable tray supports as required for a rigid installation. Provide cable tray supporting components comprised of clamps, clips, concrete inserts, hanger rods, insulators, racks, frames, trapeze, hangers, beams, structural steel clamps, U-bolts, slotted angles and fittings, machine screws, wall anchors, and similar items. Use 1/2 inch diameter minimum bolts, rods, etc., in the support system unless otherwise approved. Avoid using dissimilar metals that are not compatible with adjacent materials.
G. Provide hot-dipped galvanized steel expansion guide clamps, conduit to tray adapters and miscellaneous fittings.

H. Provide hot-dipped galvanized steel barrier strips for straight lengths 12 feet long. Provide barrier strips for elbows full length of elbow complete with drilled holes and bolts or clamps for attaching to the cable tray.

I. Bend radii: Use standard radius bends (12, 24, 36, and 48 inches) for horizontal and vertical bends. Select each bend radius to be not less than minimum bend radius of cable to be installed.

1. For incoming service cable: As required by local power company.

2. For all other cable: As recommended by cable manufacturer.

2.2 CABLE TRAY - COMM ROOM IN SERVICE BUILDING

A. General: Except as otherwise indicated, provide metal cable trays, of types, classes and sizes indicated; with splice plates, bolts, nuts and washers for connecting units. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.

B. Materials and Finish: Material and finish specifications for each tray type are as follows:

1. Aluminum: Straight section and fitting side rails and rungs shall be extruded from Aluminum Association Alloy 6063. Fabricated parts shall be made from Aluminum Association Alloy 5052.

C. Ladder type trays shall consist of 2 longitudinal members (side rails) with transverse members (rungs) welded to the side rails. Rungs shall be spaced 6 inches on center. Spacing in radiused fittings shall be 9 inches and measured at the center of the tray's width. Rungs shall have a minimum cable-bearing surface of 7/8 inch with radiused edges. No portion of the rungs shall protrude below the bottom plane of the side rails.

D. Tray Sizes shall have 3 inch minimum usable load depth, or as noted on the drawing.

E. Straight tray sections shall have side rails fabricated as I-Beams. Straight sections shall be supplied in standard 12-foot lengths, except where shorter lengths are permitted to facilitate tray assembly lengths as shown on drawings.

F. Tray widths shall be 12, 18, 24 inches or as shown on drawings.

G. Fittings must have a minimum radius of 12 inches.

H. Splice plates shall be the bolted type made as indicated below for each tray type. The resistance of fixed splice connections between adjacent sections of tray shall not exceed 0.00033 ohms. Splice plate construction shall be such that a splice may be located anywhere within the support span without diminishing rated loading capacity of the cable tray.

1. Aluminum Tray - Splice plates shall be made of 6063-T6 aluminum, using 4 square neck carriage bolts and serrated flange locknuts. Hardware shall be zinc plated in accordance with ASTM B633, SC1. If aluminum cable tray is to be used outdoors then hardware shall be Type 316 stainless.

I. Cable Tray Supports: Shall be placed so that the support spans do not exceed maximum span indicated on drawings. Supports shall be constructed from 12 gauge steel formed shape channel members 1-5/8 inch by 1-5/8 inch with necessary hardware such as Trapeze Support Kits. Cable trays installed adjacent to walls shall be supported on wall mounted brackets.

J. Center hung supports shall be manufactured of 12 gauge, 1-5/8 inch by 1-5/8 inch B-Line B22 steel strut with a pipe welded at the middle of the support to provide eccentric loading stability. Support shall withstand 700 pounds in a 60 percent versus. 40 percent eccentric loading condition with a safety factor of 3.

K. Trapeze hangers and center-hung supports shall be supported by 1/2-inch (minimum) diameter rods.

L. Barrier Strips: Shall be placed as specified on drawings and be fastened into the tray with self-drilling screws.

M. Accessories - special accessories shall be furnished as required to protect, support, and install a cable tray system. Accessories shall consist of but are not limited to: section splice plates, expansion plates, blind-end plates, specially designed ladder dropouts, barriers, etc.

N. Cable tray shall be capable of carrying a uniformly distributed load of 222 lbs./ft. on a 12 foot support span with a safety factor of 1.5 when supported as a simple span and tested per NEMA VE 1 Section 5.2.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cable trays as indicated: Installation shall be in accordance with equipment manufacturer's instructions, and with recognized industry practices to ensure that cable tray equipment comply with requirements of NEC and applicable portions of NFPA 70B. Reference NEMA-VE2 for general cable tray installation guidelines.

B. Coordinate cable tray with other electrical work as necessary to properly integrate installation of cable tray work with other work.

C. Provide sufficient space encompassing cable trays to permit access for installing and maintaining cables.

D. Cable tray fitting supports shall be located such that they meet the strength requirements of straight sections. Install fitting supports per NEMA VE-2 guidelines, or in accordance with manufacturer's instructions.
E. Ground the steel cable tray in accordance with Section 16450, "Grounding and Bonding".

F. Ground the aluminum cable tray in accordance with Section 16876, "Grounding and Bonding - Communications System".

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16114
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing wires and cables, cable connectors, and cable connections as shown.

1.2 REFERENCED STANDARDS

A. Association of Edison Illuminating Companies (AEIC):

1. AEIC CS 6 - Ethylene Propylene Rubber Insulated Shielded Cables Rated 5 through 69 KV

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire
2. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
3. ASTM B33 - Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
4. ASTM D1000 – Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
5. ASTM E662 - Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials

C. Insulated Cable Engineers Association Inc. (ICEA):

1. ICEA T-29-520 - Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 210,000 B.T.U./Hour
2. ICEA T-30-520 - Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 70,000 B.T.U./Hour

D. Institute of Electrical & Electronics Engineers (IEEE):

1. IEEE 48 - Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV Through 765 kV
2. IEEE 383 - Standard for Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations
3. IEEE 404 - Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500 000 V

E. National Electrical Manufacturers Association (NEMA):

1. NEMA WC 70 - Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
2. NEMA WC 71 - Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy
3. NEMA WC 74 - 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy

F. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
2. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems
3. NFPA 258 - Recommended Practice for Determining Smoke Generation of Solid Materials

G. Underwriters Laboratories, Inc. (UL):

1. UL 22 - UL Standard for Safety Amusement and Gaming Machines
2. UL 44 - UL Standard for Safety Thermoset-Insulated Wires and Cables
3. UL 224 – UL Standard for Safety Extruded Insulating Tubing
4. UL 854 - UL Standard for Safety Service-Entrance Cables
5. UL 1072 - UL Standard for Safety Medium-Voltage Power Cables
6. UL 1277 - UL Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members

1.3 SUBMITTALS

A. Provide Certification or product data (manufacturer's data sheets) indicating that materials comply with standards listed in this specification.
B. Submit Installation procedures for:
1. Wires and Cables.
2. Tape.
3. Heat shrink material.

C. Provide wire pulling calculations for wires and cables.

1.4 QUALITY ASSURANCE

A. Experience: Manufacturer: Select firms regularly engaged in the manufacture of wires and cables and connectors of the types specified herein, and having a performance record demonstrating a minimum of 10 years of successful operating experience.

PART 2 - PRODUCTS

2.1 SINGLE CONDUCTOR 600 VOLT CABLE FOR GENERAL USE IN ANY APPLICATION NOT REQUIRING LOW-SMOKE PROPERTIES AND PERMITTED BY NFPA 130

A. Conductors: Coated copper per ASTM B33, or uncoated. Conductors shall be stranded.

B. Insulation: Moisture resistant and heat resistant thermoplastic (type THHN/THWN) or cross-linked synthetic polymer (type XHHW). Must be rated for 194 degrees F (minimum) in dry locations and 167 degrees F (minimum) in wet locations.

C. Color code lighting and power wiring as indicated in Table 16120 - 1.

2.2 SINGLE CONDUCTOR 600 VOLT CABLE FOR LOW-SMOKE APPLICATIONS

A. Conductor: Coated copper per ASTM B33 stranded per ASTM B8, or uncoated copper.

B. Conductors shall be stranded.

C. Conductors shall be insulated with a low-smoke thermosetting dielectric based on ethylene propylene rubber elastomer meeting the requirements of NEMA WC 70.

D. Jacket insulated conductors with a mechanically rugged low-smoke compound. The jacket shall be firmly bonded to the underlying EPR insulation.

E. Color code lighting and power wiring as Table 16120 - 1.

F. General Requirements:
1. Samples of identical cables (No. 6 AWG and larger) shall pass the ICEA T-30-520 vertical tray flame test.

2. Cables shall be rated for service in dry locations at 194 degrees F continuous, 266 degrees F emergency overload, and 482 degrees F short circuit. Cables shall be rated for service in dry locations at 167 degrees F continuous.

2.3 MULTI-CONDUCTOR 600V CABLE FOR GENERAL USE

A. Conductors: Coated copper per ASTM B33 stranded per ASTM B8, or uncoated copper.

B. Insulation: Flame-retardant dielectric based on anethylene propylene elastomer meeting the requirements of NEMA WC 70. The insulated conductors shall be color coded per NEMA WC 70, Appendix K, Method 1, Table K-2, except that neutral conductor shall be colored white.

C. Assembly: The insulated power conductors, neutral conductor, and bare or green insulated ground conductor shall be cabled together with flame-retardant and moisture resistant fillers to form a substantially round core, covered by a binder tape.

D. Jacket: The cable core shall be covered by a mechanically rugged thermosetting chlorosulfonated polyethylene or chlorinated polyethylene compound which is flame-retardant, weather resistant, and resistant to most oils, acids, and alkalies.

E. General Requirements:
1. Samples of identical cable shall pass the ICEA T-29-520 210,000 Btu/hr. vertical tray flame test.

2. Cables shall be rated for service at 194 degrees F continuous for dry, 167 degrees F continuous for wet, 266 degrees F emergency overload, and 482 degrees F short circuit.

3. Individual conductors shall be UL rated VW-1.

4. Cables shall be UL approved for use in cable tray, for direct burial, and Sunlight Resistant.

2.4 MULTI-CONDUCTOR 600 VOLT CABLE FOR LOW-SMOKE APPLICATIONS

A. Conductors: Coated copper per ASTM B33 stranded per ASTM B8, or uncoated copper.
B. Insulation: Flame-retardant low-smoke dielectric based on an ethylene propylene elastomer meeting the requirements of NEMA WC 70. The insulated conductors shall be color coded per NEMA WC 70, Appendix K, Method 1, Table K-2, except that neutral conductor shall be colored white.

C. Assembly: The insulated power conductors, neutral conductor, and bare or green insulated ground conductor shall be cabled together with flame-retardant and moisture resistant fillers to form a substantially round core, covered by a binder tape.

D. Jacket: The cable core shall be covered by a mechanically rugged low-smoke compound which is flame-retardant, weather resistant, and resistant to most oils, acids, and alkalies.

E. General Requirements:
   1. Samples of identical cable shall pass the ICEA T-30-520 vertical tray flame test.
   2. Cables shall be rated for service at 194 degrees F continuous for dry, 167 degrees F continuous for wet, 266 degrees F emergency overload, and 482 degrees F short circuit.

2.5 INSTRUMENTATION CABLE

A. NEC Type shielded pair-overall shield (SP-OS) shielded triads with each triad twisted with a drain wire and shielded with an aluminum polyester tape in accordance with UL 1277.

B. Other configurations of single conductors, pairs, triads, etc., shielded or unshielded, as described on drawings. Assemble multiple groups with flame and moisture resistant fillers where required.

C. Insulate conductors with low smoke generation insulation. Provide wall thicknesses of insulation consistent with the system nominal voltage.

D. Fabricate jacket with low smoke non-halogenated compound meeting the requirements of NEMA WC 70.

E. Minimum conductor size: No. 16 AWG uncoated copper in accordance with ASTM B3, Class B, stranded per ASTM B8.

F. Flame test the cables to meet requirements of IEEE 383.

G. Provide the cross-sectional area and conductor resistance in accordance with NEMA WC 70.

2.6 COAXIAL CABLE

A. Assemble single and multiple elements of the coaxial cables with flame and moisture resisting fillers in the interstices and a binder tape over the conductors.

B. Jacket single element cables with low-smoke non-halogenated compound meeting the requirements of NEMA WC 70.

C. Cover the individual elements of a multiple element assembly with low smoke non-halogenated compound meeting the requirements of NEMA WC 70.

D. Make circuit identification using printed color coding in accordance with NEMA WC 70.

E. Flame test the completed multi-conductor cables to meet requirements of NEMA WC 70.

2.7 WIRE CONNECTION ACCESSORIES

A. Connectors:
   1. Provide connectors for No. 8 AWG and smaller of the pressure indent type with nonflammable, self-extinguishing insulation of temperature rating equal to that of cable being connected.
   2. For wires No. 8 through No. 22, use low smoke, low toxic insulated compression terminals, or as approved.
   3. Where insulated connectors are not required, use uninsulated terminals or as approved.
   4. Terminate wire and Cable No. 6 AWG and larger with bolted pressure type connector. Design connectors compatible with the conductors for which they are used.
   5. For cables above 600 volt rating, provide termination kits of the correct voltage rating, including a heat shrink stress control tube, a heat shrink non-tracking outer insulation, and the mastic and sealant materials required. For cables 600 volts and below, heat shrink terminations may be used at Contractor's option.
   6. Provide solderless lugs for connections to motor leads.
   7. Provide connectors for connecting lighting fixtures to branch circuit wiring of the pre-insulated permanent pressure electrical spring connector type encased in an insulating cover.
   8. Provide compression terminals for control and instrumentation cables.
   9. No crimp-on connectors shall be used on solid conductors.
B. Conductor Bundling Straps:

1. Formed from self-extinguishing nylon having a temperature range of 0 degrees F to 250 degrees F.

2. Equip each strap with a locking hub or head with a stainless steel locking barb on one end with a taper on the other end.

3. Provide ultraviolet-resistant bundling straps for outdoor locations.

C. Splices:

1. For wires No. 8 AWG and smaller, provide pressure indent type splices with nonflammable, self-extinguishing insulation of temperature rating equal to that of the wires.

2. For wires No. 6 AWG and larger, provide bolted pressure type connectors with nonflammable, self-extinguishing insulation of temperature rating equal to that of the wires.

3. For cables 600 volts and below, heat shrink splices may be used at Contractor's option.

D. Insulation Tapes (use limited to wires and cables below 600 volts in locations other than tunnels and underground):

1. Of the type approved by UL for the particular use, location and voltage, 3/4 inch nominal width.

2. Plastic electrical insulating tape for general use: Vinyl plastic tape with rubber-base pressure-sensitive adhesive, pliable at 0 degrees F with the following minimum properties when tested in accordance with ASTM D1000:
   a. Thickness: 0.085 inches.
   b. Breaking strength: 15 pounds per inch width.
   c. Elongation: 200 percent.
   d. Dielectric breakdown: 10,000 volts.
   e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

E. Heat Shrink Cable Terminations:

1. Description: IEEE 48; Class I, heat shrinkable cable terminations in kit form, capable of properly terminating cables specified in this section.

2. Terminations for single-conductor cables shall consist of heat-shrinkable radiation cross-linked high dielectric constant linear stress relief material and heat-shrinkable radiation cross-linked non-tracking outer insulation. Terminations shall contain a high relative permittivity electric stress relief mastic for insulation shield cutback treatment and a heat activated sealant for environmental sealing.

3. In addition to the components described above, three-conductor kits shall contain heat shrinkable components to seal the cable jacket, phase connectors, ground wire and rejacket phase and ground conductors.

4. Kits shall be factory engineered and shall accommodate any common form of cable shielding or construction without the need for special adaptors. Kits shall accommodate a wide range of cable sizes and be completely independent of cable manufacturer's tolerances. Kits shall accommodate commercially available standard connectors.

F. Heat or Cold Shrink Cable Splices:

1. Description: IEEE 404, heat or cold shrinkable cable splices in kit form, capable of properly splicing cables specified in this section.

2. Splice kits shall contain necessary components to reinstate primary cable insulation, metallic shielding and grounding systems and overall jacket to the equivalent of the cable itself. Splices shall be of a uniform cross-section and shall consist of heat-shrinkable radiation cross-linked insulation. The outer insulating layer shall be bonded to a conducting layer for shielding. The splice shall be rejacketed with a heavy-wall, heat-shrinkable sealant lined sleeve to provide a waterproof hot melt adhesive seal. Splices shall contain a high relative permittivity electric stress relief mastic for insulation shield cutback treatment and a heat activated sealant for environmental sealing.

3. Kits shall be factory engineered and shall accommodate any common form of cable shielding or construction without the need for special adaptors. Kits shall accommodate a wide range of cable sizes and be completely independent of cable manufacturer's tolerances. Kits shall allow splicing cables with different conductor sizes and shielding construction. Kits shall accommodate commercially available standard connectors.
G. Heat Shrink Identification Markers:

1. Description: Heat-shrinkable radiation cross-linked, thermally stabilized, flame-retarded modified polyolefin sleeves. Markers shall be recognized to UL 224.

2. Sleeves shall be smear resistant prior to shrinking and achieve mark permanency when shrunk without the need for permatizing equipment. Sleeves should achieve mark permanency when standard ballpoint pens or high-carbon content fabric ribbons are used. The markers shall be flattened and mounted on a carrier suitable for use with typewriters or printers. Markers shall be resistant to common industrial fluids including Freon TF, Isopropyl alcohol, and Ethylene Glycol.

3. Markers shall be compatible with an integrated hardware and software system allowing high speed, automated, set or batch, wire list printing. System shall allow external data to be imported from mainframe computers. System shall be compatible with panel and wraparound markers specified in this section.

4. Locations: Each conductor at panelboard gutters, pull boxes, outlet and junction boxes, and each load connection.

5. Legend:
   a. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
   b. Control Circuits: Control wire number indicated on schematic and interconnection diagrams on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wires in conduits after conduits are in place and related work is completed and the area cleared for a safe working condition.

B. Use UL-listed lubricant and provide suitable installation equipment to prevent cutting and abrasion of wire during the pulling of feeders. Avoid using any lubricant that may be injurious to the materials of the wires and cables to be installed. Provide installation procedure as recommended by the cable manufacturer, and approved by the Contracting Officer.

C. Pull in cables or wires to be installed in a single conduit at the same time. Use steel cable or other pulling material with a low coefficient of elongation. Avoid use of nylon or other rope that elongates during pulling, causing uneven stress on cables.

D. Install branch circuit, neutral and ground wires in accordance with the requirements of the latest provisions of the NEC and local agencies having jurisdiction.

E. Join conductors securely both mechanically and electrically to engage strands equally by use of proper connectors and terminal lugs.

F. Make wire and cable splices in outlet, junction or pull boxes, or in manholes or handholes. Make splices in accessible locations. Keep splices to a minimum. Do not pull splices into the conduit.

G. Replace cables for any rupture of insulation.

H. Use nylon straps to bundle and secure wires and cables in panel boards, cabinets, switchboards, motor control centers, and switchgear.

I. Connect branch circuits in each panelboard serving single-phase loads in a manner that will balance the load on all phases as closely as possible.

J. No. 1/0 AWG and larger cables require a 2-bolt connector.

K. For wires above 600 volts, cover joints, taps and splices with approved type heat shrink tubing. For wires 600 volts and less, use tape or heat shrink materials (Contractor’s option).

L. Install compression connectors and terminal lugs using tools and pressures recommended by manufacturer and approved by the Contracting Officer.

M. Make tap connections for lighting and receptacle wiring No. 12 AWG and No. 10 AWG with screw type connectors.

N. Identify phases of wires by using colored wire as listed elsewhere in this section. For wires not available in needed colors, use colored plastic tape. Wrap the tape in 3 layers at pull boxes, junction boxes, manholes, wire ways, splicing and access points. Provide the length of wrap sufficient to permit easy identification but not less than 12 inches per conductor.

O. Provide No. 12 AWG as the minimum conductor size for power and lighting and No. 14 AWG as the minimum conductor size for control, signal, and alarm circuits, unless otherwise indicated.

P. Label main and feeder cables in pull boxes, junction boxes, wire ways, wiring gutters, and panels. Label branch circuits and control wiring in panels. Label control wiring in outlet boxes and at the control devices. On each wire or cable indicate wire or cable number and/or piece of equipment served. Use heat shrink tubing, with lettering applied by typewriter or computer printer.

Q. Connect and label wires to equipment on 3-phase circuits so that the phases are arranged A, B, and C
from left to right, when viewed from the front of the equipment.

R. Secure cables passing through manholes to the embedded channel inserts. Place utility power supply cables and traction power cables on insulating saddles secured to cable racks.

S. Use grip type cable supports where cables are installed in raceways with a vertical rise of more than 20 feet.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

<table>
<thead>
<tr>
<th>Wiring</th>
<th>First Leg</th>
<th>Second Leg</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>120/240 volts, 1-Phase, 3 Wire</td>
<td>Black</td>
<td>Red</td>
<td>White</td>
</tr>
<tr>
<td>Phase A</td>
<td>Phase B</td>
<td>Phase C</td>
<td>Neutral</td>
</tr>
<tr>
<td>208/120 volts, 3-Phase, 4 Wire</td>
<td>Black</td>
<td>Red</td>
<td>Blue</td>
</tr>
<tr>
<td>480/277 volts, 3-Phase, 4 wire</td>
<td>Brown</td>
<td>Orange</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Color ground wire green.

Provide colored tape to identify wires that are not available with colored insulation.

END OF SECTION 16120
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing electrical boxes as shown including interior demarcation panels for Comm Room in Service Building at Aerial Stations.

B. Exterior demarcation cabinets at At-Grade Stations are specified in Section 16135 “Exterior Demarcation Cabinets”.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME):
   1. ASME B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

C. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

D. Underwriters Laboratories, Inc. (UL):
   1. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment
   2. UL 508A - UL Standard for Safety Industrial Control Panels
   3. UL 514A - UL Standard for Safety Metallic Outlet Boxes
   4. UL 514B - UL Standard for Safety Fittings for Cable and Conduit

1.3 SUBMITTALS

A. Product Data: Provide manufacturer's standard catalog data for items described in this Specification indicating conformance and compliance with standards and criteria listed.

1.4 QUALITY ASSURANCE

A. Manufacturer: Select a firm regularly engaged in the manufacture of electrical boxes of the types specified herein.

PART 2 - PRODUCTS

2.1 ELECTRICAL BOXES

A. Include outlet, junction, terminal, device, splice, and pull boxes.

B. Conform to UL 50, UL 514A and 514B.

C. Provide the volume required by NEC for the number of conductors enclosed.

D. Provide boxes of the material, finish, type, and size specified and required for the location, kind of service, number of wires, and function.

E. Provide weatherproof boxes for outdoors and for locations subject to moisture, with neoprene cover gaskets.

F. Provide watertight surface mounted boxes with external mounting lugs where required.

G. Provide boxes for exposed switches, receptacles, and telephones fabricated of cast aluminum alloy, Type FS, and FD, or of hot dipped galvanized steel, or of malleable iron.

H. Fabricate boxes 12 inches square and larger of stainless steel, copper-free cast aluminum, cast iron, or cadmium plated malleable iron, with NEMA rating based on location and application. Provide factory installed hubs. Fabricate boxes smaller than 12 inches square with hot-dipped galvanized steel in accordance with ASTM A123.

I. Follow instructions on drawings if different materials are called for. Do not install aluminum boxes in contact with or embedded in earth or in concrete.

J. Provide boxes complete with covers suitable to the purpose for which they will be used, except equip boxes in which or on which no devices or fixtures are to be installed, with flat or raised blank covers as required. Equip ceiling fixture outlet boxes with 3/8 inch boltless fixture studs.

K. Furnish covers of the same material thicknesses and finish as boxes, secured in position by means of screws compatible with the material of the box and with the environment. Arrange covers to be readily and conveniently removed.

L. Galvanize steel junction boxes after fabrication inside and outside to prevent oxidation. Where outlet boxes are used as junction boxes, do not provide boxes smaller than 4 inches square by 1-1/2 inches deep. Provide boxes with flat blank covers fabricated of galvanized steel. Galvanize (hot-dip) junction boxes and covers in accordance with ASTM A123.
ELECTRICAL BOXES

M. Provide boxes for flush mounting in concrete fabricated of Ferroalloy hot-dip galvanized cast body and screwed on cover with neoprene gasket.

N. Provide outlet boxes of hot-dipped galvanized steel, in accordance with ASTM A123, and not smaller than 4 inches square by 2-1/8 inches deep.

O. Galvanize concealed switch boxes in accordance with ASTM A123. Provide covers with rectangular openings of proper size and shape. Furnish special boxes and install as required to suit the kind of service for the building construction requirements.

P. Furnish brackets, supports, hangers, fittings, bonding jumpers, and all other accessories required.

Q. Use flat terminal strips made of polyamide 6.6 insulation or bakelite suitable for No. 22 to No. 12 wires, with 6-32 by 5/16 inch long screws in accordance with ASME B1.1 for ring or spade lugs, rated at 20 amperes, 300 or 600 volts as required.

R. Terminal strips for wires larger than No. 12: Provide compression type line terminals rated 600 volts and equipped with two washer head screws per wire.

S. Cast boxes shall be of aluminum or ferroalloy, deep type, with gasketed cover and threaded hubs. Do not install aluminum boxes in or touching concrete.

T. Cast Iron Boxes: For Cast iron box installations indicated on the plan drawings or shown within electrical details, the substitution of concrete polymer boxes is acceptable.

U. Concrete Polymer Boxes: The concrete polymer boxes shall be the same size and have equivalent conduit entry locations. Provide proper grounding for conduit. The concrete polymer boxes shall have gasketed bolt down covers. Where the boxes are shown to be installed so the covers are exposed to the surface and visible to the public, provide with bolt down cast iron covers. Exposed covers shall be flush with the surface grade.

2.2 INTERIOR DEMARCATION PANELS IN COMM ROOM IN SERVICE BUILDING AT AERIAL STATIONS

A. Single-door enclosures conforming to UL 508A, Type 12.

B. General construction:
   1. Bodies: 14 gauge steel.
   2. Doors: 14 gauge steel.
   3. Optional panels: 12 gauge steel.
   4. Seams continuously welded and ground smooth, no holes or knockouts.

C. Provide:
   1. Door clamps and removable heavy gauge continuous hinge pin.
   2. Hasp and staple for padlocking.
   3. Data pocket of high-impact thermoplastic inside door.
   4. Oil-resistant gasket attached to the door with oil-resistant adhesive.
   5. Collar studs for mounting optional panels.
   6. Bonding provision on door.

D. Finish: White inside with ANSI 61 gray outside finish over phosphatized surfaces. Optional terminal block panels white.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install electrical boxes for switches and receptacles flush in finished areas and exposed on walls and columns in unfinished areas or as shown.

B. Install boxes plumb and straight, rigidly secured in place.

C. Install conduit fittings in boxes for conduit connectors.

D. Install brackets, supports, hangers and accessories required for installation of boxes. Provide additional support, independent of conduit system, for boxes weighing substantially more than an equal length of conduit.

E. Provide suitable bushings, shields, or fittings having smooth rounded edges where conductors pass through partitions and at other locations where necessary.

F. Install bonding jumpers across all boxes from conduit to conduit, where conduits contain 1 or more feeders.

G. Install receptacle outlet boxes 18 inches from the finished floor to the center of the outlet box unless shown otherwise. Install switch boxes measuring 4.5 feet from the finished floor to the center of the switch box unless shown otherwise. Locate outlets as shown on the Drawings.

H. Do not obstruct access to boxes. Provide removable box covers without interference to or from other conduit boxes or equipment.
I. Coat with coal tar mastic as per Section 13100, "Corrosion Control", all embedded boxes with exposed covers for underground installations.

J. Clean boxes thoroughly after installation and correct any damage to boxes and to finish.

K. Provide adequate support for all boxes. Boxes in conduit runs shall be supported independently of the conduit, unless conduit supports (adequate to support the additional weight) are placed within 24 inches of the box on both sides.

L. In damp or wet locations, do not mount boxes against walls. Provide 1/2 inch or more of air space between box and wall. If strips or channels are used for standoffs, mount them vertically so they will not collect moisture.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16130
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing exterior demarcation cabinets at At-Grade Stations as shown.

B. Interior demarcation panels for Comm Room in Service Building at Aerial Stations are specified in Section 16130, “Electrical Boxes”.

1.2 REFERENCED STANDARDS

A. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

B. Underwriters Laboratories, Inc. (UL):
   1. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment
   2. UL 514A - UL Standard for Safety Metallic Outlet Boxes
   3. UL 514B - UL Standard for Safety Fittings for Cable and Conduit

1.3 SUBMITTALS

A. Product Data: For terminal blocks, manufacturer’s standard data sheet including mounting track and end barrier indicating conformance and compliance with standards and criteria listed.

B. Shop Drawings:
   1. Scale 1 inch to the foot for elevations and details to scale to reflect graphically the construction elements.
   2. Demarcation cabinet layout, including plan and elevation drawings.
   3. Conduit entrance layouts and details.
   4. Schematic wiring diagram of the demarcation cabinet cable terminations labeled “Facilities Side Schematic Wiring Diagram”. The schematic wiring diagram shall be enclosed inside of a protective transparent plastic envelope and affixed to one of the interior side walls of the demarcation cabinet.

1.4 QUALITY ASSURANCE

A. Manufacturer: Select a firm regularly engaged in the manufacture of stainless steel cabinets of the types specified herein.

B. Conform to NEC, UL 50, UL 514A and 514B.

PART 2 - PRODUCTS

2.1 EXTERIOR DEMARCATION CABINETS

A. Constructed of 12 gauge stainless steel and shall be equal to NEMA 4X specifications.

B. Demarcation cabinet shall be equipped with a copper grounding busbar for demarcation cabinet and terminal blocks grounding.

C. Demarcation cabinets shall have 2 doors on the front side and no rear doors.

D. Doors shall be gasketed and hinged, and shall lock closed with an Abloy hasp lock. Install steel plates as backing on the lockset or hasp.

E. Dimensions of demarcation cabinet shall be as shown on Contract Drawings.

F. Data pocket of high-impact thermoplastic inside door.

2.2 TERMINAL BLOCKS

A. Terminal block lengths shall be 3 feet minimum mounted on snap-off mounting tracks with screw-on end clamps.

B. Terminal blocks mounted on snap-off mounting tracks shall be easily broken every 5/16 inch. Blocks that are broken off shall have slip-in end clamps and end barriers.

C. Each terminal block shall have a blank vinyl marking strip.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment according to Contract Drawings and manufacturer’s requirements.

B. Install cabinets plumb and straight, rigidly secured in place.

C. Coordinate with the local telephone company to provide conduit from the telephone enclosure to the demarcation cabinet.
D. Install 3/4 inch plywood backboard over the entire interior area of the demarcation cabinet rear wall.

E. Mount terminal blocks on backboard within demarcation cabinet as shown on Contract Drawings.

F. Bond the protected terminal block ground terminals together using No. 8 AWG stranded ground conductor as shown on the Drawings.

G. Connect the protected terminal clock ground terminals to the copper grounding busbar as shown on the Drawings with No. 8 AWG stranded ground conductor.

H. Connect the copper grounding busbar to a ground rod(s) below grade with No. 6 AWG stranded ground conductor as shown on Contract Drawings and as specified in Section 16450, “Grounding and Bonding”.

I. Terminate communication, signal and control cables at terminal blocks as shown on Contract Drawings.

J. Label each terminal on the terminal blocks with the number shown on Contract Drawings.

K. Route, harness and support cables within demarcation cabinet with bending radii not less than recommended by cable manufacturer.

3.2 TESTING

A. Inspect the demarcation cabinet after all installation is complete and verify that each cable terminated therein is securely attached to the terminal blocks.

B. Verify that ground connections are securely attached to the protected ground terminals and grounding busbar.

C. Verify continuity of each cable from its origin to its termination point.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16135
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing supporting devices for electrical equipment and materials.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1.3 SUBMITTALS
A. Product Data: Catalog cuts, covering types of fasteners to be used for supporting devices.
B. Shop Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS
A. Furnish inserts and fastenings necessary for the rigid and secure installation of equipment.
B. Provide supporting hardware including steel bolts, nuts, washers, lockwashers, and screws with either hot-dipped galvanized steel in accordance with ASTM A123 or cadmium plated steel.
C. Use wood screws or lag screws of appropriate length to securely fasten equipment to wood.
D. Use inserts, expansion bolts, or self-drilling type anchors and drive pins for fastening to masonry. Provide inserts of the type to receive machine bolts after installation.
E. Provide channel inserts not lighter than 12-gauge steel channel not smaller than 1-1/2 inches by 1-1/2 inches, and a continuous 7/8 inch wide slot. Hot dip galvanize all channel inserts in accordance with ASTM A123 after fabrication. Cover inserts with a zinc chromate solution. Channels may be PVC coated.
   1. Provide surface mounted channel inserts with a 3/8 inch by 3 inch base slot on 4 inch centers. Galvanize inserts for surface mounting on concrete surfaces or for installation in damp or wet areas.
   2. Provide concrete embedded channel inserts with a solid base, and provide concrete anchors welded to the base during fabrication and before galvanizing.
   3. Provide channel insert assemblies with a pull-out load rating of not less than 4,500 pounds per linear foot uniformly distributed. Fill the channel with styrofoam in a manner which will prevent concrete from entering into channel during installation.
   4. Rate spot inserts at 800 pounds, and with a safety factor of five. Fabricate inserts from steel, hot dip galvanized in accordance with ASTM A123 after fabrication. Cover inserts in a manner which will prevent the entering of concrete during installation.
F. Hot dip galvanize hangers in accordance with ASTM A123 after fabrication. Provide hangers consisting of two or more steel rods, a steel horizontal member and U-bolts, clamps, and other attachments necessary for securing hanger rods and conduits. Furnish hanger rod not smaller than 3/8 inch diameter, threaded either full length or for a sufficient distance at each end to permit at least 1-1/2 inches of adjustment. Provide hangers capable of supporting a load equal to 200 pounds plus the sum of the weights of the conduit, cable tray, conductors, and hangers.
G. Furnish miscellaneous steel consisting of steel supports, angles, flats, and channels for the proper spacing and support of lighting fixtures, starting and control equipment, disconnect switches, panelboards, switchboards, wall mounted transformers, and other electrical equipment.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install fastenings, supports, and devices as necessary for the installation requirements of the electrical equipment and material.
B. Fasten exposed conduit to structures acceptable to the Contracting Officer by clamps, straps, or hangers spaced at intervals not more than 10 feet when fastened to a steel structure or more than 7-1/2 feet when fastened to concrete. Do not support or fasten conduit by welding directly to equipment or to the building structure. Do not use C clamps as a permanent method of supporting vertical conduit risers. Install clamps within 3 feet but not closer than 6 inches to couplings, boxes, and fittings in conduit runs in which expansion joints are installed. Install exposed raceways parallel to
or perpendicular to walls and structural members, and parallel to intersections of vertical plans and ceilings. Provide all conduit straps and clamps with base fittings or back plates which provide an air space of 1/4 inch minimum between the conduit run and supporting surfaces. Do not use perforated iron or wood plugs and nailing as methods of attachment. Make fastenings to steel members with granular flux filled welded studs.

C. Locate cable tray supports to ensure a rigid installation on centers not greater than 8 feet. Provide interconnections of sections for a rigid mechanical assembly. Provide cable tray supporting components comprised of clamps, clips, concrete inserts, hanger rods, insulators, racks, frames, trapezes, beams, structural steel clamps, U-bolts, slotted angles and fittings, machine screws, wall anchors, and similar items. Provide that components of dissimilar metals are compatible with the raceway, cable tray, and cable equipment which such components support. The cable tray layouts are described in Section 16114.

D. In damp or wet locations, do not mount electrical equipment (including boxes, starters, panels, and conduit) so that it touches the walls. Provide 1/2 inch or more of air space between wall and equipment. If strips or channels are used for standoffs, mount them vertically, so they will not collect moisture.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”.

END OF SECTION 16190
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section of the Specification describes in detail the requirements for the final design, fabrication, delivery and other Work required for the Traction Power Substations (TPSS).

B. The TPSS shall operate as a single unit to transform, convert, protect and distribute electrical power to the Overhead Contact System (OCS).

C. TPSS shall consist of a weatherproof enclosure as specified in the Contract Documents, with integrated Alternating Current (AC) Switchgear, Direct Current (DC) Switchgear, transformer rectifier/thyrister, and all the necessary auxiliary equipment to construct a complete and operational Light Rail Substation.

D. Each TPSS shall be uniform in physical and electrical design in every respect. Equipment providing like functions shall be of the same design and manufacture. Equipment of the same rating shall be identical and interchangeable.

1.2 REFERENCED STANDARDS

A. Publications: The technical documents and publications pertaining to the requirements for the fabrication of the TPSS are listed in this section and elsewhere in the Contract Documents, and are applicable to the extent cited in these Specifications. Note that some references and publications may be “inactive”; however this Standard may be used in production as guidelines and reference values, and therefore are considered for reference.

B. American National Standards Institute (ANSI):

1. ANSI B1.1 - Unified Inch Screw Threads.
2. ANSI B1.13M - Metric Screw Threads.
4. ANSI C12.11 - Transformers, Instruments for Metering.
7. ANSI C34.2 - Semiconductor Power Rectifiers.
10. ANSI C37.06 - Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
12. ANSI C37.09 - Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
13. ANSI C37.1 - Definition, Specification, and Analysis of Systems used for SCADA.
14. ANSI C37.100 - Standard Definitions for Power Switchgear.
15. ANSI C37.11 - Electrical Control for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis or a Total Current Basis.
17. ANSI C37.121 - Switchgear-Unit Substation Requirements.
20. ANSI C37.16 - Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Breakers.
21. ANSI C37.16a - Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Breakers.
22. ANSI C37.17 - Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers.
25. ANSI C37.20.2 - Standard for Metal-Clad Switchgear.
26. ANSI C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear.
27. ANSI C37.21 - Control Switchboards.
29. ANSI C37.30 - Definitions and Requirements for High-Voltage Air Switches, Insulators, and Bus bars Supports.
30. ANSI C37.31 - Indoor Apparatus Insulators.
31. ANSI C37.32 - HV Air Switches, Bus bar Supports Application Guide.
32. ANSI C37.34 - Test Code for High-Voltage Air Switches.
33. ANSI C37.35 - Application, Installation Operation and Maintenance of HV Switches.
34. ANSI C37.40 - Service Conditions and Definitions for HV Fuses.
35. ANSI C37.41 - Design Tests for Power Fuses.
36. ANSI C37.46 - Specifications for Power Fuse and Fuse Disconnecting Switches.
38. ANSI C37.50 - Low-Voltage AC Power Circuit Breakers Used in Enclosures Test Procedures.
40. ANSI C37.52 - Test Procedures for Low-Voltage AC Power Circuit Protectors used in Enclosures.
41. ANSI C37.54 - Indoor Alternating Current High Voltage Circuit Breakers in Metal Enclosed Switchgear Conformance Test Procedures.
42. ANSI C37.55 - Medium Voltage Meta-Clad Assemblies-Conformance Test Procedures.
43. ANSI C37.57 - Metal-Enclosed Interrupter Switchgear Assemblies Conformance Testing.
44. ANSI C37.58 - Conformance Test Procedures for Indoor AC Medium Voltage Switches for Use in Metal Enclosed Switchgear.
46. ANSI C37.91 - Guide for Protective Relay Applications to Power transformers.
47. ANSI C37.97 - Protective Relay Applications to Power System Busbars.
49. ANSI C37.100 - Standard Definitions for Power Switchgear.
50. ANSI C39.1 - Requirements for Electrical Analog Indicating Instruments.
51. ANSI C39.5 - Controlling Instrumentation.
52. ANSI C57.12.00 - General Requirements for Distribution, Power, and Regulating Transformers.
53. ANSI C57.12.01 - General Requirements for Dry Type Distribution and Power Transformers.
54. ANSI C57.12.10 - American National Standard for Transformers, 13.8KV and below.
55. ANSI C57.12.50 - Requirements for Ventilated Dry Type Distribution Transformers, 1 to 500 KVA.
56. ANSI C57.12.51 - Requirements for Ventilated Dry Type Power Transformers, 501 KVA and Larger.
57. ANSI C57.12.55 - Dry Type Transformers used in Unit Substations.
58. ANSI C57.12.70 - Terminal Markings and Connections for Distribution and Power Transformers.
61. ANSI C57.12.91 - Test Code for Dry-Type Distribution and Power Transformers.
63. ANSI C57.13 - Requirements for Instrument Transformers.
64. ANSI C57.18.10 - Requirements for Semiconductor Power Rectifier Transformers.
65. ANSI C57.94 - Recommended Practice for Insulation Application, O&M of Dry Type Transformers.
66. ANSI C57.96 - Guide to Loading Dry-Type Distribution and Power Transformers.
69. ANSI C62.2 - Systems.
70. ANSI Z358.1 - Emergency Shower and Eyewash Equipment.
71. ANSI Z55.1 - Gray Finishes for Industrial Apparatus.

C. American Society of Testing and Materials (ASTM):
1. ASTM A36 - Structural Steel.
2. ASTM A446 - Steel Sheet, Zinc-Coated, Structural Quality.
3. ASTM B187 - Copper Bus Bar, Road and Shapes.
4. ASTM D229 - Rigid Sheet and Plate Materials Used for Electrical Insulation.
5. ASTM D1532 - Polyester Glass-Mat Sheet Laminate.

D. Electronic Industries Association (EIA):
1. EIA RS-422 - Electrical Characteristics of Balanced Voltage Digital Circuit.
2. EIA RS 443 - Solid State Relays.
3. FS L-P-387 - Plastic Sheet, Laminated, Thermosetting.

E. Institute of Electrical and Electronics Engineers (IEEE):
1. IEEE 1 - General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.
2. IEEE 4 - Techniques for High-Voltage Testing.
12. IEEE 484 - Recommended Practice for Installation Design and Installation of Large Lead Storage Batteries for Generating Stations and Substations.


18. IEEE 730 - Software Quality Assurance Plans


F. Instrumentation, Systems and Automation Society (ISA):

1. ISA S18.1 - Annunciator Sequences and Specifications.

G. International Organization for Standardization (ISO):

1. ISO 3001 - Recommended Practices and Procedures, Quality Assurance and Quality Control.


H. National Electrical Manufacturers Association (NEMA):

1. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.

2. NEMA AB 2 - Procedures for Field Inspection and Performance Verification of Molded Case Circuit Breakers Used in Commercial and Industrial applications.

3. NEMA AB3 - Molded-Case Circuit Breakers and their Application.

4. NEMA AB4 - Guideline for Inspection & Maintenance of Molded-Case Circuit Breakers.

5. NEMA BU 1 - Busways.

6. NEMA CC1 - Power Connections.

7. NEMA EI 2 - Instrument Transformers.

8. NEMA FU 1 - Low-Voltage Cartridges Fuses.

9. NEMA IB 1 - Definitions and Precautionary Labels for Lead-Acid Industrial Storage Batteries.

10. NEMA ICS 1 - General Standards for Industrial Controls and Systems.

11. NEMA ICS 2 - Industrial Control Devices, Controllers and Assemblies.

12. NEMA ICS 4 - Terminal Blocks for Industrial Control Equipment.

13. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

14. NEMA LA 1 - Surge Arresters.

15. NEMA PB 1 - Panelboards.

16. NEMA PE 5 - Constant-Potential-Type Electric Utility (Semiconductor Static Converter) Battery Chargers.

17. NEMA R 12 - General Purpose and Communication Battery Chargers.

18. NEMA SG 3 - Low Voltage Power Circuit Breakers.

19. NEMA SG 4 - AC High-Voltage Circuit Breakers.

20. NEMA SG 5- Power Switchgear Assemblies.

21. NEMA SG 6 - Power Switching Equipment.

22. NEMA ST 20 - Dry-Type Transformers for General Applications.

23. NEMA TR 1 - transformers, Regulators, and Reactors (Sound Levels).

24. NEMA VE 1- Metal Cable Tray Systems.

25. NEMA VE 2 - Cable Tray Installation Guidelines.

27. NEMA WC 7 - Standard to Cross-Linked Thermosetting Polyethylene Wire and Cable.

28. NEMA WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable (ICEA S-68-516).

29. NEMA 250 - Enclosures for Electrical Equipment (1,000 Volts Maximum).

I. International Electrical Testing Association (NETA):
   1. ATS03.

J. National Fire Protection Association (NFPA):
   1. NFPA 10 - Portable Fire Extinguishers.
   2. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

K. National Uniform Seismic Installation Guidelines (NUSIG):
   1. IUBC (As adapted by the AHJ).

L. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
   1. SMACNA 15d - HVAC Dust Construction Standards.

M. Underwriters Laboratories (UL):
   1. UL 50 - Standard for Safety Enclosures.
   2. UL 67 - Panelboards.
   3. UL 94 - Flammability test for plastic.
   4. UL 100 - DC Low Voltage Power Circuit Breakers.
   5. UL 154 - Carbon Dioxide (CO2).
   6. UL 486A - Lugs for Use with Copper Conductors.
   7. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures.
   8. UL 752 - Bullet Resisting Equipment.
   9. UL 1236 - Battery Chargers.
   10. UL 1564 - Industrial Battery Chargers.

1.3 ABBREVIATIONS

A. AC – Alternating Current
B. BIL - Basic Impulse Insulation Level
C. CIC - Communications Interface Cabinet
D. CPU - Central Processing Unit
E. CQCP - Contractor Quality Control Program
F. CQCR – Contractor’s Quality Control Representative
G. CTs - Current Transformers
H. DART – Dallas Area Rapid Transit
I. DC - Direct Current
J. DPM - Digital Power Meter
K. ETS - Emergency Trip System
L. HVAC - Heating Ventilation and Air Conditioning
M. LED – Light Emitting Diode
N. LRT – Light Rail Transit
O. LRV – Light Rail Vehicle
P. LSRVDR - Load-side Voltage Detection Relay
Q. MCOV - Maximum Continuous Operating Voltage
R. NIC – Not In Contract
S. NLT - No Later than
T. NRGU - Negative Rail Grounding Unit
U. NTP - Notice to Proceed
V. O&M - Operations & Maintenance
W. OCC - Operations Control Center
X. OCS - Overhead Contact System
Y. PLC - Programmable Logic Controller
Z. PTs - Potential Transformers
1.4 SUBMITTALS

A. Submit the following in accordance with these Specifications and Contract Documents.

B. NLT (120 days after NTP): Manufacturer’s Equipment Drawings including

1. Product and equipment literature, inclusive of:
   a. Catalog data.
   b. Ordering information.
   c. Supplementary information for all equipment used in the fabrication and manufacture of the Units.

2. Equipment arrangement drawings including:
   a. Dimensions and section views.
   b. Elevation drawings for the substation enclosure.
   c. Detail drawings for each item of the transformer-rectifier unit.
   d. AC switchgear.

C. NLT (150 days after NTP):

1. TPSS One Line Diagram including:
   a. Sequence of operation for substation and individual equipment.
   b. Transformer and power rectifier circuit diagrams.
   c. Control power one line and data for TPSS.
   d. Include 125 VDC one line.
   e. 120 VAC, 240 VAC and 480 VAC one line.

2. Equipment control schematics, logic diagrams and elementary diagrams for:
   a. AC Switchgear.
   b. Transformer-Rectifier Unit (TRU).
   c. Negative drainage unit.
   d. DC switchgear.
   e. Annunciator.
   f. CIC.

3. Substation lighting and low voltage AC wiring, equipment load data.

4. Fire alarm, telephone and power distribution layout drawings.

5. Supervisory Control and Data Acquisition (SCADA) Remote Terminal Unit (RTU) points listing and data table memory address assignment.
g. SCADA RTU.
h. Battery Charger.
i. Distribution panels, test stations, etc.

3. Battery and battery charger sizing calculations.

4. Heating and Air Conditioning (HVAC) Load Calculations: Include heat loss and heat gain calculations for each type of TPSS supplied on this Contract.

5. TPSS equipment arrangement drawings including:
   a. Cross section views.
   b. Structural details and views.
   c. Elevation drawings.
   d. Equipment weights:
      1) Overall TPSS and each shipping section.
      2) Transformer.
      3) Rectifier.
      4) Lifting instructions.

D. NLT (180 days after NTP):
   1. Rectifier/Transformer Design Calculations of the following:
      a. Rectifier transformer resistance.
      b. Rectifier transformer impedance.
      c. Rectifier transformer X/R ratio.
      d. Rectifier transformer voltage and current harmonic study; primary and secondary side.
      e. TRU voltage regulation curve.
      f. TRU efficiency-load curve.
      g. TRU temperature rise curve.
      h. TRU power loss curve.
      i. Rectifier power factor-load curve.
      j. Rectifier harmonics.
   k. Rectifier momentary peak and sustained short circuit currents.
   l. DC Filter configuration and DC voltage ripple content.

2. Internal wiring diagrams.
3. Interconnection wiring diagrams.
4. Operation and maintenance spare parts.

E. NLT (240 days after NTP):
   1. Include any application software or any software developed or modified under or as a direct result of this Contract.
   2. Submit for all and any software furnished under this Contract including software for the Thyristor Control System and SCADA/RTU equipment.
   3. Calculations:
      a. Battery and Charger sizing calculations.
      b. Heat load calculations.
      c. Equipment sizing Calculations.
      d. Seismic bracing for floor, ceiling, etc Calculations.
      e. Load calculations for the concrete pad/piers.
      f. Cable tray fill calculations.

4. Software Requirements Specification (SRS). SRS document shall include:
   a. All functions (including system management functions and off-line functions), to the point where there is no remaining ambiguity or interpretations, and covering all cases and bounds.
   b. All external interfaces in terms of the functions, behavior, and performance, of the interface.
   c. All inputs to the subsystem, and all outputs produced by the subsystem.
   d. All user interfaces (e.g. display formats, user commands, controls and indicators, etc.), their behavior, and their attributes.
e. All data flows between interfaces and functions, and between functions.

f. All performance requirements (e.g. availability, response times, capacity and throughput, integrity of operation, etc.).

g. Conceptual database design represented by an Entity-Relationship Diagram or an Authority approved equal.

h. A detailed 2-way cross-reference mapping between (each atomic requirement of) the technical specification and (each atomic requirement of) the SRS.

5. Software Design Description (SDD). SDD shall include:

a. Any application software or firmware or any software or firmware developed or modified as a result of this Contract:

b. The architecture of the system shall identify and describe the relationship between all top-level modules and all second-level modules in terms of both data flow and control flow.

c. All global data structures and databases, all data structures, which are used to help implement externally visible functions, and all data structures that are used to determine system-level and module-level control flow.

d. All external interfaces.

e. Identification and description of all top-level software modules, a mapping of all top-level software modules to hardware, and a mapping of all top-level software modules to the system software they use.

f. A description of software design principals or rules for areas such as:

1) Error detection, handling and recovery.

2) Transaction management, database consistency and data consistency between various holders of the same data.

3) Failure detection, handling and recovery.


F. NLT 200 days prior to Shipment of each Substation Unit:

1. Utility Service Studies:

a. Utility Coordination Study.

b. Utility Three Phase Harmonics Study.

c. Utility AC Power Factor Study.

d. Utility Voltage Distortion.

1) Calculations and Study for individual substations (50 percent, 100 percent, 200 percent and 300 percent Load).

2. Protective Relay Study and Settings.

G. NLT 90 days prior to testing:

1. Factory test procedures.

2. Acceptance and Verification Test Plan.

3. Acceptance and Verification Test Report Forms.

H. NLT 10 days after Factory Testing: Certified Test Reports.

I. NLT 120 days prior to Shipment of each Substation Unit:

1. RTU I/O memory address assignments listing).

2. Integration Systems Tests Forms.

3. Spare Parts and Special Tools Listing (with each TPSS).

J. As required:

1. Special Test Plan.

2. Special Test Reports.

3. Test equipment data and calibration certificates.
K. Organize submittal in 3-ring binders with tabs inserts sectionalizing each submittal, organized in alphabetical order.

1.5 QUALITY ASSURANCE

A. Contractor shall perform the Work included in this section in compliance with the requirements of these Specifications and in strict accordance with the requirements of the Contractor's Quality Control Program (CQCP). Contractor shall as a minimum:

1. Perform material qualification testing and certification for acceptance of all equipment, cables, raceway, cable tray, material components, assemblies and appurtenances associated with the Substations.

2. Perform inspections and tests during the fabrication of the Substations to guarantee proper and safe operation of all systems and sub-systems and to prove the adequacy and acceptability of the total installation.

3. On tests to be performed shall cause each system and sub-system to be sequenced through its required operations, including imposition of simulated conditions to prove that the equipment and assembly's installed complies with all specified fail-safe requirements.

4. The main supplier and manufacturer of the TPSS shall have an ANSI/ISO/ASQC Q9001 compliant Quality Assurance Program (QAP) in practice at its facility.

B. The Authority reserves the right to witness all tests and inspections in the Contractor's plants or other manufacturing facilities. In concurrence with the standard QC functions the Contractor shall:

1. Notify the Authority of all testing, testing procedures and inspection procedures. Test results shall be reviewed by the Authority.

2. Supply and maintain test equipment of proper type, capacity, range and accuracy necessary to perform the required tests and inspections.

3. Maintain all testing equipment in good working order and properly calibrated.

4. Contractor shall advise the Authority a minimum of 30 days in advance of each factory test.

5. When tests are to be conducted continuously as in a production-line routine, the Authority shall be advised at least thirty days in advance of the start of such tests and duration period in which such tests will be conducted.

C. Contractor shall perform QC and Quality Assurance (QA) practices, procedures, methods, and policies in accordance with these specifications during all phases of fabrication including:

a. Design
b. Development
c. Material Procurement
d. Fabrication
e. Processing
f. Assembly
g. Packaging
h. Shipping
i. Storage
j. Site Specific Data
k. Site System Interface
l. Substation Final Certification
m. Calibration Plan and Procedure
n. Configuration Management Control Plan and Procedure
o. Witness, Installation, Certification and reporting

D. To demonstrate that the installed equipment meets these Specifications and design requirements the Contractor shall perform all system and sub-system tests prior to performing operational testing.

1.6 SUBSTATION EQUIPMENT

A. Each TPSS and associated equipment shall be of proven design manufactured for the intended purpose.

B. All equipment shall be provided and installed in an enclosure with the approximate dimensions of 45 feet long, 16 feet wide and 12 feet high (excluding any roof mounted equipment).
C. Contractor shall integrate all specified Substation equipment into a “Package Substation”, including AC switchgear, transformer, thyristor rectifier, DC switchgear, feeder breakers, and other equipment as specified in these Contract Documents.

D. Each unit shall be assembled and tested by one manufacturer in one manufacturing plant.

E. All Substation equipment and products shall be made by manufacturers and suppliers with proven experience.

F. Prior to shipment:
   1. Each Substation will be fully assembled, tested and certified to be in full compliance with the Referenced Standards and these specifications.
   2. All Substations shall be inspected by an Underwriter Laboratory (UL) Inspector and a UL Field Evaluated Product Label applied to all equipment that does not bear the UL Listing Mark.

G. Equipment Interchangeability: Contractor shall furnish the same design and equipment for similar assemblies and sub-assemblies at all Substations; similar equipment shall have interchangeable parts.

H. Equipment Arrangement:
   1. Contractor shall as near as possible use the Substation design layout as shown on the Contract drawings to locate equipment within the substation enclosure.
   2. Deviations from the indicated arrangements to accommodate Contractor’s final design are subject to approval by the Authority.
   3. The final arrangement shall result in minimum space requirement and optimum accessibility for maintenance and shall comply with the Referenced Standards. Arrangements must conform to the NEC equipment clearance requirements and other applicable codes.
   4. Equipment, devices, and components shall be arranged to be conveniently accessible and easily visible. Grouping shall be neat, modular, and logical with like related functions in proximity.
   5. Devices shall be plumb and square with the lines of the panel and mounted as recommended by the manufacturer. Devices of the same general type shall be manufactured by the same company and shall be similarly arranged and mounted.

6. Substations may be shipped fully assembled or in shipping sections, if shipping sections are required, no more than 2 shipping splits will be permitted. Substations shall be fitted with impact recorders prior to shipment. Cost for re-assembly of Substations at the job site will be by this Contract.

I. Accessibility:
   1. All equipment and components shall be readily accessible for inspection, maintenance, adjustment, and reading of data.
   2. All devices, including protective relays, from which data are to be read, shall be mounted on the front panels. Devices mounted on the front panels and elsewhere shall be limited to a height of 78 inches from the Substation floor. The minimum height for panel-mounted devices shall be 18 inches from the Substation floor.
   3. All other devices shall be readily accessible on the surface of the equipment or by opening a hinged door or panel.

J. Warranty:
   1. All equipment, assemblies, and sub-assemblies shall be warranted for defects and workmanship for a period of not less than 1 year.
   2. Some equipment shall have an “extended” warranty, and shall be as specified in the Contract Documents.

K. Maintenance and Repair:
   1. Equipment and assemblies furnished under this contract shall be field repairable to the maximum extent possible.
   2. Contractor shall furnish materials and equipment that can be maintained or repaired on-site by the Authority, using its own facilities and personnel.
   3. Return of equipment to the manufacturer’s facilities, for repair or replacement shall be required only where necessary to comply with Warranty provisions.
1.7 APPLICATION

A. TPSS shall consist of the specified electrical traction power supply equipment and associated electrical systems.

B. TPSS will be used to convert incoming Utility High-Voltage AC, 3-phase, power to Low Voltage DC for transit rail vehicles.

C. The Substation shall also provide low-voltage, station service AC power, for auxiliary equipment in the substations and nearby communication and signal installations.

1.8 QUANTITIES AND TPSS LOCATIONS

A. Contractor shall fabricate and furnish, Free On-Board (FOB) to each TPSS site location as required by Section 01010, “Summary of Work” and Contract Drawings.

B. Contractor shall verify the utility voltage, Kw and KVA rating prior to ordering material and beginning fabrication.

C. A total of 2 Substations will be furnished by this Contract.

D. Each TPSS shall be fabricated as specified herein, with the DC switchgear assembly consisting of a DC main breaker and 4 feeder breakers unless indicated otherwise.

1.9 DESIGN REQUIREMENTS

A. Provide a design that will integrate the following substation equipment:

1. Substation Enclosure: TPSS equipment shall be installed in this enclosure. The enclosure provides the equipment with protection from the weather and allows protected access to the equipment.

2. AC Switchgear: The service point for the incoming 3 phase utility service. This section shall contain an AC circuit breaker and an auxiliary compartment(s) for station service and signal service power.

3. Rectifier Transformer: Rectifier transformer transforms the voltage from service voltage to 670/346 volts or as required by the rectifier. The main protection for the transformer is the AC circuit breaker

4. Thyristor-controlled rectifier (TCR): TCR shall consist of 2 thyristor-controlled power modules, a control module, a negative bus section and a positive output bus

5. DC Switchgear: DC switchgear distributes the DC power to the OCS and provides protection and control functions for each feeder circuit

6. 125 VDC Battery System: 125 VDC battery system consists of batteries, rack, enclosure, battery charger, battery disconnect switch and DC distribution panel.

7. Communications Interface Cabinet (CIC): CIC provides termination points for interconnecting the TPSS’s with adjacent TPSS’s and to the master Supervisory Control System (SCS).

8. AC Station Service Panel: Provides 120/240VAC power as required to various sub-systems

9. AC Signals Services Panel: Provides 480VAC single-phase power to the signal system

10. Local Annunciator Panel: Located in the CIC panel and shall provide information on the status of system components and is used in detecting and troubleshooting substation malfunctions

11. AC and DC Breaker Test Cabinets:

a. Provide for routine maintenance as a convenient way to test the circuit breakers while they are disconnected and racked out of their cells.

b. The test cabinet cable plug shall have an electrical interlock with the circuit breaker receptacle to prevent the cable plug being energized without it being properly connected to the circuit breaker.

12. HVAC Control Panel: HVAC Control Panel shall provide controls to the air conditioners in the TPSS

13. Fire Alarm Panel: Locate this panel near the AC switchgear section and next to the entry door to be activated by the smoke and heat detectors located in the Enclosure

14. Intrusion Alarm Panel: Intrusion alarm panel shall provide a signal to the CIC panel for local and SCADA indication

15. Design the TPSS for the following “Modes of Operation”.
a. Disconnected Mode: As received from the factory, no external cables are connected and the unit is safe to work on

b. De-energized Mode: The AC and DC circuit breakers are open. Work on the unit is limited to trained maintenance personnel only

c. Energized, off line Mode: The AC and DC main circuit breaker is closed with the DC Feeder breakers open. This is an intermediate mode, encountered during startup or a maintenance condition with both of the Contact sections de-energized

d. On Line Mode: The AC and all DC breakers are closed. This is the normal operating mode

e. Feed-Through Mode: The Main AC and main DC breaker are open; the DC feeder breakers are closed. This is desired to tie the inbound and outbound Contact systems together with the rectifier and transformer out of service

f. Maintenance Mode: Maintenance modes may be any combination of the above; work on the unit can only be accomplished by qualified maintenance personnel

16. Each TPSS shall include all equipment and materials from utility termination point in the utility service cubicle to the points of connection to positive feeder cables, negative-return cables, and negative drainage cables.

17. Provide a design to supply low voltage AC and DC power for station service, auxiliary equipment, communication equipment, signal equipment and SCADA.

18. Furnish all equipment and materials required for the Substations to be complete and operable. Prior to shipment, all equipment shall be completely assembled, wired, and tested. The Substations shall be ready for energization upon off-loading at the project site and connection to the incoming utility feeder.

19. Each TPSS will be designed for below grade utility service, service shall be provided by underground conduits.

20. Each Substation shall be designed to provide DC service feeders via underground conduits to an OCS with the negative return by the “running” rails.

21. All substations DC systems shall have a high resistance floating ground system unless noted otherwise.

22. Ambient Conditions. Substations shall be capable of operating satisfactorily in the Dallas/Metroplex area (which includes occasional icing) and as follows:

a. Elevation: to 400 feet.

b. Ambient Temperature:
   1) Minimum: 4 degrees F.
   2) Maximum: 115 degrees F.

c. Humidity: 5 to 100 percent

d. Precipitation:
   1) Maximum rainfall rate: 7 inches per hour
   2) Average maximum: 1 inch per hour

e. Wind Speed:
   1) Maximum: 70 mph
   2) Average: 10 mph.

23. Safety Design Requirements. Contractor shall provide a system design and operational procedures that shall incorporate the following as a minimum:

a. Incorporating fail-safe principles where failures would disable the system or cause human injury, damage to equipment or inadvertent operation of critical equipment.

b. Locating equipment components so that access to them by the required personnel during operation, maintenance, repair, or adjustment shall not require exposure to hazards such as entrapment, chemical burns, electrical shock, cutting edges, sharp points, or toxic atmospheres.

c. Provide suitable warning and caution notes in operations, assembly, maintenance, and repair
instructions, and distinctive markings on hazardous components, equipment or facilities for personnel protection.

d. All components containing or generating obnoxious, flammable, or harmful gases shall be vented to the outside.

e. Cables or wires of different systems and/or high and low voltage conductors shall be physically segregate/ separated from each other in accordance with these specifications and the Referenced Standards.

24. Utility Company Service:

a. Utility service will be provided by the local utility company(s).

b. Three phase, 3-wire, 15KV (Class), 60 Hz. AC Service will be provided.

c. This Contract shall coordinate with each TPSS Installation Contractor and verify the nominal service voltage for each site location.

d. Contractor shall coordinate this Contract’s requirements with each TPSS Installation Contractor and local utility(s) for each Substation site; the Contractor shall obtain the utility short circuit MVA and other utility data as required to complete the final design and fabrication.

e. Each unit shall be designed for not less than 95KV basic impulse insulation level (BIL).

25. Wiring Arrangement:

a. All power, control wiring and labeling shall be the same for all Substations.

b. Similar termination labels and wire markings shall be used at all Substations.

c. Incoming cables, incoming terminations, conduit, and equipment foundations/pads shall be coordinated and provided.

26. Warning Signs:

a. Warning signs, operational warning and designation labels and signs shall be furnished for all devices and equipment.

b. All electrical equipment operating over 600 Volts shall be provided with “High Voltage” warning signs.

27. Uniformity. Contractor shall provide TPSS that are identical as much as feasible. Provide:

a. Device function numbers as cited in the Specifications and Contract Drawings or as provided in the Referenced Standards.

b. Equipment enclosures, assemblies, sub-assemblies and components that do not differ in operational, functional and performance characteristics shall be designed so that all components are positioned in the same location and internal wiring is routed in between components in a like manner.

28. Where identical installations exist the following requirements shall be adhered to:

a. Unless site conditions prevent it, equipment enclosures shall be mounted and installed in a like manner.

b. Penetrations for conduit, grounding and access panels shall be located in the same locations.

c. Location of equipment relative to adjacent equipment shall not differ.

d. The routing of conduit, cable trays and cables between equipment enclosures shall not differ.

e. Termination and mounting of hardware shall be located in a like manner.

f. Cables and wire terminations shall be located in a like manner.

29. Seismic Design Considerations: Provide a final design for equipment, conduit, cable trays and associated mounting hardware/anchors that conforms to the Referenced Standards and shall be intended to operate in a seismic zone 1 environment.
30. Testing:

a. Manufacture, factory and on-site (Acceptance) tests shall be performed on each component, assembly and sub-assembly. Testing shall demonstrate that the equipment will perform correctly for its intended application.

b. Failure to meet this requirement to the satisfaction of the Authority will require retesting by the Contractor. Cost associated with re-testing necessitated by failure to comply with this requirement shall be borne solely by the Contractor.

1.10 PRODUCT DELIVERY, STORAGE AND HANDLING

A. General:

1. This sub-clause is a guide for the handling, storage, and installation of the TPSS and emphasizes safety aspects and other considerations in working with this type of equipment. It supplements, but does not replace, the manufacturer’s detailed instructions. The objective is to furnish additional guidelines to promote and enhance a reliable installation.

2. Contractor shall include instruction books and drawings, Operations and Maintenance Manual (O&M manual), with each TPSS unit. The O&M manual shall contain detailed recommendations for storage, handling, installation, operation, and maintenance.

3. Personnel responsible for these functions should review these recommendations before handling the equipment. Particular attention should be given to recommendations for the preparation of the foundation and forms on which the TPSS is to be installed.

4. One set of manufacturer’s instruction books should remain with the TPSS at all times.

B. Receiving:

1. This contract shall deliver each completed TPSS to individual site locations or to a storage area designated by the Authority. Off-loading shall be provided in accordance with Specification 16312, Traction Power System Substation Installation. Each TPSS unit shall be carefully inspected and packaged before leaving the factory.

2. Immediately upon receipt, the equipment should be examined for damage that may have been sustained during transit. If damage is evident or indications of rough handling are visible, the carrier (transportation company) and the manufacturer should be notified promptly. A list of all found damage, shortages and discrepancies will be made by the inspecting personnel and sent to the Contractor.

3. Only authorized personnel should be permitted to handle the equipment. Care should be exercised in handling each piece of equipment, even if crated, because parts may be damaged.

C. Rigging:

1. Instructions for lifting and handling of each shipping section and piece of equipment shall be contained in the O&M manual and drawings.

2. Rigging should be adequate for the size and weight of the equipment.

3. Contractor shall furnish the “rigging” information to the Site Contractor or TPSS Installation Contractor at a minimum of 2 weeks prior to shipment.

D. Storage:

1. Indoor units that cannot be installed immediately shall be stored in a dry, clean location and shall remain in crates and packing during the storage period. The longer the period of storage, the greater the care required for protection of the equipment.

2. Outdoor units shall be placed directly on the Substation foundation if possible. If unit is to be stored, the Substation shall be placed on proper cribbing or ties.

3. During storage, the TPSS shall be placed on a level surface to prevent unnecessary strain and possible distortion.

4. During the fabrication period, protection should be provided against dust, dirt, falling objects, dripping water, excessive water, excessive moisture, and other possible causes of damage to the equipment.

5. Temporary covering should not restrict ventilation and should not be removed until the equipment is ready for installation.
a. Store equipment in a heated building. If this is not possible, special precautions should be taken to keep the equipment sufficiently warm with adequate ventilation to prevent condensation during the storage period.

b. If necessary, temporary heating should be installed in the equipment.

c. If outdoor switchgear cannot be installed and energized, temporary power must be provided for the operation of the space heaters to minimize condensation of moisture within the housing.

PART 2 - PRODUCTS

2.1 STATIONARY STRUCTURE(S)

A. General:

1. Each switchgear section and equipment lineup shall be comprised of the required number of metal-clad and metal-enclosed equipment sections, assembled together to form a rigid self-supporting structure with barriers of galvanized steel between each section.

2. Equipment sections shall be segregated by grounded metal barriers into separate compartments for circuit breakers, instrument transformers, main bus, instruments, relays, and incoming service connections.

3. Completed assembly shall provide front accessibility to the power fuses, instruments, relays, control wiring and wiring terminations. Unless full compliance with NEC is demonstrated and approved by the Authority, rear access will not be allowed.

B. Compartments:

1. Each compartment shall be provided with a separate hinged door or a removable bolt-on cover for servicing without exposing circuits in adjacent compartments.

2. Adequate provisions shall be provided for escape of gases from the compartments to the outside by means of louvered vent openings covered with grilles, and arranged in such a way that hot gases, hydrogen or other materials cannot be discharged in a manner hazardous to personnel.

C. Doors and Panels:

1. Each circuit breaker, voltage transformer(s), and fused switch compartment shall be provided with a formed, hinged door with handle and 3-point lockable latch.

2. Each door shall be furnished with a stop to hold the door in the open position. Circuit breaker and voltage transformer compartment doors shall not hinder withdrawal of the element from the compartment when the door is open and doorstop set. Relays, instruments, meters, and secondary control devices shall be mounted on formed front-hinged panels and provided with handle, lockable latch, and a doorstop to hold the door panel in the open position. Equipment mounted on the panel shall be isolated by grounded metal barriers from all primary circuit elements.

3. Access to main bus, incoming service connections, bus duct or feeder cable terminations, current transformers, bushings, and other stationary devices shall be rear access and provided with removable bolted panels. Instrument wiring shall terminate on the front of each cubicle and shall not require access to the rear of the compartment.

D. Station Service and Signal Power Transformer Compartments:

1. Separate transformer compartments shall be designed to house the Station Service transformer and the Signal Power transformer.

2. Adequate ventilation shall be provided in each transformer compartment to prevent heat buildup.

3. Separate draw-out fuse trunnion carriages shall be installed on the front of each transformer compartment cubicle to allow removal of primary voltage. The draw-out fuse trunnion carriage shall be equipped with the following:

   a. Fuse clips mounted on the trunnion centers for accommodating primary and secondary fuses.

   b. Silver-plated contacts designed to provide adequate contact pressure.
c. Provide a design so that all primary contacts will be disconnected from the energized circuit and visibly grounded before the fuses become accessible for replacement. A minimum of 95 kV BIL is required in the open position.

d. The fuse draw out carriage shall be grounded in all de-energized positions. This may be accomplished by use of a grounding strap. Sliding or rolling ground connections are not acceptable.

e. The fuse draw out carriage shall be sealable in the closed or operating position.

4. Provide a key interlock system for each service and the associated LV panel board main circuit breaker to prevent withdrawal of the fuse carriage without first opening the LV main circuit breaker. The key shall remain captive in the LV panel until the main LV circuit breaker is opened.

E. Space Heaters: Each switchgear compartment, front and rear, shall be furnished with strip space heaters, thermostats and humidistat.

2.2 AC SWITCHGEAR

A. General Requirements:

1. Contractor shall furnish for each TPSS, high-voltage, metal-enclosed, indoor, AC power switchgear. Switchgear assembly shall be comprised of an integrated lineup of metal-clad equipment and an incoming power cable termination enclosure.

2. AC Switchgear assembly shall form a deadfront, freestanding, enclosure. Switchgear assembly shall be metal-clad type. Each assembly shall incorporate a draw-out type AC circuit breakers, power fuses, surge arrestors, bus and bus connections, instrument transformers, meters, relays, control wiring, and accessory devices as specified herein and as shown on the Contract Drawings.

3. AC Switchgear assembly will provide the power supply to the transformer-rectifier assembly from the incoming utility service. Contractor shall verify the primary nominal voltage for each site prior to material procurement and fabrication.

4. Switchgear assemblies and major components shall be tested in accordance with the requirements in these specifications and the Referenced Standards.

5. Contractor shall provide, install and test the high-voltage AC switchgear as an integral part of the TPSS. All components and equipment shall be as specified and shall be so assembled to produce a complete and operational system. Provide:

   a. 15 KV Circuit Breaker Assembly.
   b. 15 KV incoming Utility Line Section.
   c. 15 KV Bus Assembly.
   d. Lightning Arrestors (3).
   e. Station Service Transformer.
   f. Signal Service Transformer (unless specified otherwise).
   g. Associated meters, instruments and relaying.

6. Submit the following as part of the submittals specified in this section and elsewhere in the Contract Documents:

   a. Manufacturer’s general arrangement and detail drawings for each type of switchgear assembly inclusive of all prime components.
   b. Manufacturer’s and fabricator’s schematic wiring and interconnection diagrams.
   c. Protection device instruction bulletins, coordination curves, and relay setting data.
   d. O&M manuals, including spare parts list.
   e. Design and Production test reports.
   f. AC utility cubicle entrance details, including plan, profile and sections views.
   g. Provide certification that the switchgear complies with the floor loading design criteria and conforms to all specified standards.

7. AC power switchgear assemblies shall be fabricated in accordance with the requirements of the Referenced Standards, the local utility company
electrical service requirements and the AHJ requirements for each site location.

B. Switchgear Ratings. Switchgear assemblies shall have the following ratings unless industry or design practice requires higher values:

1. Service Voltage Class: 15KV.
2. Nominal Operating Voltage, kV, rms: 13.2KV (verify for each site).
3. Rated Maximum Voltage, kV, rms: 15KV.
4. Rated Frequency: 60Hz.
5. Rated Insulation Levels:
   a. Low Frequency Withstand: 36 KV.
   b. Full Wave withstand (BIL): 95.
   c. Rated Bus Continuous Current: 1200 Amps.
   d. Rated Momentary Current Withstand, kA, rms, corresponding to circuit breaker.

C. Main AC Bus:

1. Main 3-phase bus shall be comprised of 98 percent conductivity electrical grade copper.
2. Bus shall be fully insulated over its entire length with flame-retardant, nonhygroscopic, track-resistant insulation.
3. All bus tap connections, including bus taps and circuit breaker connections, shall be silver-plated.
4. Main bus and connections shall be braced to withstand the mechanical stresses associated with the rated short-circuit momentary currents without deformation or damage to the supports or the bus.
5. Bus compartments within the AC switchgear section shall be insulated to metal-clad switchgear standards.
6. AC incoming bus connections shall be pre-drilled for standard NEMA termination.

D. Utility Company Service Entry:

1. AC switchgear shall be designed for utility service to be provided by below grade conduit. Provide removable panels for future conduit and cable installation.

2. Service feeder cables, conduit and terminations shall be provided in accordance with Specification 16312, Traction Power System Substation Installation.

3. Incoming service feeder compartments shall have adequate space to accommodate feeder cable terminations, grounding, lighting protection and future maintenance.

4. Means for supporting, connecting, and shield grounding of the service cables shall be included in each incoming service section.

5. Lightning arrestors shall be furnished as specified herein and installed in the service entrance compartment. Coordinate and verify with the local utility and the TPSS Installation Contractor for the proper sizing of the Lightning Arrestors.

6. Back panel of this compartment shall be removable for inspection and terminations of the incoming primary cables. Provide a hinged panel with a viewing window for infrared measurements with means for padlocking for limited access. Provide padlock for each access door, key to specifications as required by the Authority to match existing Substations.

7. Utility Company Metering:

   a. All revenue metering will be by the local utility and shall not be installed in the TPSS.
   b. Contractor shall be responsible for interfacing the TPSS with the site revenue metering.
   c. Contractor shall coordinate with each Line Section Contractor, local utility, the Authority to receive the proper pulse from the service utility meter.

E. High-Voltage AC Circuit Breakers:

1. Incoming AC main circuit breakers shall be indoor, 3-pole, draw-out type, with sealed vacuum interrupters, and motor-charged spring-operated mechanisms.
2. Circuit breakers of each type and rating shall be physically and electrically interchangeable.
3. Ratings:
   a. The circuit breakers shall be rated on a symmetrical current basis and have the following ratings and required related capabilities as defined in the Referenced Standards.

   1) Nominal voltage: 12.47/13.2 KV (verify per site).

   2) Short Circuit Level at Nominal Voltage: 500MVA.

   3) Rated maximum voltage: 15 KV.

   b. Rated withstand test voltage:

      1) Insulation Level: 36 KV.

      2) Impulse Withstand: 95 KV.

      3) Rated continuous current: at 60 Hertz, 1200 Amps.

      4) Rated interrupting time, cycles: 5.

      5) Rated permissible tripping delay, sec: 2.

      6) Rated voltage range factor (k): 1.30.

      7) Rated short-circuit current at rated maximum kV. Amperes, ms: 18,000.


     10) Closing and latching capability, Amperes, crest 62,000.

4. Insulation:
   a. Materials used for circuit breaker insulation shall be of a type that is noncombustible, nonhygroscopic and tracking-resistant.

   b. Mechanical strength and physical characteristics of the insulation structure shall match the stresses imposed by the circuit breaker closing and latching current capability.

5. Removable Assembly:
   a. Circuit breaker removable elements shall be track-mounted suitable for manual removal and insertion from the stationary compartment. The circuit breaker element must roll in and out of the cubicle without the use of ramps or lifts.

   b. Removable element shall be provided with a fully interlocked, manually operated racking mechanism to move the circuit breaker between the “Test/Disconnect”, and “Connected” positions. A clearly visible position indicator shall be provided.

   c. Removable element frame shall be provided with a full front metal shield to prevent access to any live primary bus or load terminals when the circuit breaker is in the “Connected” position.

   d. Circuit breaker removable element’s primary disconnecting contacts shall be provided with heavy-duty, self-aligning, spring-loaded, silver-plated, copper disconnect fingers that engage with the line- and load-side stationary disconnecting contacts.

   e. Circuit breaker interrupters shall be provided with a means for determining contact wear without dismantling the unit.

   f. Control wiring connections, from the circuit breaker compartment to the removable element, shall have provisions for maintaining or automatically re-instating circuit continuity when the removable element is moved between the “Connect” and “Test” positions.

   g. Recessed stationary receptacle and a set of self-aligning multiple contact plugs shall be provided for simultaneous disconnection of the control wiring connections when the removable element is fully withdrawn from the compartment.

   h. Tripped SCADA indications shall be maintained when circuit breaker is
in the “Test” or “Disconnected” position.

i. Circuit breakers shall be provided with auxiliary switches for the functions specified herein and as indicated on the Contract Drawings, in addition 2 spare normal open and 2 spare normal closed contacts shall be wired to the control compartment.

e. Each mechanism shall be provided with a 4-digit non-resettable mechanical register operation counter to record each circuit breaker close/open cycle.

f. For test purposes and for use in emergency, the mechanism shall be provided with “Open” and “Close” mechanical control push buttons, mounted on the front of the removable element.

g. Mechanism shall also be furnished with an easily readable mechanical position indicator, mounted on the removable element, to indicate the “Open” and “Closed” positions of the main moving contacts.

7. Circuit Breaker Control:

a. Circuit breaker shall be designed for electrical operation at the local control voltage of 125 VDC and remote supervisory control voltage of 24 VDC. Supervisory Control interposing relays (24VDC) shall be installed and wired out to a terminal block for interconnection with the SCADA/RTU.

b. Closing mechanism shall be provided with a spring release coil, anti-pump relay, and spring charging motor suitable for operation over a voltage range of 90 to 140 VDC.

c. Tripping mechanism shall be provided with a shunt trip coil suitable for operation over a voltage range of 70 to 140 VDC.

d. Local-Remote: Each circuit breaker unit shall be provided with a “Local-Remote” selector switch arranged for operation as follows:

1) Local Position: Permit local open and close operation of the circuit breaker by its associated control switch, when the removable element is in the “Connected” or “Test” positions.
2) Remote Position: Permit open and close operation of the circuit breaker from the SCADA equipment when the removable element is in the “Connected” position.

3) A white LED indicating light with nameplate indicator shall be provided which illuminates when the Local-Remote control switch is in the Local position.

4) A blue LED indicating light and nameplate indicator shall be provided which illuminates when the Local-Remote control switch is in the Remote position.

e. Permissive electrical interlock circuits shall be provided with the AC main circuit breaker to allow closing the main DC circuit breaker once the main AC circuit breaker is closed, and to automatically open the main DC circuit breaker in the event the main AC circuit breaker is “tripped”.

f. Provide auxiliary contacts to indicate the status of the AC circuit breaker to SCADA and the local Annunciator Panel.

g. Provide auxiliary contacts to operate the AC circuit breaker by the SCADA/RTU system.

3. Ratings:
   a. Arrester ratings shall be suitable for use at the utility company nominal service voltages.
   b. Contractor shall coordinate with TPSS Installation Contractor and the local utility company for arrester installation and rating.

4. Arrangement:
   a. Arrester pressure relief diaphragm shall be arranged in the enclosure so that the vent ports are directed away from all energized adjacent apparatus.
   b. Preferably, the generated ionized gases during normal operation shall be vented to the outside of the switchgear enclosure.

5. Provide means for the surge arrester ground terminals to be connected to the Substation ground system.

6. TPSS Installation Contractor shall design and install the TPSS AC and DC ground mats. Contractor shall coordinate with the site contractor to meet the resistance requirements and connection arrangements as recommended by arrester manufacturer and the ground mat design.

G. Digital Power Meter (DPM):

1. Provide a DPM to monitor the incoming AC line circuit as indicated on the one-line diagram and as specified herein.

2. Provide a Siemens 9510 or Authority approved equal, the DPM shall:
   a. DPM shall measure the real-time RMS values of phase currents, ampere, demand, phase and line voltages plus power measurements including KW, KW demand, KW-hours, KVA, KVAR-hours, in addition the DPM shall:
   b. Monitor loss of incoming line voltage for each phase and send this signal to the local and remote annunciators.
   c. Monitor Power Factor and frequency.
d. The KW demand period shall be user programmable from 1 to 60 minutes.

e. Accuracy of current and voltage measurements shall be 0.2 percent for KW. KWH and other power measurements shall be 0.4 percent or better.

f. Re-settable minimum and maximum values for each measured value shall be recorded in nonvolatile memory.

g. A user-defined password shall be required to change configuration, reset minimum/maximum log and kW/KVAR-hours or change any relay set points.

3. DPM shall be provided with an auxiliary voltage input.

4. DPM shall be capable of high-speed sampling of the power waveform for power quality analysis and measurement of harmonics in both the current and voltage waveforms.

5. DPM shall be UL listed and meet all the requirements of the Referenced Standards.

6. All configuration information such as CT ratios, voltage scales, and communications address shall be stored in nonvolatile memory so that the DPM can be set either from the integral display or remotely using the communications module.

   a. No batteries shall be required to maintain configuration information indefinitely.

7. DPM shall derive power from a dedicated 125 VDC source provided by the DC distribution panel board.

8. DPM with integral display shall be flush mounted on the AC equipment door. Operation of the power meter to read real-time or minimum/maximum measured values or to program configuration and any relay set points shall not require opening doors or removing panels.

9. Display:

   a. DPM shall include an integral illuminated display for reading all real-time and minimum/maximum measured values as well as any relay set points.

   b. The display shall consist of at least 20 alphanumeric characters, 0.4-inch high and be operated using clearly labeled sealed membrane keys with stainless steel switch elements for long mechanical life and resistance to atmospheric contamination.

10. Relay output:

   a. Three programmable relay outputs shall be provided to activate based on threshold and time-delay values associated with any of the measured parameters or for kilowatt demand pulse initiation.

   b. One relay output shall be programmed and annunciate loss of incoming line voltage. Provide indication for loss of any one phase.

   c. Remote relay operation shall be possible through the communications module.

   d. Relay contacts shall be form C rated 10A 120 VAC/24 VDC.

   e. Activation and release of the relays shall be recorded in a nonvolatile log with cause of operation. The log shall record at least the last 50 events.

   f. Provide a programmable auxiliary 0 to 1 mA or 4 to 20 mA analog output.

11. Relay input:

   a. Provide a minimum 8 discrete inputs to monitor status of “Normal Open” and “Normal Close” AC and DC Circuit Breaker status.

   b. One of the discrete inputs shall also be capable of counting state changes.

12. Communications:

   a. A communications module shall be provided using an Authority approved standard bus to remotely read all system parameters (Voltage, Current, Power, KVAR, Power Factor, KVA, circuit breaker status) in real-time and min/max...
measured values. Send all data to the SCADA RTU.

b. A means shall be provided to periodically synchronize the meter's internal clock with a master bus clock so that the meter's event and minimum/maximum logs are accurately time-stamped within 1 second.

c. Provide, install and test Ethernet Converter(s), Data Reporting and Data Power Management Software to provide remote monitoring and analysis of the electrical distribution system. Provide reporting software for cost analysis; load shifting, maintenance reporting, power quality and revenue billing.

13. Extended memory: DPM shall include extended nonvolatile memory to record at least 100 snapshots of each measured parameter. Interval between snapshots shall be readable using the communication module.

14. Portable Interface Device:

a. As specified herein, provide 4 data acquisition type portable notebook computers with latest Intel (or equal) processor shall be provided prior to acceptance of the first Substation with appropriate interface software to access the DPM communications module.

b. A minimum of 8 hours of on-site, field instruction for the DPM shall be provided for each Line Section. This shall be in addition to the requirements for training listed elsewhere in the Contract Documents.

H. AC Switchgear Maintenance Accessories:

1. Each TPSS shall be provided with the following for AC power accessories:

a. AC Circuit Breaker test cabinet, wall-mounted, complete with test jumper cable and connectors – Qty: 1

b. Cranks for manually racking circuit breaker from cubicle – Qty: 2

c. Spare sets of each type of high-voltage and low voltage fuses – Qty: 2

2.3 TRANSFORMER/RECTIFIER UNIT (TRU)

A. General:

1. Each Substation shall contain a TRU. The TRU shall consist of a rectifier transformer and a thyristor controlled power rectifier with all standard and specified accessories, auxiliaries, controls, hardware, interconnecting busses, wiring, and related devices as specified herein and as required for a safe and reliable operation.

2. Description and Scope:

a. Each TRU shall receive power from the Substation high-voltage AC switchgear and supply power to the associated DC switchgear. Connections between the rectifier and the AC switchgear shall be by AC busway; Connections between the rectifier and the DC switchgear shall be by DC cables or bus, with bus being the preferred option where/if feasible.

b. Tests shall be performed on each fully assembled TRU in accordance with industrial standards, as specified herein and the Referenced Standards.

c. Contractor shall provide, install and test a TRU as an integral part of the TPSS. All components and equipment shall be integrated into the TPSS as specified herein and shall be so assembled to produce a complete and operational system. Provide:

1) Rectifier Transformer.

2) Rectifier.

3) Power Module.

4) Control Module.

5) Protective Relaying.

6) Associated meters and instruments.

3. Submittal Requirements. Submit the following as part of the submittals specified in this section and elsewhere in the Contract Documents: Manufacturer's general arrangement and detail drawings for each Transformer/Rectifier assembly:
a. Manufacturer's drawings.
b. Protection devices, coordination curves, and relay setting data.
c. O&M and instruction manuals.
d. Spare parts list.
e. Design and Production test reports.
f. Installation and bracing drawings, including plan, profile and sections views.
g. Provide certification that the TRU complies with the design criteria and conforms to all specified standards.

4. Types and Ratings: The Traction Power Supply TRU shall be 12-pulse, double-way type, designed for rectifier circuit No. 31 as identified in the Referenced Standards, with the inter-phase transformer removed and replaced with a large output filter capacitor (if required). The size of the filter capacitor shall be such that the ripple of the DC bus voltage and its harmonic content shall not exceed those of a diode-based TRU with the standard ANSI circuit No. 31

5. Thermal Rating. TRU shall be rated as indicated herein and shall be designed to meet the following heavy-duty traction overloads cycle:

a. After steady-state temperatures at full load has been reached by all TRU components, the TRU shall be capable of operating at 150 percent base load for 2 hours, with superimposed 5 periods of 1 minute duration each at 300 percent of rated load which are equally spread over the 2 hour period.

b. The temperature of any component of the TRU shall not exceed its normal design limit by the end of the specified 2 hour overload period and the TRU shall be designed to support 2 such overloads per day, separated by a 6 hour interval at full load.

c. TRU shall be designed to meet the above daily duty cycle without damage to any parts or the insulation of the equipment for a period of 30 years.

6. Fault Current Withstand: TRU, including interconnecting bus and switchgear, shall be certified as capable of withstanding 100 percent of the theoretical maximum short-circuit current, with the short circuit applied at the load terminal of a DC feeder circuit-breaker, without damage to any component for the time period for the DC feeder breaker to open and clear the fault using its inherent over-current trip device.

7. Efficiency: Each TRU’s overall efficiency shall be 98 percent or better at its continuous kilowatt rating.

8. Power Factor: At the rated AC primary voltage, and from 25 percent to 100 percent rated kilowatts, the power factor of each TRU shall be 0.95 lagging or greater.

9. Voltage Regulation:

a. From no-load to 115 percent load, the TRU shall maintain a constant voltage of 845VDC at the DC bus, assuming a nominal primary AC voltage is maintained.

b. For loads from 115 percent to 300 percent of rated load, the DC voltage shall decrease linearly from 845 Volts in accordance with the inherent voltage regulation of the TRU, which shall be 4.5 percent. Current limiting after 300 percent rated load shall be employed thereafter.

B. Rectifier Transformer:

1. General:

a. Rectifier transformers shall be designed and manufactured in accordance with the requirements specified herein and the Referenced Standards.

b. Provide a dry-type construction, self-cooled, heavy-duty traction power transformer suitable for installation in a ventilated indoor enclosure.

2. Design:

a. Manufacturer of the rectifier transformer shall have been regularly engaged in the design and production of rectifier transformers for TPSS, and shall demonstrate a successful record of providing rectifier transformers of similar kind,
rating and insulation on at least 1 mass transit project over a period of no less than 5 years.

b. Primary windings shall be delta-connected and rated for the utility nominal voltage (13.2 or 12.47KV) on a 3-phase, 60-Hz system. The primary insulation voltage class shall be 15KV and the power frequencies withstand shall be 31KV. The BIL of the primary windings shall not be less than 95KV.

c. Secondary windings shall be delta/wye connected for the two 6-pulse, double-way rectifiers in accordance with the Referenced Standards. The BIL of the secondary windings shall not be less than 45 KV.

d. Output (LV) windings rated voltage, ampacity, related characteristics, and winding connection shall be designed for use with the required power rectifier circuit configuration, voltage regulation, etc.

e. Rectifier transformers shall be harsh environment indoor design, 3-phase, 60 Hz, ventilated, dry-type, self-cooled, class AA, similar to Uniclad™ design from Virginia Transformer or a Authority approved equal.

3. Transformer Impedance:

a. Transformer impedance shall be selected to provide the required minimum voltages at the rectifier load terminals under the specified loading conditions and utility service system characteristics.

b. The design shall coordinate the Transformer Impedance with the DC power switchgear circuit breaker short-circuit ratings assuming a bolted fault at the nearest feeder breaker load side terminals.

4. Transformer Winding Temperature:

a. Transformer winding temperature limit requirements, shall be based on the transformers being housed in a Substation enclosure in an indoor environment, suitably designed for an interior operating temperature as defined in Section 13121, “Substation Enclosures – Traction Power Substations”, of these specifications.

b. Average winding temperature rise measured by resistance, when operating at 100 percent rated continuous load, shall not exceed the Referenced Standards.

c. Average winding temperature rise measured by resistance method after a 2-hour overload cycle shall not exceed the referenced standards.

5. Audible Noise Level:

a. Rectifier transformer in particular, and the TPSS in general, shall be designed to meet the specified maximum noise levels as specified herein and in the Referenced Standards.

b. Equipment design, enclosures with acoustic mitigation capacity, and other measures, as appropriate, shall be employed to achieve compliance with the audible noise level criteria.

c. Noise levels outside the TPSS measured at a distance of 50 feet from the substation during operation at 100 percent load and with the normal air conditioning on line shall not exceed 45 dB.

d. Noise level inside the Substation enclosure, at a distance of 5 feet from the rectifier transformer during operation at 100 percent load and with the normal air conditioning on line, shall not exceed 80 dB.

6. Harmonics:

a. Thyristor rectifier current harmonics in the transformer windings shall be factored into the design of the transformer to meet the transformer temperature limitations, voltage regulation, efficiency, power factor and other performance parameters.

b. Harmonic loading shall be evaluated under the full range of load conditions with the thyristor conduction angle in a minimum and maximum position, (i.e. worse case conditions).
c. A harmonic study shall be performed for each type of transformer in accordance with the recommendations in the Referenced Standards to verify that the voltage harmonics (6 pulse and 12 pulse mode) produced on the Utility Service Connection Feeder does not exceed the voltage harmonic limitations specified by the Authority and the local Utility Company.

7. Mechanical Characteristics:
   a. General: Transformers shall be so designed and installed that all parts are easily accessible for maintenance and replacement.
   b. Enclosure:
      1) Transformer enclosure shall be moisture-resistant and shall be substantial enough to protect the transformer coils against accidental mechanical damage.
      2) Enclosure shall be of self-supporting steel construction with bolted removable panels for access to the winding taps, and bolted removable panel for access to the core and coils.
      3) Panels shall be provided with close mesh ventilating grilles.
      4) The complete case structure shall be removable.
   c. Base Structure:
      1) Base structure shall be comprised of base members suitable for mounting the core and coil assembly and for skidding or rolling the complete assembly in any direction.
      2) Base assembly shall have provisions for jacking the base-mounted core and coil assembly, to permit insertion of rollers between floor and base.
      3) Tuned vibration shall be provided to ensure the best mitigation of noise transfer by mutual resonance.
   d. Core Design and Assembly:
      1) Provide a steel type core using high-grade, cold-rolled, heat-treated, grain-oriented, high efficiency, high electrical resistance, high magnetic permeability, low sulphur and carbon content, non-aging, electrical grade silicon steel alloy to produce transformers with low no-load and load losses.
      2) Joints in winding or at terminals shall be brazed or clamped.
      3) Core-bolt insulation shall be high temperature resistant, stepped mitered lap core construction and the entire assembly braced or bolted adequately to prevent displacement and distortion under all normal conditions of handling and operation under normal, overload and short-circuit conditions.
      4) Design adequate core supports so that the transformer can withstand the highly fluctuating load currents and the high occurrence of short circuits on the rail system without overheating, decrease in life expectancy, and injury.
      5) Design clamps, and braces to strengthen the core to withstand mechanical and thermal stresses without damage.
      6) Provide locking provisions for units at all inside bolted members or connections.
      7) The serial number for each unit shall be stamped on the core in an easily accessible and conspicuous place.
   e. Core and Windings:
      1) Core and coils shall be rigidly braced to withstand the mechanical forces under...
short-circuit conditions and resist normal vibration and shock forces during shipment.

2) Core laminations shall be of non-aging cold rolled, high magnetic permeability, and of a suitable Grade of silicon steel to provide a transformer as specified herein and in the Referenced Standards, including but not limited to all structural and efficiency requirements. Select appropriate thickness of laminating to restrain eddy current losses in the transformer core, but to maintain adequate mechanical strength of the core. Select only flat laminations with no waviness to minimize stresses when the sheets are pressed flat in a core.

3) Core legs shall be firmly clamped by glass fiber bands, structural steel members and insulated bolts. The outside surfaces of the core shall be protected by an evenly applied coating of resin base paint.

4) Core clamps and structural members shall be grounded by a bolted copper strap.

5) The high-voltage AC and low-voltage output winding coil assembly shall permit adequate circulation of air in the core-to-coil and coil-to-coil insulation system.

6) Eyebolts shall be furnished for lifting the entire assembly by hoist or crane.

8. Winding Insulation Systems:
   a. Coil insulation systems shall be appropriate for the traction rating class and limiting temperatures specified herein and in the Referenced Standards.
   b. Insulation systems shall be nonhygroscopic, have high thermal stability and mechanical strength suitable for the daily loading cycles imposed by traction service duty, and mechanical forces due to vibration and short-circuit current.
   c. Dry-type insulation system shall be minimum Class F, 155C construction.

9. Windings:
   a. Windings shall be Vacuum Pressure Impregnated (VPI) or Cast-coil Construction.
   b. Each coil shall be oven dried at atmospheric pressure through which hot air is continuously circulated to remove any moisture.
   c. After the coil is preheated and dried, the bottom coil ends shall be sealed with a cast-in-place epoxy end ring formulated to match the material characteristic of the coil.
   d. Each coil shall be VPI with a flexible silicon varnish under vacuum of 3 to 5 mm mercury minimum for at least 3 hours, then pressurized at 4 or more atmospheres of pressure for 3 hours to allow trapped air bubbles to be purged.
   e. Immediately following each VPI cycle, the coil shall be oven baked and cured following an established temperature vs. time baking cycle in a hot air circulating oven.
      1) VPI process and baking cycle shall be completed 4 times for each coil.
      2) Adequate drying time shall be allotted to allow curing of the insulating liquid.
      3) Upon completion of the 4-step VPI process, the second cast-in-place coil end ring shall be made to seal the top coil end.
      4) Each coil shall receive a final seal using a modified 220 C epoxy cladding.
   f. The entire transformer assembly shall be dipped in a cladding mixture of high temperature varnish, resin and silica baked to
impert the final seal against the environment.

1) All resins shall be oven cured under controlled temperature and air circulation.

2) The silicone resin insulation system shall seal the winding coils against moisture, be chemical resistant, and eliminate voids, which could create hot spots or cause corona formation.

10. Electrostatic Shield:
   a. Provide a shield between the primary and secondary windings to attenuate transient common mode primary over voltages.
   b. Connection between the shield and its terminal shall be short and direct and of heavy gauge to minimize its impedance at high frequencies.

11. Winding Taps:
   a. Provide a no-load tap changer on the high-voltage winding with two 2½ percent taps above rated voltage and two 2½ percent taps below rated voltage.
   b. Taps shall be changed by removable links on a tap board with taps and connections identified.
   c. To prevent access to the tap board when the transformer is energized provide tap board accessible through a door key interlocked with transformer feeder breaker.
   d. Provide a tap board that is segregated from the winding so that winding cannot be touched when changing taps.
   e. Taps shall be rigidly supported by brazing to the coils. Tap connections shall be clearly identified and tap positions changed by the movement of bolted links between connection points.
   f. With the approval of the Authority, and where the design of thyristor rectifier controls can compensate for sustained utility voltage regulation (within plus or minus 10 percent), transformer-winding taps will not be a requirement.

12. Busses and Bus Connections:
   a. Busses shall be 98 percent conductivity electrical grade copper.
   b. Provide busses braced to withstand the maximum theoretical short circuit forces.
   c. Bus connections shall be silver-plated.

13. Winding Terminations:
   a. AC windings line termination arrangement shall be in accordance with the Contractor's standard design practice subject to approval by the Authority.
   b. Terminals shall be adequately braced to withstand the mechanical forces and thermal stresses produced by a bolted short circuit.
   c. Output winding leads shall be brought out to a flanged throat, for connection to bus duct by means of flexible bolted links.
   d. Means and materials used for interconnecting the output winding leads to the rectifier terminals shall be subject to approval by the Authority prior to implementation by Contractor.

14. Accessories. Transformers shall be furnished with accessories as follows:
   a. Device 49:
      1) Provide hot-spot temperature indication, with maximum reading indication and with the thermocouple incorporated in each winding coil at the point of highest expected temperature rise.
      2) Device shall be factory-set with first-stage operation to initiate remote supervisory and local annunciation.
      3) Second stage shall operate the substation lockout relay, device No. 86 and initiate
C. Power Rectifier:

1. Contractor shall design, furnish and install voltage-controlled thyristor type traction substation rectifiers with automatic voltage regulation.

2. General:

   a. Thyristor rectifier manufacturer shall provide a proven and tested design for use as a traction substation rectifier, and shall have a minimum of 5 consecutive years of operational use in a transit system.

   b. Thyristor rectifier shall be equipped at a minimum, with all auxiliary equipment as specified herein and in the Referenced Standards.

   c. Thyristor rectifier shall be designed to take advantage of the full voltage and current control capabilities of the units.

   d. Thyristor units shall be metal-enclosed and freestanding with hinged lockable access doors. Provide with windows of translucent material to allow visual inspection of the diode and thyristor fuse indicators and other equipment.

   e. Surge protective devices shall be employed to limit reverse voltages across the thyristor to a value within the peak-reverse-voltage rating of the thyristor during voltage transients originating in either the AC or DC power circuits.

   f. Thyristor rectifier shall be of proven and tested design as a traction substation rectifier, such as manufactured by Powell Power Electronics Co. model VGF-2500, or Asia Brown Boveri model 3AUB470052-UFBA, or an Authority approved equal.

   g. Thyristor rectifier controller shall have the capability of manually viewing and changing all parameters from an integral touch-pad and 12-line LED display, along with the capability of manually viewing and changing all parameters using the Contractor supplied laptop computers.

3. Enclosure:

   a. Description:

      1) Thyristor rectifier enclosure shall be a NEMA-1, indoor type, ventilated, metal structure with hinged doors, high-resistance grounded, forced-air or natural convection ventilated structure.

      2) Power rectifier shall be mounted on a rigid self-supporting structural steel or formed metal framework with all principal members bonded together and containing louvered expanded metal or mesh opening for ventilation.

      3) As required by the final design, provide ventilation or other openings in the top of the enclosure to allow the heated air to be mechanically discharged outside the Substation enclosure.

   b. Materials:

      1) Choose materials to preclude the possibility of corrosion or galvanic action interfering with the proper operation or appearance during the life of the equipment.

      2) Provide similar and completely compatible materials to be used for thyristor cases, studs and heat sinks.
c. Openings: Provide openings and mounting holes for front-mounted indicating and control devices that are neatly cut out, drilled or punched without marring or distorting the finished surfaces.

d. Accessibility:
   1) Provide convenient access for all normal maintenance and inspection activities.
   2) Equip each door with a mechanical latch and doorstop to hold the door in the open position.

e. Thyristor Visibility:
   1) Locate thyristors and fuses adjacent to windows in the enclosure or internal lighting to allow visual inspection of all fuses and diodes without opening the enclosure doors.
   2) Source of power for light fixture shall be 125 VAC from the Station Service.

4. Voltage Regulation:

   a. Output voltage characteristics of the thyristor rectifier shall maintain a constant voltage of 845 VDC from no-load to 115 percent full load with a linear decrease of the voltage from 115 percent to 300 percent. Current limiting after 300 percent shall be employed.

   b. Thyristor rectifier shall be equipped with a digital control system and the DC output voltage regulation shall be by means of a phase angle control system with the following features:

      1) In the remote operating mode, the DC voltage regulation curve shall be adjustable by an increase/decrease command from the remote control center.

      2) Control system shall include 2 controllers implemented in the digital control system.

   a) One for the DC output voltage using a feedback signal obtained through an isolating voltage sensing device.

   b) One for the DC output current using a current feedback signal obtained through an isolating current sensor.

   3) A selector switch shall be provided on the thyristor rectifier to enable control mode selection (local/remote).

   4) Digital control system shall insure a continuous, smooth and efficient regulation of the DC output voltage.

   c. Voltage regulation curve resulting from the automatic phase controller shall be within the following bandwidth (deviation in regulation is given in percent of rated values):

      1) Steady state deviation in regulation during normal operating conditions from zero percent to 115 percent load shall not deviate more than plus or minus 0.4 percent at no load.

      2) Dynamic deviation in regulation during normal operating conditions of more than plus or minus 0.4 percent shall be corrected within 1 second (regulating time).

      3) Increasing DC voltage is obtained by decreasing the phase angle delay. No further increase in the phase angle will be permitted when the minimum limit is attained. Minimum phase angle delay (firing angle) shall be 0 to 15 degrees and shall be user selectable from the thyristor control system. This parameter shall be password protected. Minimum firing angle shall be set at the factory to limit the output voltage to a
maximum of 895vdc under all operating conditions.

d. Increasing DC voltage is obtained by decreasing the phase angle delay. No further increase in the phase angle will be permitted when the minimum limit is attained.

e. Output DC voltage regulation curve shall be adjustable by means of programmable software parameters in the digital control system.

5. Control Section:

a. Thyristor shall contain all the necessary equipment for:
   1) Trigger pulse amplification and distribution.
   2) Current measuring.
   3) Voltage measuring.
   4) Ventilation monitoring.
   5) Energy Management Control and Indication (as required).
   6) SCADA indication.

b. Control cubicle shall contain all necessary equipment for:
   1) Sequential control (ON, OFF, TRIP sequences).
   2) Voltage and current regulation.
   3) Protection.
   4) Operation and indication.
   5) Voltage and current monitoring.
   6) Internal power supply.

c. Thyristor control panel shall include alarms, visual indicators, metering, and digital counters for the following functions or operations.
   1) Digital meters (4-digit) shall be provided for:
      a) DC output voltage set point.
   2) Analog meters with digital display shall be provided for:
      a) DC output voltage.
      b) DC output current.
      c) DC negative current.
      d) DC drainage current.
      e) DC negative rail voltage.
   3) Indicator lights shall be provided for:
      a) AC breaker status: green-open, red-closed.
      b) Rectifier ready: yellow.
      c) Computer fault: red.
      d) 6-pulse mode: red.
      e) 12-pulse mode: yellow.
      f) Local Mode: blue.
      g) Remote Mode: white.
      h) TCR modes
         (1) Constant current mode: white
         (2) Constant voltage mode: white
         (3) Diode mode: white

6. Other TRU Features. TRU shall also include the following:

a. TRU shall be provided with surge protection against incoming AC transients.

b. Busses and Bus Connections:
   1) Rectifier busses shall be made of rigid, 98 percent
conductivity electrical grade copper with silver-plated contact surfaces.

2) Busses shall be suitably braced between each other and to the enclosure with high-strength, non-tracking insulators.

3) Busses shall be designed to safely withstand the theoretical maximum short-circuit current without damage to the bus or the enclosure.

4) Rectifier output bus bars shall be suitably designed to carry currents under worst case loading.

7. Power Module Design. Thyristor rectifier power section shall perform and be equipped with the following features and capabilities:

   a. Designed to maintain current balance between parallel-connected thyristors in each phase within plus and minus 10 percent of their proportionate share under all specified load conditions.

   b. Output voltage ripple shall not exceed 5.0 percent RMS at rated load. For this purpose, filtering equipment may be required.

   c. Rectifiers shall use multiple thyristors in parallel in each leg such that failure of any one thyristor shall not take the rectifier out of service. If a second thyristor fuse blows and the TRU cannot meet the load requirements, the transformer rectifier AC breaker and DC main breaker shall trip, providing local and remote indication.

   d. Anyfaulted thyristor shall be electrically removed from the circuit by means of a fast acting current limiting fuse.

   e. Blown fuses shall have clear and easily visible indicators to outside the enclosure.

   f. Replacement of faulted thyristors and blown fuses shall be made possible without the removal of adjoining healthy thyristors.

   g. Each thyristor or group of thyristors shall be provided with a surge protective device to limit the peak inverse voltage to within its value as appropriate to the present application.

   h. Thyristor gating shall be by means of isolating pulse transformers with 120 electrical degrees "picket fence" signals.

   i. Thyristor and associated circuitry including fuses, snubber circuits, gating circuits, fans, etc. shall be arranged with interchangeable modules for each full-wave bridge.

   j. Each thyristor module shall have its own forced air-cooling fan.

   k. Variable speed fan motor controlled from a variable frequency drive shall be used.

   l. Secondary current transformers on each AC lead to the thyristor modules shall be used for current feedback and metering.

   m. In the event of a component failure in one of the thyristor bridges or fan blower, the digital control system shall be programmed to allow the thyristor to operate as a 6-pulse rectifier (half power), for a preset time delayed period (1 day to 7 days), programmable from the control system.

   n. In the event of a system trip due to a transient condition such as an AC under-voltage or DC overcurrent momentary fault, the thyristor control system shall attempt to restart the rectifier unit 3 times before defaulting to an alarmed tripped condition.

8. Protective Relays and Instrumentation:

   a. The following protective relays and devices shall be provided with each rectifier assembly. Rectifier protective relay and device contacts shall be wired to terminal blocks located in the control compartment.

   b. Device No. 26 (R1 and R2) 2-stage factory-set rectifier over-temperature detector:
1) First stage shall detect an abnormal rise in actual or calculated heat sink temperature and initiate local and remote supervisory annunciations.

2) Second stage shall operate the unit lockout trip relay, device No. 86 and 186. This function may be performed by the rectifier control processor.

c. Device No. 98 (Thyristor Failure):

1) First thyristor failure shall initiate local and remote supervisory annunciations.

2) Loss of a second thyristor shall operate the unit lockout trip relay, device No. 86 and 186.

d. Device No. 33 (Door interlock):

1) Located at the top and bottom of the rectifier enclosure doors.

2) Contacts shall operate the lockout relay, device No. 86 and 186 on opening of the door and shall prevent closing of the rectifier transformer AC circuit breaker and rectifier main DC circuit breaker when any of the rectifier enclosure doors are open.

3) Operation of device No. 33 shall also initiate remote supervisory annunciation.

e. Device No. 64R/64MR (Enclosure Ground Relaying):

1) DC Switchgear, rectifier cubicle, and negative enclosure shall be isolated from the AC Switchgear transformer, substation enclosure walls and floor, all other grounded items.

2) DC enclosure shall be connected to station DC ground grid through a high resistance ground relay. Ground relay system shall be furnished with contacts to initiate alarm and tripping of the station lockout relay(s) when the enclosure is energized or grounded.

3) Ground relay system shall be provided with a contact to initiate annunciation upon the occurrence of any of the following:

   a) Enclosure in contact with the positive of the DC system.

   b) Enclosure in contact with ground.

   c) Enclosure in contact with the negative of the DC system.

   d) Enclosure in contact with the 125VDC, 120 VAC or 24 VDC power supplies.

   e) Malfunction of the ground relay.

   f) Loss of potential between the DC equipment enclosures and station ground.

9. Rectifier Accessories. Spare Parts (Optional):

a. At least 1 full set of power module circuit boards, electronic assemblies, 6 main thyristor, 6 main fuses, and any other manufacturer recommended spare parts shall be furnished with the first shipment.

b. Special maintenance test accessories including 2 new portable, hand held, dual trace, digital oscilloscopes, Fluke or Authority approved equal, shall be furnished with the delivery of the first substation to perform diagnostics and troubleshooting.

2.4 DC SWITCHGEAR

A. Work specified in this section describes the furnishing and integration of a metal-enclosed DC power switchgear assembly and associated accessories for each TPSS.
B. General:

1. Select a switchgear manufacturer and supplier of DC circuit breakers of proven quality and design, and who have demonstrated a successful record of providing similar type and rating of equipment for at least 5 similar transit projects.

2. Tests shall be performed on each complete DC switchgear assembly and components in accordance with the requirements given herein and in Referenced Standards.

3. Contractor shall provide, install and test the DC switchgear as an integral part of the TPSS. All components and equipment shall be integrated into the TPSS as specified and shall be so assembled as to form a complete and operational system. Provide:

   a. DC Main Circuit Breaker.
   b. DC Feeder Circuit Breakers.
   c. DC Main Bus (Positive Bus).
   d. DC Negative Bus.
   e. Surge (Lightning) Arrestors.
   f. Associated meters, instruments and relaying.

4. Switchgear assembly shall form a lineup of dead-front, metal-enclosed, freestanding enclosures suitable for indoor service.

5. Each switchgear assembly shall include draw out, single pole, DC circuit breakers, DC positive busses and bus connections, positive feeder cables terminal connectors, indicating lights, terminal blocks, protective and auxiliary relays, control circuitry, wiring, local/remote control switch, and all other devices necessary to make a complete and operable assembly.

6. Switchgear insulation level shall be coordinated with the maximum crest voltage to ground that can be produced by the rectifier circuit and shall withstand peak voltage surges of 1,200 V during train regenerative braking.

7. Unless otherwise indicated in these specifications, each DC switchgear assembly for each Substation shall be comprised of the 1 main DC circuit breaker (cathode breaker) and 4 feeder breakers.

8. Submittal Requirements. Submit the following as part of the submittals specified in this section and elsewhere in the Contract Documents:

   a. General arrangement and detail drawings for each DC Switchgear assembly.
   b. Manufacturer's shop drawings, product literature and bill of materials for all installed components.
   c. One-line diagrams, elementary schematics, equipment wiring, interconnection and connection diagrams.
   d. Floor and panel layout drawings including equipment layouts, arrangements, elevations and section detail drawings.
   e. Placement drawings for all relays, instruments and protective devices.
   f. Protection devices, coordination curves, and relay setting data.
   g. Operation, maintenance and instruction manuals.
   h. Spare parts list.
   i. Design test reports or certified copies of test reports to the latest standards, for identical units performed for each type and rating of switchgear and circuit breakers as assembled in its complete switchgear unit, furnished under this contract.
   j. Production test reports, Conformance testing reports and Acceptance testing reports.
   k. Installation and bracing drawings, including plan, profile and sections views.
   l. Certify that the DC Switchgear complies with the design criteria and conforms to all specified standards.
   m. Short-circuit calculations and system coordination study for system protection and selective overcurrent tripping in accordance with the Referenced Standards for
fault calculations and coordinated system protection.

n. Complete bill of materials and cut sheets for all selected components and devices.

C. Switchgear Enclosure:

1. DC switchgear assembly shall be metal-enclosed, dead front, freestanding, indoor, with draw-out power circuit breakers.

2. All serviceable components such as relays, instruments and other devices shall be accessible from the front of the switchgear lineup.

   a. If these limitations cannot be satisfied with all the equipment required for each circuit breaker housed in 1 cubicle, a separate control panel shall be provided to house the remaining components, relays, and devices.

   b. Not more than 1 circuit breaker shall be assigned to a control panel.

D. Switchgear Ratings. Switchgear assemblies shall have the following ratings and requirements:

1. Rated Nominal Voltage, volts, DC: 845

2. Maximum Rated Voltage; DC: 1,200

3. Rated current, amperes, DC Main: 6,000 amps

4. Rated current, amperes, DC Feeder: 3,000 amps

5. Power Frequency: Withstand Insulation Level 4.6 KV

6. Rated Short-time Current: amperes 72,000

7. Rated Short-circuit Rating: amperes 158,000

E. Doors and Panels:

1. Each circuit breaker compartment shall be furnished with a formed hinged door on the front of the structure to cover the compartment opening.

   a. Door shall be provided with a handle and lockable latch. Hinges shall be heavy-duty type. Doors shall be provided with stops and latches to hold them securely in the open position.

   b. Not more than 1 circuit breaker shall be assigned to a control panel.

F. DC Power Circuit Breakers:

1. Switchgear shall be equipped with individually enclosed, high-speed power circuit breakers rated for use with the TRU. Main switching and interrupting device shall be of the removable type, arranged for moving physically between the connected, test, and disconnected positions. Power circuit breakers for the DC power switchgear shall be manufactured in accordance with the requirements in the Referenced Standards.

2. Type:

   a. Low-voltage power circuit breakers shall be DC, air-break, single-pole, and single-throw, high-speed.

   b. Provide draw-out type circuit breakers with electrically controlled closing and electrically controlled tripping, mechanically and electrically trip-free, suitable for local and remote supervisory control, provided with trip devices as specified herein and on the Contract Drawings.

   c. For the purposes of this Specification, a single-pole breaker constitutes a switching device with a single current path and a single arcing path during current interruption.

   d. DC circuit breakers shall be equipped with a mechanical device on the front of the breaker, (available with door closed), to
manually, without electrical power, trip the circuit breaker.

e. Provide indication on the front of each circuit breaker, visible with door closed, to mechanical show the position of the circuit breaker (open or closed).

f. Circuit breakers shall be operable in the disconnected, test and connected positions. There shall be indications to the control and indication circuits to indicate the position of each breaker. Indications for the connected position, test position, and disconnected position (breaker in the cell). When the breaker is in the test or disconnected position, Operations Control Center (OCC) shall display a “breaker open” signal regardless what state the breaker is in. If no breaker is in the cell, the OCC shall display a “no breaker” indication.

g. Circuit breaker element must roll in and out of the cubicle without the use of ramps or lifts.

h. Circuit interruption arc chutes shall be suitable for bi-directional current flow and designed for positive interruption of all currents within the circuit breaker ratings. The arc chute may be furnished with air puffer device, if required to positively extinguish low current arcs within the arc chute.

i. Provide with each Substation a portable lifting device to remove and replace the circuit breaker arc chutes. Lifting equipment may be rail mounted on the front of the DC Switchgear.

3. Circuit Breaker Ratings:

a. DC power circuit breakers shall be tested and certified to the requirements of the Referenced Standards and shall be designed for use on transit rail systems.

b. DC circuit breakers shall have certification to the preferred ratings as specified in the Referenced Standards according to maximum rated voltage, and to the following:

1) Rated Continuous Current, rms, amperes:

2) Main CB 6,000, Feeder CB 3,000

3) Maximum Rated Voltage, volts, DC: 1000 or 1200

4) Power Freq. Withstand Insul. Level, kV, rms 4.6

c. Each circuit breaker compartment shall be closed at the top to prevent objects from the top being dropped on live parts.

d. Materials shall be of a type that is noncombustible, nonhygroscopic and tracking resistant.

e. Mechanical strength and physical characteristics of the insulation structure shall match the stresses imposed by circuit breaker rated momentary current.

4. Circuit Breaker Compartments:

a. A separate metal-enclosed compartment shall be provided to house each draw out circuit breaker. Guide rails for positioning the removable element shall be provided as an integral part of the compartment.

b. Removable assembly (rack) shall be provided with 3 positions:

1) Connected.

2) Test.

3) Disconnected.

c. Provide a fully interlocked, manually operated racking mechanism for placing the circuit breaker in the “Test” and “Connected” positions. A clearly visible position indicator and indicating light shall be provided to display the connected position. Racking handle (if required) shall be clearly and permanently labeled “DC Breaker Racking Handle”.

d. Means shall be provided for positively holding the circuit breaker in place in the housing when the removable element is in the “Connected” or “Test” position.

e. Interlocks shall be provided so that when a breaker is in the
“Connected” position the circuit breaker cannot be closed when the door is open and the compartment door cannot be opened when the circuit breaker is closed.

f. Circuit breaker primary disconnecting contacts shall be comprised of heavy-duty, self-aligning, spring-loaded, silver-plated, copper disconnect fingers that engage with the line and load-side stationary disconnecting contacts.

g. Each compartment shall be suitably shrouded or provided with automatic safety shutters to prevent accidental contact with live parts.

h. Circuit breaker control wiring connections between the removable element and stationary compartment shall have provisions for maintaining, or automatically reinstating, circuit continuity when the removable element is moved between the “Connected” and “Test” positions within the compartment.

i. Recessed stationary receptacle and set of self-aligning multiple contact plugs on the removable element shall be provided for simultaneous disconnection of control wiring connections when the removable element is moved between connect, test and disconnected position.

j. After racking out the DC breakers to the test position or the disconnect position, then pulling out the control cable from the DC breaker control receptacle, a transfer trip shall not occur and OCC should get an empty rectangle symbol for indication.

k. Circuit breaker compartments shall only permit the interchange of circuit breaker removable elements of the same type and rating.

5. Circuit Breaker Positions:

a. Provisions shall be made for moving each circuit breaker to the “Connected”, “Test” and “Disconnected” position. In the “Connected” position, both the primary disconnecting devices and the secondary disconnecting devices shall be in full contact and the breaker shall be in position for normal operation.

b. In the “Test” position, the primary disconnecting device shall be open and separated by a safe distance, and the secondary disconnecting devices shall be in full contact.

c. In the “Disconnected” position, both the primary and secondary devices shall be open and separated by a safe distance.

d. Mechanical interlocks shall be provided to prevent moving the circuit breaker in or out of the “Connected” position when the circuit breaker is in the closed position. An indicator shall be provided to show the circuit breaker in the “Connected”, “Test” or “Disconnected” position. The circuit breaker shall be prevented from closing electrically, unless the circuit is in the “Connected” position with the primary disconnecting devices in full contact, and the compartment door fully closed and latched, or in the “Test” position.

e. Each AC and DC Circuit Breaker shall be provided with one “a” and “b” contact and shall interface with the DPM for status indication.

6. Operating Mechanism:

a. Circuit breaker operating mechanism shall be magnetic, solenoid or motor-charged, stored-energy, spring-operated type. The mechanism shall be mechanically trip-free.

b. Operating mechanism shall be furnished with mechanical indicators to show the open and closed positions of the main moving contacts.

c. The main DC circuit breaker closing mechanism shall be furnished with a unique key interlock coordinated with the associated rectifier negative disconnect switch.

1) Interlock system shall prevent closing of the circuit breaker unless the disconnect switch is closed and shall prevent the opening of the disconnect
switch unless the circuit breaker is open.

d. A minimum of 8 spare, electrically separate sets of reversible auxiliary switch contacts shall be provided in addition to those required for the circuit breaker control and annunciation circuits, for use as “a” and “b” contacts. All auxiliary switch contacts shall be operated by the breaker mechanism in both the “Connected” and “Test” positions. All auxiliary contacts, both used and spare, shall be wired to terminal blocks on the structure through secondary disconnecting device contacts.

e. A 4-digit, nonresettable register-type operations counter shall be provided on each circuit breaker to record tripping operations.

7. Breaker Position Indications:

a. Open or closed positions for the breakers shall be indicated by green and red indicating LEDs mounted on the front panel and by mechanical flag indicators. The LEDs shall provide a visible indication of the circuit breakers status when the circuit breaker compartment door is closed.

b. The red indicating light shall be connected to supervise the continuity of the trip circuit. Connections to the terminal blocks shall be provided for parallel remote indication.

c. The mechanical flag indicators shall be visible from outside the compartment with the compartment door closed.

A white LED indicating light shall be provided to indicate that the stored-energy closing mechanism is charged.

8. Circuit Breaker Control:

a. Circuit breakers shall be designed for both Local and remote supervisory electrical operation.

1) When the circuit breaker is in the local position, the breaker shall operate via dry contacts placed in the DC control “trip” scheme such that failure of any control or system components shall not defeat the tripping function.

2) When the circuit breaker is in the Remote mode, the unit shall operate via the SCADA system.

3) Closing mechanism shall be suitable for operation over a voltage range of 90 to 140 VDC.

4) Triping mechanism shall be suitable for operation over a voltage range of 70 to 140 VDC.

5) Supervisory control interposing relays shall be installed and wired to a terminal block for interconnection to the SCADA RTU.

b. Each circuit breaker unit shall be provided with a “Local-Remote” control selector switch arranged for operation as follows:

1) Local Position: Permit local close and open operation of the circuit breaker by its associated electrical control switch, when the removable element is in the “Connected” or “Test” positions.

2) Remote Position: Permit open and close operation of the circuit breaker from the SCADA equipment when the removable element is in the “Connected” position.

c. A white LED indicating light with nameplate indicator shall be provided which illuminates when the Local-Remote control switch selector switch is in the Local position.

d. A blue LED indicating light with nameplate indicator shall be provided which illuminates when the Local-Remote control switch selector switch is in the Remote position.
e. When the DC Breaker is completely removed from the cell, the OCC should get an empty rectangle symbol to indicate “no breaker”.

f. When 125VDC control power is disconnected from the DC breaker and the breaker is in the “Test” or “Disconnected” positions, a transfer trip shall not be initiated and OCC should receive an empty rectangle symbol.

g. DC breaker control cell door latching mechanism and limit switches shall be mechanically strong and not be susceptible to bending or warping.

9. Supervisory Control Requirements:

a. Each switchgear assembly shall be provided with the following circuits to interface with the SCADA system.

b. Each circuit breaker compartment shall be equipped with 24 VDC interposing relays for SCADA control: (94C, 94T)

   1) One relay for closing the circuit breaker (94C).

   2) One relay for tripping the circuit breaker (94T).

c. Provide interposing relays with 20 percent spare contacts for:

   1) Control Circuits:

      a) DC Circuit Breaker: CLOSE.

      b) DC Circuit Breaker: TRIP.

   2) Status Indication Circuits:

      a) DC Circuit breaker: CLOSE (Circuit breaker closed and in the connected position).

      b) DC Circuit breaker: TRIPPED (Circuit breaker open or in the test or disconnected position).

   3) DC Circuit Breaker Local/Remote:

      a) Local: (Circuit breaker local/remote switch in the local position).

      b) Remote: (Circuit breaker local/remote switch in the remote position).

      c) DC Circuit Breaker in disconnected position.

10. Instruments:

a. DC power switchgear assemblies shall be furnished with DC voltmeters, ammeters, and accessories, as indicated on the Contract Drawings and as specified herein: All meters shall have an integral digital display along with the analog display.

b. Provide ammeters scaled to have an overload capacity for repeated over currents of up to 300 percent of scale range.

c. Ammeter shunts shall comply with the Referenced Standards and have a rated output of 50 mV.

d. Voltmeters shall be scaled as required with 0 to 1000 VDC with signal input from a 1000 VAC insulated voltage transducer.

e. Shunt/Isolation/Amplifier (Voltage Transducer):

   1) Shunt/Isolating transducers shall be provided for all 750/845-VDC relays and instruments. However, if the sensitivity of the protection relays will be jeopardized, use of DC shunts will be accepted as an alternate.

   2) Control wiring associated with the shunts shall be housed in a separate nonmetallic trough. Wire terminating to the devices shall be covered with insulating boots.
3) Shunt/isolating transducer shall be a linear amplifier designed to amplify DC shunt millivolt signals.

4) Provide complete isolation of the input signal. A magnetic amplifier shall be used in the input circuit to isolate the inputs from all other circuits and grounds.

5) Input shall be tested at 4000 Volts DC for 1 minute to insure that no breakdown will occur when connected to shunts operating at high voltage.

6) Output shall be a hybrid amplifier operating in the transconductance mode to provide a constant current output. Load resistance variations from 0 to 10K ohms shall have less than 0.1 percent effect on the output current to make the amplifier an ideal device for telemetering, scaling and recording applications.

7) Output should be filtered.
   f. A variable resistor with adjustments from zero to maximum gain shall be provided and be accessible through the top cover. Large gain changes should be accomplished by changing the auxiliary gain resistor.

1) Power Requirements: 125 VDC within plus or minus 10 percent 10 VA (Max)

2) Input Impedance: 5000 ohms/Volt

3) Load Impedance: Any load between 0 to 10K ohms

4) Accuracy: Within plus or minus 0.5 percent RO at 77 degrees F

5) Temperature Range: 14 degrees F to 158 degrees F

6) Temperature Coefficient: Within plus or minus 0.04 percent °C

g. Transducers shall be compatible with the rating of the DC switchgear.

h. Control devices, instruments, and circuits, whether mounted on the compartment door or other portion of the stationary unit structure, must be physically accessible and so connected as to permit safe testing and maintenance of relays and control circuitry.

i. Shunt/Isolation/Amplifier shall be SMC type or an Authority approved equal.

G. DC Bus:

1. Negative Disconnect Switch:
   a. A negative disconnect switch shall be included within a separate metal-enclosed compartment for each rectifier unit.

   b. Disconnect switch shall be single-pole, single-throw, bolted pressure contact, stationary type, rated at 2,000 VDC, with continuous and momentary current ratings to match the associated rectifier Main DC circuit breaker ratings.

   c. Disconnect switch shall be furnished with an insulated operating handle and shall be key-interlocked with the rectifier-main DC circuit breaker.

   d. Interlocking shall prevent opening or closing of the switch unless the main DC circuit breaker is open, and similarly, prevent the main DC circuit breaker from closing unless the disconnect switch is closed.

2. Negative Rail Grounding Unit (NRGU): (Device No 57NR):
   a. NRGU shall consist of a bi-directional solid state switch with potential and current sensors, associated relaying and control circuitry in parallel with a manual reset, lockout, electromagnetic, spring-loaded mechanical shorting contactor.

   b. The purpose of this solid state switch unit is to ground the negative system should the voltage between the system negative and ground
exceed a safe value, settable between 50 V and 100 Volts in steps of 10 volts.

c. The shorting contactor shall be rated to sustain 750 Amps continuously, with a peak capability of 15,000A for 0.3 seconds, the shorting contactor closes and locks-out if the resulting current flow exceeds a set level (approximately 700 amperes).

d. Annunciation shall be provided both locally within the rectifier unit, at the Annunciator Panel and remotely through SCADA.

e. The unit shall be mounted inside the rectifier unit.

f. NRGU shall be isolated from the incoming negative return cables and negative bus. When manually resetting the NRGU, personnel cannot contact the negative bus and switch.

g. NRGU shall send the following 4 signals to the thyristor-rectifier controller for permanent recording and storage with date and time stamp:

1) Negative rail to ground overvoltage.

2) Ground to negative rail overvoltage.

3) Over-Current lockout forward.

4) Over-Current lockout reverse.

h. Enclosures:

1) Negative drainage equipment shall be contained in the rectifier enclosure.

2) Hinged doors shall be provided for access to the negative equipment.

i. Disconnect Switches:

1) Negative drainage disconnect switches shall be manually operated, single-pole, single-throw, bolted pressure type, solid copper blades with silver-plated contacts, rated at 2000 VDC, 100 Amps.

2) Switches shall be equipped with insulated operating handles.

3) A minimum of 3 switches shall be provided.
j. Shunts: DC instrument shunts shall comply with the requirements of the Referenced Standards.

k. Cable Terminations:

1) Negative drainage panel enclosure shall provide adequate space for spreading and termination of the drainage cables as required by the final design.

2) Cable entry cover plates shall be bolted to permit field drilling of holes for conduit.

3) Cover plates shall be 18 inches minimum distance from the cable termination bus.

4. Surge Arrestors. Surge arrestors shall be provided for protecting the negative bus as follows:

a. Provide 1 surge arrester for each feeder section, and 2 surge arresters for the negative bus. Surge arresters shall be of the metal oxide varistor type.

b. Each surge arrester shall have an energy discharge capability of 2.6 kJ/kV for currents of 500A or less.

c. Provide Type MCOV, 1280 V, Model No. 6007-006 as manufactured by SMC, or an Authority approved equal.

d. Each surge arrester shall be individually connected to the station ground mat.

e. Each grounding connection shall have a grounding resistance of 5 ohms or less or as specified by the surge arrester manufacturer for the type of unit supplied.

f. Provide rear compartment-mounted, indoors style, away from rectifier components.

g. Arrestors shall be suitable for connection to a 845 VDC power supply for protection of the rectifier against lightning surges.

h. Arrestors shall have a maximum continuous operating voltage of 1280 V. Maximum peak spark over

and residual voltage values shall be coordinated with the dielectric withstand voltage characteristics of the rectifier insulation structure, as well as the maximum arcing voltage produced by the DC Circuit Breakers during interruption.

i. Cable connection between the surge arrester and the rectifier b-negative bus shall be kept as short as possible and sufficient clearance from any metallic parts shall be maintained. Cable connection to the surge arrester shall be taped to 4 times rated voltage.

H. Emergency Trip System (ETS):

1. Provide an ETS to disconnect all power to and from the TPSS under emergency conditions. Provide a Control System as shown on the drawings and as described herein.

   a. Contractor shall provide 2 interior emergency trip devices and 1 exterior emergency trip device for each TPSS.

   b. Provide 1 interior device at each access door as shown on the Contract Drawings. The indoor device shall be a “mushroom” shaped large pushbutton switch, with a protective cover. Clearly, label the device “EMERGENCY TRIP” and protect from accidental trip. The ETS device or relay shall be a lockout type, requiring manual reset.

   c. Outdoor disconnect device shall be mounted in a lockable type Knox Box such as series Model No. 4400 or an Authority approved equal, Recess mount, with dual entry locks in a dark bronze color or an approved equal.

   d. ETS pushbutton inside the substation enclosure and the ETS outside at the substation entrance door, shall initiate trips to the AC high-voltage incoming primary breaker, the DC main breaker, all DC feeder breakers, and initiates transfer trip to the adjacent substations feeder breakers with “disallow reclosure”.

   e. Exterior lock system shall be keyed to the appropriate keying system for the local jurisdictional Fire
Department and the Authority maintenance. Contractor shall contact the Authority’s “Technical Services” Department for the proper form’s and procedures prior to purchasing the Knox Boxes or keying. Keys shall be furnished for each Knox switch.

2. Local Annunciator Panel Circuits: Circuits shall be provided between each DC Switchgear assembly and the local Annunciator panel for the alarm points as indicated on the Contract Drawings and as specified herein.

I. Switchgear Maintenance Accessories:

1. Each TPSS DC switchgear assembly shall be provided with the following:

2. One DC circuit breaker test cabinet, wall-mounted, complete with test jumper cable and connectors.

3. One set of circuit breaker removal accessories, including lifting and handling devices (i.e. 3 wheel) and racking crank.

4. Two sets of all sizes and ratings for any associated fuses, circuit breakers or indicating lamps.

2.5 STATION SERVICE AND SIGNAL POWER TRANSFORMERS

A. Provide Station Service and Signal Power Transformers, sized as required by the TPSS equipment requirements, as specified herein, or as required by the final design.

B. General:

1. Contractor shall provide, install and test Station Power and auxiliary power as an integral part of the TPSS. All components and equipment shall be integrated into the TPSS as specified, and shall be so assembled as to form a complete and operational system. Provide:

   a. Station Service Transformer.

   b. Signal Service Transformer.

   c. Distribution Panel Boards.

   d. Associated meters, instruments and relaying.

2. Provide ventilated dry type, self-cooled distribution transformers manufactured and tested in accordance with the Referenced Standards.

3. Insulation class: Provide 15 kV BIL of 95 kV full-wave.

4. Maximum allowable temperature rise under continuous full load shall not exceed the values in the Referenced Standards.

5. Efficiency shall be 98 percent or better.

6. Fuse:

   a. Each transformer shall be protected on the “primary” by draw-out fuses mounted on a withdrawable trunnion carriage in the HV Switchgear.

   b. Trunnion shall be mechanically interlocked (i.e. Kirk-Key) with the LV panel secondary main breaker ensuring that the load is removed prior to fuse trunnion withdrawal.

   c. Transformer compartment(s) shall be equipped with a gasketed wire glass window to allow visual inspection of the fuses. Provide blown fuse indication visible from the substation enclosure interior aisle.

   d. Alternate arrangements are subject to prior approval by the Authority.

C. Station Service Transformer:

1. Provide Substation AC Power by providing a Station Service Transformer as part of the Substation package. The transformer shall be sized as required by the connected loads but no smaller than:

   1) 50KVA.

   2) Single phase.

   3) 12.47/13.2 KV - 240/120 VAC.

   4) Within plus or minus percent primary taps above and below rated voltage in 2.5 percent steps.

2. Protection shall be in accordance with the latest edition of the NEC with metering and monitoring as indicated herein and as shown on the Contract Drawings.

3. Contractor shall verify the primary nominal voltage for each Substation site.
D. Signal Power Transformer:

1. Provide power for track signal’s functions by providing as part of the Substation package a “Signal Power Transformer”. The transformer shall be:
   1) 75 KVA.
   2) Single phase.
   3) 12.47/13.2 KV - 480VAC (primary voltage is site specific).
   4) Within plus or minus 5 percent primary taps above and below rated voltage in 2.5 percent steps.

2. Protection shall be in accordance with the latest edition of the NEC with metering and monitoring as indicated and as shown on the contract drawings.

3. Contractor shall verify the primary nominal voltage for each Substation site.

2.6 PANELBOARDS

A. Furnish and install a Station Service AC Distribution Panel, Signal AC Distribution Panel and a DC Distribution Panel in accordance with the Contract Drawings and these specifications.

B. General:

1. Panelboards shall be surface mount suitable for indoor use.
2. Panelboards bus shall be copper.
3. Provide panelboards with 100 percent rated insulated neutral bus.
4. Provide multiple lugs if final design requires parallel conductors.
5. Provisions for additional breakers shall be such that no additional connectors will be required to add breakers.
6. Circuit breakers shall be bolted securely to the panelboards bus. Push on or plug in breakers are not acceptable.
7. Where circuit breakers are intended for supplying HID or fluorescent loads, they shall be rated and labeled for use on HID loads.
8. Provide GFI breakers where required by the NEC and per the final design.
9. Panelboard lugs shall be UL listed to accept solid or stranded copper. Lugs shall be suitable for 194 degrees F rated wire, sized according to the 75-degree temperature rating per NEC.
10. Provide panelboards rated for connection to the rated voltages as specified herein and as indicated on the Contract Documents, with 22,000 amperes RMS short-circuit current available, as a minimum.
11. Panelboards shall be sized to provide adequate wire gutters and bending space so as to not exceed the fill and bending requirements in accordance with the Referenced Standards. Mount the Station Service Panelboard and the Signal Panelboard side by side in the enclosure. Provide a wire raceway beneath the Station Service Panelboard extending past the Signals Panelboard. The raceway shall be of adequate size to accommodate four 4-inch conduits and two 2-inch conduits for future extension to other TPSS site equipment.
12. Panelboard fronts shall be of the door-in-door type such that breaker handles can be accessed by opening the inner door and panel wiring can be accessed by opening the outer door.
13. Circuit directory frame and card with a transparent protective plastic covering shall be provided on the inside of the door. The directory card shall provide a writing space at least 1/4 inches high by 3 inches long for each circuit. Contractor shall provide a typed circuit directory identifying all connected loads.
14. Enclosure shall be steel, with rigidity and gauge as specified by the Referenced Standards with full finish rust-inhibiting primer and baked enamel finish, furnish ANSI 61 gray color or as specified herein and as directed by the Authority.
15. Provide engraved nameplates for each Panelboard.
16. Panelboards shall be rated NEMA Type 1.
17. Provide step-down transformers, fuses, cabling and distribution panelboards as required to make a complete power distribution system for AC and DC service to the TPSS and the Substation assemblies and sub-assemblies.
18. Each service distribution panelboard shall include a main molded case circuit breaker sized per the equipment load requirements; lugs only panelboards will not be accepted.

19. Provide all necessary molded case branch circuit breakers as required by the final design. Furnish no less than 20 percent spare circuit breakers with a minimum of 4 for each panel.

20. Separate branch circuits shall be provided for control and power circuit, size per the latest edition of the NEC.

21. Provide surge protection devices for each distribution panel.

22. Contractor shall coordinate panel design and sizing of all circuit breakers with substation equipment loading requirements.

23. As part of the submittals listed above, provide panelboard calculations, design and circuit breaker ratings to the Authority for approval.

C. Station Service Distribution Panel:

1. Distribution Panel shall be surface mounted, dead-front type, housed in a NEMA Type 1 steel enclosure with hinged front cover, lockable handle, and 2-point latch.

2. Provide a keyed interlock with the Station Service AC main breaker and the Station Service transformer.

3. Mount on 1 exterior wall a 20 Amp, fused safety disconnect switch for use by the TPSS Installation Contractor for irrigation service.

4. Provide at a minimum a 225 amp, 240/120 VAC station service distribution panel.

5. As part of the sizing requirements for this panelboard, provide, in addition to the sizing requirements for the TPSS, a 240/120-volt, 125 amp, 2-pole circuit breaker for use by the Communications Contractor.

6. Contractor shall also provide for the Communications Contractor a 2-inch conduit or raceway from the Station Service Distribution Panel to an interface point location in the TPSS. The Communications Contractor will extend the conduit to the nearest Communications manhole. Power cable and installation will be by the Communications Contractor.

D. Signal Power Distribution Panel:

1. Provide for use by the Light Rail Signals Contractor an AC distribution panel suitable for 480 VAC, single-phase, 2 wire service. Provide power from the signal step down distribution transformer.

2. The Distribution Panel shall be surface mounted, dead-front type, housed in a NEMA Type 1 steel enclosure with hinged front cover, lockable handle, and 2-point latch.

3. Furnish a complete system inclusive of key interlocks and accessories to provide a complete functioning system.

4. Provide a panelboard with a keyed interlock with the main breaker and the Signal Service transformer. This panelboard shall contain a 150 amp, 2 pole, main breaker with branch breakers and spare breakers.

5. This Contract shall also provide for the TPSS Installation Contractor a 2-inch conduit or raceway from the Signal Service Distribution Panel to an interface point location in the TPSS. TPSS Installation Contractor will extend the conduit to the nearest Signals manhole or as shown on the site drawings. Power wiring will be by the TPSS Installation Contractor.

E. DC Distribution Panel:

1. Provide 2-wire DC system panelboard of appropriate size in each Substation and protect the panelboard with a main molded-case circuit breaker.

2. Distribution Panel shall be surface mounted, dead-front type, housed in a NEMA Type 1 steel enclosure with hinged front cover, lockable handle, and 2-point latch.

3. Contractor shall calculate the required rating of the DC control power distribution panel and submit the calculations to the Authority for approval.

4. DC panel shall be supplied with 2 main incoming lug terminals for separate connection of battery and battery charger.

5. Furnish the appropriate quantity of circuit breakers with a minimum of 20 percent spare circuit breakers.
6. DC panel shall be OSHA red and connected on the line side of the DC battery disconnect switch to permit continuous operation of the DC load when the batteries are disconnected for service.

2.7 PROTECTIVE DEVICES

A. General:

1. Contractor shall design a complete protective scheme to protect the substation equipment and the overhead distribution system as well as provide back up to the LRV protective devices. Base the protective scheme on the connected load, overload, and available short circuit currents. Select the characteristics and ranges of all protective relays and fuses to ensure optimum coordination of all devices and fast fault clearance to prevent equipment damage.

2. Relay scheme shall be designed, constructed, and tested in accordance with the applicable provisions specified herein and the Referenced Standards. Design the protective scheme to be immune to noise, harmonic distortion, traveling waves, and instrument transformer saturation.

3. Protection relay functional designations and circuits shall be as indicated on the Contract Drawings, in the Referenced Standards and as specified herein. Relay contacts shall be rated for the intended duty and meet the performance characteristics indicated. Contacts and adjusting devices shall be readily visible, accessible, and adjustable from the front of the relay.

4. Arrange all protective relays to be conveniently accessible, easily visible, and logically grouped. Locate devices of related functions in proximity to each other. Install the protective relays semi flush on the circuit breaker cubicle door.

5. Interposing relays for input/output interface with other devices and the SCADA equipment shall be plug-in style with stainless steel hold-down spring clips. Mounting boards shall be provided with pressure plate terminals.

6. Relay types shall be UL approved. Contractor shall use only high quality, utility-type draw-out protective devices enclosed in rustproof, dustproof, high-impact cases with integral test switches and silver-to-silver non-bonding contacts.

7. Contractor shall provide a protective device relay coordination study, coordination curves, proposed relay settings, fuse rating and supporting calculations for all Substation sites. Initial setting shall be made at the factory; final field setting and field-testing of the protective relays will be by this Contract.

8. The minimum protective requirements are specified below, described in the individual section of these Specifications and shown on the Contract Drawings. The Contract Drawings show the minimum protective schemes and are intended to serve as an aid to the protective scheme(s) functional requirements; final design shall be by this Contract and shall be approved by the Authority.

9. Contract Drawings do not show all components such as auxiliary relays, isolating diodes, fuse(s) and similar devices required for a complete protective system. This Contract shall perform all final design including selection of device characteristics, model numbers, style, connections and settings for all auxiliary devices.

10. Contractor may, if approved by the Authority, as an option to individual relays as described in this section furnish a Multi-Purpose Relay or relays that integrate the functions of several relays. Contractor shall provide, at a minimum, the following relay and protective functions:

B. AC Switchgear:

1. Device 50/51-(50N/51N): (Overcurrent Relay):

   a. Each AC Switchgear section shall be provided with a 3-phase multifunction nondirectional overcurrent relay. Provide overcurrent and instantaneous phase and neutral protection.

   b. In addition, the relay shall have selectable time current curves to coordinate with the Substation short circuit and coordination study.

   c. Relay shall have time overcurrent and instantaneous elements for phase and ground tripping.

   d. Provide Cooper Power Systems model DM30AE or an Authority approved equal.
2. Device 86H: (Lock-Out Relay-LOR):
   a. Provide a “lock-out” relay to function as indicated herein and on the Contract Drawings.
   b. “Lock-out” relay shall be manual reset, with a mechanical target as part of the nameplate; black for reset, orange for trip, to indicate the condition of the LOR.
   c. Provide Electroswitch Series 24 LOR or an Authority approved equal.

3. Device 94C/94T: (Interposing Relay)
   a. Each AC Switchgear section shall contain SCADA interposing relays for remote “trip” (94T) and remote “close” (94C) functions by the Authority’s OCC.

   a. Provide 3-phase voltage monitoring of the incoming service feeder.
   b. Protective relay(s) shall provide protection for phase loss, phase reversal, over-voltage, and under-voltage conditions.
   c. Upon detection of an unstable service voltage condition the protective device shall “trip” the AC main circuit breaker. Provide means for, “local” and “remote” reset. The relay shall provide protection even if regenerative voltages are present.
   d. Provide ABB WVM series, 3-phase voltage monitor or an Authority approved equal.

C. Rectifier Transformer:
   1. Device 49T/49TH: (Transformer Thermal Relay):
      a. Provide transformer-winding temperature monitoring and relaying.
      b. Protective relay (monitoring device) shall be equipped with a temperature display, trip contacts, alarm contacts and shall directly control transformer fans if required by the final design.
   c. Each stage setting shall be adjustable over a range of temperatures. The device shall indicate when an over-temperature condition has occurred and how long it lasted.
   d. Provide the ability to download and print rectifier faults from rectifier computer to a laptop computer. Data collected should be date and time stamped.

D. Rectifier:
   1. Device 98: (Current Limiting Fuse): A high-speed current limiting fuse shall be provided in series with each Thyristor full wave bridge, complete with an indicator to a blown fuse. Fuses shall be clearly visible from a viewing window and sized to protect the rectifier against internal faults resulting from a thyristor losing its blocking ability. Fuse shall prevent spreading of the fault to adjacent Thyristor(s), by fast fault current interrupting. Thyristor fuses shall not open or fail during external faults or rated overload conditions.
   2. Device 26R/26RH: (Thermal Relay): Overtemperature Protective Relays, provide 2 stage relaying to monitor the heat sink temperature. Each stage setting shall be adjustable over a range of temperatures. Relay thermal sensors shall be mounted in the hottest location of the rectifier.
   2. Surge Protection: Rectifier shall be equipped with a surge protection device(s) to limit the reverse voltage across the diodes and thyristors to a value lower than the peak reverse voltage rating of the diodes and thyristors. The device shall protect the rectifier irrespective of whether the surges originate in the AC or DC power circuits.
   3. Device 33R: Provide enclosure position contacts at the top and bottom of all rectifier enclosure doors. Upon opening the enclosure doors, the contacts shall trip the AC circuit breaker and the DC main circuit breaker and shall initiate annunciation. AC and DC main breakers shall not be allowed to close unless all rectifier enclosure doors are closed.

E. Main DC Circuit Breaker:
   1. Device 32 (DC Reverse Current Instantaneous Relay):
a. A reverse current relay shall be furnished on the incoming main DC bus and shall detect reverse current on the outgoing DC positive bus from the rectifier. Relay shall trip the Main AC breaker relay on reverse current and shall be adjustable between 5 percent and 100 percent of the combined feeder circuit breakers continuous current ratings. The relay shall be equipped with an unidirectional direct-acting overcurrent trip, set as low as practically possible and reacting on reverse currents only. In addition, each main DC breaker shall be equipped with a direct acting reverse current tripping device.

b. Provide contacts indicating an operation of the Device 32 relays to the local Annunciator panel and the SCADA system.

c. Provide Swartz Type 32 Reverse Current Relay or an Authority approved equal.

d. If the main DC breaker Device 32 is tripped, the DC feeder breakers shall remain closed and the main AC Circuit Breaker shall trip. When Device 32 is reset, and the main AC breaker is then closed locally or by the OCC, a transfer trip shall not occur.

e. Main DC breaker shall be allowed to be closed when it is in the “test position” and the AC breaker is open. Whenever the main DC breaker is in the “test position” it should be allowed to open and close without regard to the status of other TPSS electrical equipment.

2. Relay 186H (DC Lockout Relay):

a. Provide a “lock-out” relay to function as indicated herein and as indicated on the Contract Documents.

b. “Lock-out” relay shall be manual reset, with a mechanical target as part of the nameplate; provide black indication for reset, orange for trip, to indicate the condition of the relay.

c. Provide Electroswitch Series 24 LOR or an Authority approved equal.

3. Device 86H (AC Lock-out Relay):

a. Provide a manual reset, mechanical target lock-out relay.

b. Relay shall trip on an overcurrent, reverse current, ETS emergency trip, TCR fault 3 and “hot structure”.

F. Feeder DC Circuit Breakers:

1. Device 150/151: (Overcurrent Relay):

a. Each DC feeder breaker shall be equipped with an overcurrent relay protecting the distribution system from overloads, arcing and high resistance faults. Relay characteristic shall closely follow the maximum permissible DC current overload characteristic of the distribution system to prevent conductor annealing during sustained overloads or faults.

b. Provide a solid state overcurrent multi-purpose relay with the following functions:

1) Instantaneous overcurrent.

2) Reverse overcurrent.

3) Extra-long timed overcurrent.

4) Timed overcurrent.

5) Rate-of-rise overcurrent.

6) Undervoltage protection.

7) Arcing protection.

c. Relay shall be front-panel mounted, plug-in type, and self-contained.

d. Relay shall have automatic reset feature and shall directionally trip for high impedance faults on the overhead positive distribution system.

e. Relay shall not trip for train starting currents.

f. Rate-of-rise overcurrent trip device shall discriminate between remote short-circuit currents and inrush currents of starting trains.
g. Relay shall have the ability to manually scan faults on the display without the use of a laptop computer interface and be able to download and print faults to a laptop computer. Data collected should be date and time stamped.

2. Device 196/197: (Extra Long Time Overcurrent Relay):

a. Provide for each DC feeder circuit breaker an “extra long overcurrent relay” that shall initiate a trip if the current exceeds the trip limit and stays above the set limit during the delay time. If the current drops below the trip level during the delay time, the delay timer shall reset.

b. This protection is intended to detect low current faults, which are well below train normal currents.

c. This function may be incorporated into the MPR.

3. Device 182/183: (Automatic Reclosing Relay):

a. Provide automatic reclosing for each feeder breaker, incorporating automatic reclosing and load measuring devices No. 182 and No. 183 to provide load-side fault verification before the breaker is closed.

b. Each mainline Substation feeder circuit breaker shall be furnished with a front panel mounted, plug-in type, and self contained, solid-state DC breaker recloser relay, including a load measuring network consisting of a load measuring reclosing relay, voltage sensing relay, loading measuring contactors, load measuring resistors, adjustable time-delay reclosing relays, counters and other associated devices as required. Contractor may furnish an alternative automatic reclosing scheme if approved by the Authority.

c. Load measuring circuit shall be activated only when the feeder breakers are in the connected positions and before the circuit breaker closes or attempts to close. When activated, circuit shall measure the resistance on the circuit on the load side of the circuit breaker. Circuit breaker shall close only when the track load resistance is within an acceptable range and the bus voltage is above the preset point. The acceptable range, which includes the LRV loads, shall be adjustable. Load measuring circuit shall prevent the circuit breaker from closing if the circuit measurement indicates a fault on the load side of the circuit breaker. Reclosing shall only be permitted when a circuit breaker is tripped by the direct-acting overcurrent trip devices and overcurrent relay. Reclosing shall not be permitted when a circuit breaker is tripped by local control switch or station lockout relay, or by the transfer trip-disallow reclose command from SCADA. Load measuring scheme shall be designed to prevent initiating the load-measuring circuit when the circuit breaker is in either the closed or disconnected position.

d. Automatic reclosing shall be activated after a short adjustable delay (1 to 5 sec) after the circuit breaker has been tripped by its own overcurrent series trip device, overcurrent relay(s), or by the transfer trip-allow reclose command from SCADA. Reclosing circuit shall be set for only 1 reclosing attempt at the factory with reset capability of up to a minimum of 5 attempts. Circuit shall be deactivated if the closure of the circuit breaker does not occur within a preset time, which shall be adjustable from 5 to 10 seconds. Circuit shall remain deactivated until reset by a new close command of the circuit breaker. The new close command can be initiated by either local or remote control. An enable-disable toggle switch shall be provided in the breaker control compartment to permit disabling of the automatic reclosing function.

e. Load measuring resistors shall be rated for repeated operations. Circuit breaker may be subjected to repeat operating cycles due to a malfunction of another control device. Load-measuring device shall operate only if the circuit breaker is in the connected position. Means shall be provided to disconnect the load measuring device from the 845VDC whenever the circuit breakers are in the test or disconnect position. Relay
components shall be assembled in a separate isolated plug-in housing assembly within the breaker cubicle to facilitate testing and replacement. Reclosure relay can be reset by initiating an open command both locally or remotely.

f. Test cycle shall be initiated by a local “Test” pushbutton, but shall not close the circuit breaker when the removable element is in the “Connected” position.

g. Each feeder circuit breaker control compartment shall be furnished with a 2-position, AUTO-BYPASS selector switch with spring return to the AUTO position. Selector switch shall permit the automatic reclosing and load measuring system to be bypassed only when the circuit breaker is selected for LOCAL control.

h. Load measuring circuit shall compensate for preexisting (rail drop) voltage up to 20 volts and shall preclude closing on a fault at any preexisting voltage. Load measuring resistor shall be mounted on top of the cubicle for ventilation and space efficiency.

i. Each automatic reclosing and load measuring system shall be furnished with a test function, which shall check the functioning of all devices. Reclosure relay shall not be activated when the DC feeder breaker is in:

1) “Test” or “Disconnect” position.

2) The feeder breaker is tripped manually, by the ETSA or from SCADA.

j. Provide Swartz Type 82 reclosing relay or an Authority approved equal.

4. Device 32: (Reverse Overcurrent Relay):

a. Each DC feeder shall be equipped with a reverse overcurrent relay that shall trip the feeder breaker if the reverse current exceeds the trip limit.

b. If the reverse current drops below trip level during the delay time, the delay timer shall reset and start counting anew.

c. Reverse Overcurrent Relay shall have the ability to be “on” or “off”

5. Device 85 (Transfer Trip Relays): Each DC feeder circuit breaker shall be equipped with a transfer trip protective scheme as specified herein:

a. Provide a transfer-trip relay and relay scheme to open adjacent Substation circuit breakers in the event of a fault condition being detected between the circuit breakers on each end of an overhead contact wire section, defined as the “tripping zone”.

b. In the event of a fault in the tripping zone, resulting in the operation of the overcurrent, relay device, overcurrent, device 150, or activation of the ETS, the transfer trip relay shall initiate tripping of the remote (adjacent) circuit breaker(s).

c. Two types of transfer trips shall be provided.

1) First type shall be automatically resettable or "Allow Reclosure":

a) Transfer trip with "Allow Reclosure", will be initiated by the feeder breaker overcurrent devices (150/151 and 176).

2) Second type shall require manual resetting or "Disallow Reclosure".

a) Second type, requiring manual resetting, shall “Disallow Reclosure” of feeder breakers until the emergency trip relay (device ETS, EDS) in the originating Substation, is manually reset.

d. Trip signal to the adjacent circuit breaker shall operate through the SCADA/RTU and the fiber optics communication system.
e. Contractor shall furnish and install multiple conductor cable of appropriate size and quantity from each feeder breaker transfer trip relay, to the CIC and SCADA/RTU for interface with the communications equipment. It is the responsibility of this Contract to provide the proper interface and “handshake” with the Communication Central Contract.

d. LSVDR shall consist of a 0 to 1000 VDC voltage, shunt/isolation transducer in combination with an analog threshold detector to monitor the level of analog signal in relation to a fixed preset threshold. Provisions shall be made to provide for adjustment of the preset thresholds setting.

f. Sufficient quantity and voltage rating of interposing relay contacts and relays shall be provided with the transfer trip devices to interface with the SCADA/RTU.

g. Breakers within a tripping zone shall be equipped with interfacing transmitting and receiving relays.

h. Transfer tripping circuitry shall be energized for tripping only when the transfer trip function is being performed, and shall be self de-energizing when the transfer trip function has been completed. Only the faulted contact wire within the “tripping zone” section shall be de-energized.

i. Contractor shall be responsible for programming the tripping matrix for SCADA/RTU control between adjacent stations.

6. Device No. 159 (Load-side Voltage Detection Relay):

a. Each DC feeder circuit breaker shall be equipped with a Load-Side Voltage Detection Relay (LSVDR), which shall provide both local and remote indication when the load-side of the DC feeder circuit breaker is energized.

b. A red LED indicating lamp, GE ET-16 or Authority approved equal, shall be used to indicate the associated cable or bus is energized.

1) Lamp shall be mounted on the front of the individual circuit breaker compartment unit with a nameplate inscribed “FEEDER CIRCUIT ENERGIZED”.

c. Remote indication to SCADA shall be provided to the SCADA/RTU using appropriate auxiliary contacts.

1) LSVDR shall be equipped with sufficient auxiliary contacts to provide local and remote indication (minimum 2 N.O. and 2 N.C.).

7. Device 176 (Direct-acting Instantaneous Overcurrent Relay):

a. Each DC Feeder circuit breaker shall be equipped with a bidirectional direct-acting overcurrent trip relay, set to open the circuit breakers on short circuits currents.

b. Provide a bi-directional, direct acting relay, with adjustable setting range of 100 to 400 percent of rated continuous current.

c. Use of control power for direct acting tripping shall not be permitted.

G. DC Enclosure Protection:

1. Device 64R/64MR (Structure Ground Energized Relay):

a. DC equipment shall operate as a high-resistance grounding system. Provide a highly sensitive relay that will operate in the event that any part of the DC enclosure becomes energized or grounded.

b. DC switchgear enclosure shall be insulated from the Substation enclosure floor and any adjacent grounded metal work and protected using a high-resistance grounding relay.

c. DC switchgear, rectifier cubicle, and negative enclosure shall be insulated from each other and from ground, and connected through isolating links.

d. The structure ground relay shall be connected to the middle enclosure and single point grounded by means of an insulated No. 12 AWG
copper conductor(s) connected directly to the Substation DC ground bus.

e. A panel-mounted voltmeter (digital readout and analog needle display) shall be connected in parallel with the high-resistance ground relay to indicate the potential between the enclosures and the station ground. The relay shall detect any part of the enclosures which may become energized in the event of a fault between the enclosure and any of the current carrying components and initiate tripping of the AC Main Circuit Breaker and all DC Circuit Breakers through the 86 and 186 lockout relays.

f. Ground relay shall be provided with a contact to initiate tripping of all DC circuit breakers upon the occurrence of any of the following:

1) Enclosure in contact with ground or the positive DC system.
2) Enclosure in contact with the negative of the DC system.
3) Malfunction of the high-resistance ground relay.
4) Loss of potential between the DC equipment enclosures and station ground.
5) Enclosure in contact with any voltage 24 volts and above including 125VDC and 120VAC.

g. Ground relay shall also be furnished with contacts to initiate an annunciation alarm for:

1) Grounded structure.
2) Energized structure.
3) A red rotating type light, Federal Signal model 225, or an Authority approved equal, shall be furnished and installed on the rectifier enclosure to operate when the structure is energized or grounded.

h. If the 64MR device senses an energized enclosure, the thyristor rectifier control system shall wait 2 seconds before sending a transfer trip to the adjacent substations. If after the AC breaker and DC breakers trip open, the DC enclosure is no longer energized, then there is no reason to send a transfer trip. Since the enclosure is high resistance grounded, there will be no high fault current to damage equipment.

H. Other Protection:


2. Devices 86H and 186H: (lock-out relay): Provide as indicated and specified herein.

3. Station Service Power and Signal Power:

   a. Provide and coordinate primary and secondary, fuses, and circuit breakers.
   
   b. Coordinate all molded-case circuit breakers protecting the AC auxiliary system.
   
   c. Coordinate all molded-case circuit breakers protecting the DC auxiliary system.


5. Surge Protection: Furnish suitable surge arresters and transient voltage suppression devices to protect all electronic equipment in the Substation. Apply protection to the power supply and data lines as appropriate. Select the appropriate voltage rating, energy dissipation rating, and other characteristics to be compatible with the equipment to be protected. As a minimum, protect the following equipment:

   a. Programmable logic controller(s) (PLC).
   
   b. SCADA system equipment.
   
   c. Electronic relays.
6. Fire Detector: Use the fire detector device to de-energize and lock out all substation circuit breakers in the event of fire.

I. Lockout relays:
1. Lockout Relays shall be hand-reset by a red pistol-grip handle, complete with amber indicating light rated at 125 VDC.
2. The light shall be connected to supervise the relay-operating coil.
3. Relays shall be furnished with independent contacts for tripping, indications, closing and lockout of circuit breakers.

J. Auxiliary relays:
1. Auxiliary relays shall be installed where required by the final design or as specified herein.
2. They shall be accessible from the front and protected with a dustproof case.
3. Relays shall be semi-flush mounted unless not suitable, in which case they shall be surface mounted within the equipment control compartment.
4. Surface mounted relays shall be provided with transparent dust covers.

K. Loss of Voltage:
1. Loss-of-voltage relays shall be provided as indicated on the Contract Drawings and as specified herein:
   a. Substation AC incoming utility.
   b. DC power.
   c. Signal power.
   d. Station Service power.
2. Relays shall be equipped with a dry contact to be wired to the supervisory control interface terminal cabinet for remote supervisory annunciation.
3. Provide indication and tripping as required for loss of incoming voltage or any “single phasing” condition.

L. Surge Suppressors:
1. Where required by the final designs, provide voltage surge suppressors. Provide units that are high-speed, high current, solid-state devices designed to protect electronic equipment and systems from transient over voltages.
2. Provide devices in a NEMA-4 wall mounted enclosure, with amber lights on the front of the enclosure to illuminate, to indicate the suppressor(s) are operational and power is applied. Suppressors shall be mounted on the enclosure back panel.
3. Suppressors shall provide continuous bipolar bi-directional, non-interrupting protection and be capable of instant automatic reset with no degradation in protection capabilities.
4. Provide electrical connections and wiring to install the units in parallel with the power distribution system. All cable lengths should be as short as possible for optimum suppressor performance.
5. Provide means for remote annunciation for each suppressor.

2.8 INSTRUMENTATION

A. General:
1. This Contract shall provide, install and test as an integral part of each TPSS, instrumentation as specified herein and as indicated on the Contract Drawings. All components and equipment shall be integrated into the TPSS as specified and shall be so assembled as to form a complete and operational system. Provide transducers, current transformers, potential transformers, protective relaying and associated meters and instruments.
2. As a minimum, provide the following instrumentation in each Substation:
   a. AC Switchgear:
      1) Provide an AC feeder voltmeter with selector switch to allow for phase selection, 1 for each feeder if dual feed.
      2) Provide an AC feeder ammeter with a selector switch to allow for phase selection, 1 for each feeder if dual feed.
      3) Provide a DPM for each incoming feeder.
b. Rectifier Transformer: Resettable drag pointer type instrument, measuring traction transformer winding temperature.

c. Rectifier:
   1) Rectifier output voltmeter.
   2) Rectifier output ammeter.

d. DC Switchgear:
   1) DC feeder voltmeter, 1 for each feeder.
   2) DC feeder ammeter, 1 for each feeder, protects the ammeters against reverse current flow.
   3) Monitoring terminals for negative busbar to ground voltage and negative drainage cable currents.

e. Substation Enclosure:
   1) Substation high ambient temperature detector.
   2) Thermometer.

3. Provide each instrument with test blocks to permit connection of portable recording and testing equipment.

B. Current Transformers (CT):

1. Provide Current Transformers (CTs) to accurately transform the system currents for metering and relaying. Select the CTs to satisfy the Referenced Standards for the accuracy classifications under the burdens imposed by the metering and protective devices.

2. CTs shall be multi-ratio or fixed ratio, epoxy-encapsulated, wound-type or bushing type as required by the final design and approved by the Authority.

3. Transformers shall be capable of withstanding the thermal and mechanical stresses imposed by currents equal to the specified switchgear momentary short circuit ratings.

4. Transformers shall comply with the requirements for C class relaying and 0.3 class-metering accuracy under the burdens imposed by the connected devices.

5. Provide current ratio as required by the final design.
   a. Provide 15 KV with BIL of 95 KV full-wave; or
   b. 600 volts with BIL of 10 KV full wave as appropriate.

6. Maximum allowable temperature rise under continuous full load above average ambient temperature of 55 degrees C:
   a. By winding resistance: 131 degrees F.
   b. By hottest spot in winding: 104 degrees F.

7. CTs shall be installed in a compartment isolated from the circuit control panel and high-voltage equipment except for primary connection bushings.

8. CTs and secondary wiring shall be protected from induced voltages by metallic shielding and shall be no smaller than No. 10 AWG. Terminate with ring type termination connectors.

9. CT secondary wiring terminal blocks shall have covers.

10. Secondary wiring shall be run to readily identifiable terminal blocks in the control compartment.

11. All CT secondary terminal blocks shall be furnished with an integral shorting bar.

12. Provide each CT with a mounting frame which bolts securely to the switchgear cubicle.

C. Potential Transformers (PTs):

1. Provide Potential Transformers (PTs) to accurately transform the system voltages for metering and relaying. Select PTs to satisfy the Referenced Standards for metering and relaying accuracy classifications under the loads imposed by the metering and protective devices.

2. Protect the primary circuits of all PTs by means of non-renewable cartridge-type fuses. Locate the primary fuses in rollout carriages equipped with disconnecting devices. Protect secondary circuits of all PTs by molded-case circuit breakers mounted in the cubicle control compartment.
3. PTs shall be molded rubber or epoxy-encapsulated, or an Authority approved equal.

4. PTs shall be Group 2 class for line-to-line or line-to-neutral connections as appropriate for the application and final design.

5. Primary voltage ratings and transformation ratios shall be as required by the final design.

6. Voltage transformers shall have an accuracy rating of not less than 0.3 class at the standard burden imposed by the connected devices.

7. Insulation class: 15 KV with BIL of 95 KV full-wave.

8. Maximum allowable temperature rise under continuous full load above average ambient temperature of 122 degrees F:
   a. By winding resistance: 86 degrees F.
   b. By hottest spot in winding: 104 degrees F.

D. Transducers and Converters:

1. Provide compact transducers and converters to convert input variables into proportional DC output signals within accuracy of no more than 0.1 percent. Select transducer and converter inputs to be compatible with the magnitude of the input variable.

2. Install the transducers and converters in a suitable enclosure.

3. Furnish 3 complete sets of transducer and converter test and calibration equipment made by the transducer and converter manufacturer. Supply calibrators for field-testing of the transducers and converters.

E. Instruments and Meters:

1. Meters, instrument and relay circuits shall be furnished, wired and connected as specified herein, and on the Contract Drawings. Provide additional components such as auxiliary relays, isolating diodes and similar devices that may not be indicated, but are required by the final design for an operable Substation.

2. Instruments and meters shall be designed, constructed, and tested in accordance with the applicable provisions of the Referenced Standards.

3. Instrument scales shall be calibrated to match the primary circuit current and voltage ranges.

4. The devices shall have 1 percent accuracy, taut-band suspension, switchboard type and a 250-degree scale.

5. Displays shall be approximately 4-1/2 inches square, with black lettering on a white background.

6. Instruments shall be metal-case, semi-flush types for panel mounting.

7. Instruments and meters shall be wired through suitable test switches.

F. Accessories:

1. Control and selector switches shall be rotary type.
   a. Switches shall have silver-to-silver contacts rated at 20 A and cam action or similar positive means for actuating contacts.
   b. All contacts shall be enclosed within easily removable covers.
   c. All switches shall have escutcheon plates.

2. Local control switches shall have heavy-duty pistol-grip handles and operation targets.
   a. Switch positions shall be “Trip-Close” with spring return to normal.
   b. Lights shall be furnished indicating, “Open” and “Closed” positions.

1) “Open” position of a circuit breaker or switch shall be indicated by an illuminated Green LED light.

2) “Closed” position shall be indicated by a Red LED light.

3. Selector switches shall have Tee handles:
   a. Switchgear control selector switches shall have “Local-Remote” positions.
b. Provide selector switches with LED indicating lights.
c. "Local" position of the switch shall be indicated by an illuminated White LED light.
d. "Remote" position shall be indicated by a Blue LED light.

4. A minimum of 2 separate isolated contacts shall be furnished for each selector switch:
   a. One contact shall be used for local control annunciation.
   b. In addition, the other contact shall be used for remote supervisory control annunciation of the "Local" position, as indicated.

5. AC Ammeter and Voltmeter Selector Switches shall have round knurled handles and:
   a. Shall indicate 4 positions (OFF-1-2-3).
   b. Provide nameplates for each position.

2.9 BUS AND CONNECTIONS

A. General. Contractor shall provide, install and test as an integral part of each TPSS, DC positive and DC negative busses. All components and equipment shall be integrated into the TPSS as specified and shall be so assembled as to form a complete and operational system. Provide:
   1. Positive Bus.
   2. Negative Bus.
   4. Cable Terminations.
   5. Lightning Arrestors.

B. Design:
   1. Provide a DC switchgear positive bus for the full length of the DC switchgear assembly.
   2. The bus shall be made of 98 percent conductivity electrical grade copper, and shall be fully insulated over its entire length with flame-retardant, nonhygroscopic, track-resistant insulation.

3. Bus and bus connections shall be of adequate strength to withstand thermal and mechanical stresses associated with short circuit currents as required by the Referenced Standards and the final design.

4. The DC bus overload rating shall be coordinated with that of the rectifier unit without exceeding the permitted temperature rise per Referenced Standards.

5. Bus connections, including bus taps, shall be silver-plated.

6. Each main bus joint shall have conductivity at least equal to that of the bus bar and each joint shall be constructed so that no loss of conductivity will occur during the life of the switchgear.

7. Connections to the bus shall be bolted.
   a. Bolts shall be cadmium-plated, galvanized, or similarly coated, high-strength steel, and of sufficient number and size to provide solidly bolted connections.
   b. Provide Bellville washers, bolts and washers as necessary for joining of shipping sections.
   c. Provide (if required) as part of the spare parts for each Substation, a torque wrench and other equipment as necessary for joining sections.

C. Ground Bus:
   1. A copper ground bus, not less than 2 inches wide by 1/4 inch thick, shall extend the length of the switchgear.
   2. In each switchgear unit, where power busses enter or leave the switchgear at the top, a copper ground bus, not less than 1 inch by 1/8 inch, shall be extended from the main ground bus up to the top of the unit.
   3. All joints in the ground bus shall be made with a minimum of 2 bolts.
   4. Bolted joints shall be silver-plated.

D. Bus Transition Units:
1. Bus Transition Units (if required) shall be provided as required by the final Substation design.

2. All transition units shall be full height with front and rear bolted panels.

3. Front panel shall be in line with those of the adjacent switchgear sections.

E. DC Control Power Bus:

1. Control power for the switchgear will be obtained directly from the DC Battery/Battery charger. The closing coil circuit for each circuit breaker shall be fused and the trip coil shall not be fused. Provide 2 separate Control Busses, 1 for the AC Switchgear and 1 for the DC Switchgear.

2. At each circuit breaker cubicle, a white LED indicating light shall be provided indicating DC control voltage is present.

3. A 125 VDC control power bus with 1000 VAC insulation shall be furnished the full length of the DC Switchgear assembly and shall be used for circuit breaker control and operation. The bus shall be terminated on a terminal block at each compartment for connection to the circuit breaker control. A single conductor negative bus with 2,000 VDC insulation shall be furnished the full length of each switchgear assembly. Control power for the switchgear will be provided from the DC battery/charger.

4. A double-pole, pullout fuse block shall be provided at each circuit breaker compartment. The device shall effectively isolate the operating mechanism from the control bus. The closing coil circuit for each Circuit Breaker shall be fused and the trip coil shall not be fused. A white LED indicating light shall be provided at each circuit breaker cubicle indicating DC control voltage is present.

5. Each DC compartment shall be provided with a control power voltage-monitoring relay connected to the load-side terminals of each pullout fuse block. Relay shall be set to drop out at 90 VDC and shall initiate local and remote supervisory annunciation.

6. If required an AC control power supply with 1000 VAC insulation shall be provided for operation of protective devices and voltage transducers. Solid-state type inverters shall be used to achieve this requirement. The inverter protection device contacts shall be wired to the local Annunciator panel and to the supervisory annunciation. A voltage-monitoring relay shall be provided at each compartment requiring an AC power supply, which shall initiate local and remote supervisory annunciation. The relay shall be set to drop out at 85 percent of the nominal voltage level.

7. All control wiring shall run in a protective raceway. The raceway shall open to the side or top, not from the bottom.

F. Cable Terminations:

1. Contact feeder cables, negative cables and drainage cables shall enter through the bottom of the switchgear. Provisions shall be made to accommodate the number and size of specified feeder cables. Ample cubicle space and bus contact surfaces shall be provided for pulling and terminating the cables entering or leaving the DC and AC switchgear.

2. Each DC circuit breaker assembly (load side) shall have adequate space for termination of the “positive” power feeder cables; provide provisions for a maximum of three 750 KCMIL feeder cables per circuit breaker and connections for surge protection.

3. For the DC negative return cables provide bus connections for an equal number of negative return cables as positive feeder cables.

4. Provide for drainage cable connections as required by the final design.

5. Provide necessary means for supporting and connecting the cables at the incoming terminals.

6. Cable-entry cover plate(s) shall be bolted and removable to permit field drilling for conduit entry.

7. DC busbars shall be sized and drilled for the load and service cables, provide standard NEMA 2-hole or 4-hole lug spacing, provide bus connections rated not less than 194 degrees F. Provide termination connections, hardware, bolts, nuts, washers, etc., for mounting and terminating all DC cable. Coordinate cable size and number of cables with the TPSS Installation Contractor for each TPSS location.

8. AC incoming busbars shall be pre-drilled for standard NEMA 2-hole and 4-hole termination. Mounting hardware,
terminations and cable shall be performed during installation.

G. Space Heaters:
1. Each switchgear assembly shall be furnished with front and rear space heaters. Provide a thermostat and humidistat control for each unit.
2. Each cubicle shall be equipped with a 2 inch AC ammeter, appropriately scaled to monitor each space heater(s) current.
3. Provide space heaters that are humistatically controlled.
4. Provide the quantity and capacity required to maintain the humidity and temperature inside the equipment enclosures to 20 percent above any anticipated dew point temperatures for the ambient conditions indicated.
5. Space heaters shall be designed for continuous operation by 120 volt or 240 volt, 60 Hz, single-phase power.

H. DC Surge Arrestors:
1. Provide an intermediate type surge arrester for each outgoing DC feeder circuit.
2. Surge arrests shall be of the metal oxide type. Arrestor selection shall be based on line to ground maximum continuous operating voltage (MCOV).
3. Each surge arrester shall have an energy discharge capability of 2.6 kJ/kV for currents of less than 500 amps.
4. Provide type MCOV, 1280 V, Model No. 6007 as manufactured by SMC, or an Authority approved equal.
5. Each surge arrester shall be individually grounded to the station DC ground mat.
6. Each grounding connection shall have a grounding resistance of 5 ohms, less, or as specified by the surge arrester manufacturer for the type of unit supplied.
7. Surge arrestors shall be:
   a. Rear compartment-mounted, indoor style.
   b. Arrestors shall be suitable for connection to a 750V DC power supply for protection of the DC power switchgear against lightning surges.
   c. Arrestors shall have a minimum continuous operating voltage of 1280 volts. Maximum peak break over and residual voltage values shall be coordinated with the dielectric withstand voltage characteristics of the switchgear bus and circuit breaker insulation structure, as well as the maximum arcing voltage produced by the DC circuit breakers during interruption.
   d. Cable connection between the surge arrester and the load-side of the feeder circuit breaker shall be kept as short as possible and sufficient clearance from any metallic parts shall be maintained.
   e. Cable connection to the surge arrester shall be taped or insulated to 4 times rated voltage.

I. Ground Bus:
1. DC switchgear shall be furnished with an isolated insulated low resistance copper ground bus for directly connecting the surge arrester ground terminals.
2. Each end of the ground bus shall be provided with terminal lugs suitable to accommodate 2 No. 2/0 AWG grounding insulated copper cables for connecting to the substation DC grounding system.

2.10 TRANSFER TRIP DEVICES

A. General:
1. Contractor shall provide, install and test as an integral part of each TPSS, transfer trip devices. All components and equipment shall be integrated into the TPSS as specified in these Specifications and shall be so assembled as to form a complete and operational system. Provide:
   a. Transfer trip relays as described herein.
   b. Factory testing.
   c. Field test procedures.
   d. Field testing (including station-to-station interface).
2. In the Authority’s Traction Electrical System there shall be a DC breaker
assigned to each power section and power shall be applied to each track in each direction by a separate breaker.

3. If a single breaker detects a fault, the faulted breaker shall remotely trip any other breaker(s) feeding the faulted section. Tripping all breakers feeding a section shall remove the possibility of a sustained fault.

4. To ensure the tripping of all breakers connected to the faulted section during contingency power supply conditions; the transfer trip circuits shall be capable of being locally and remotely configured.

5. Transfer trip relays shall be furnished and installed for all DC mainline feeder breakers for each Substation supplied under this Contract.

6. Interface new TPSS’s to transfer trip feeder breakers at adjacent existing Substations. Provide fiber optic RTU at existing Substations as required for transfer trip implementation between existing and new TPSS’s.

B. Testing:

1. Contractor shall be responsible for furnishing, installing, factory testing and field testing the transfer trip system for all new and modified Substations, this shall include interface with existing Substations.
   a. Contractor shall supply the supervision and shall retain the responsibility for the Field Testing of the Transfer Trip Scheme until accepted by the Authority.
   b. All field interface coordination and correctional work (if required) shall be by the Contractor.
   c. Contractor shall test the operations of the transfer trip system from each SCADA/RTU to the adjacent Substation upon completion of the communication system and prior to Final Acceptance.

2. Transfer tripping system will use the SCADA/RTU and fiber optics communication network as the means for transmitting transfer trip signals to adjacent Substations.

3. A test plan for field-testing shall be submitted as part of the “Acceptance and Verification” testing plan.

2.11 EMERGENCY SHUT DOWN

A. General:

1. As a safety feature, each Substation shall be equipped with 3 emergency trip stations. One button is to be recessed in a stainless steel enclosure mounted on the exterior wall and accessible by key only. The second and third button are to be located inside the Substation by each access door. Actuation of any pushbutton will trip and lock out the 15KV AC breaker and all DC circuit breakers and transfer trip and lock out the associated DC breakers at the adjacent substations, thus completely isolating the fault or trouble.

2. Provide an emergency shutdown scheme consisting of:
   a. Interior emergency trip stations (2 required).
   b. Exterior emergency trip station (1 required).

B. Installation:

1. Connect the emergency trip stations to provide a loop circuit of contacts wired in series, which shall de-energize a summary relay. Interruption of the series circuit shall cause the Substation to shut down by:
   a. Tripping and locking out the main AC circuit breaker.
   b. Tripping and locking out all DC circuit breakers.
   c. Transfer tripping and locking out the corresponding circuit breakers at adjacent Substations to achieve de-energization of the distribution system conductors.

2. Use heavy-duty, industrial grade, pushbutton operators and contact block with a large, red, mushroom shaped actuating head.

3. Design the pushbuttons so that a Substation that has been taken "off-line" by the Emergency Trip Scheme cannot be re-energized locally or from SCADA system unless the system has been manually reset.
2.12 LOCAL ANNUNCIATOR AND SUPERVISORY CONTROL REQUIREMENTS

A. General

1. Contractor shall provide, install and test as an integral part of each TPSS unit, Local Alarm Annunciation and Remote Supervisory Control and Indication Functions. All components and equipment shall be integrated into the TPSS as specified herein and shall be assembled to produce a complete and operational system. Provide:

   a. Local annunciation panel.
   b. SCADA/RTU.
   c. Thyristor rectifier alarms.
   d. CIC

2. The supervisory design requirements for the TPSS shall be for use in unattended remote Substations.

3. Final design shall use processors in the master station (existing) and in the remote stations. Contractor shall interface the new TPSS Supervisory System with the existing Authority’s Master Station.

B. Submittals Requirements

1. Submit the following as part of the submittals specified in this section and elsewhere in the Contract Documents:

   a. Connection, interconnection, elementary and internal layout drawing complete with power input points and test points.
   b. Operations and equipment reference manuals.
   c. RTU I/O memory address assignments listing.
   d. Spare part listing and parts bulletins.
   e. Program listing (e.g., ladder logic listing), of all resident software in hard copy and electronic formats.
   f. Functional requirements document consistent with the format in the Referenced Standards.
   g. SDD shall be consistent with the format specified in the Referenced Standards.
   h. SVVD plan shall be consistent with the format specified in the Referenced Standards.
   i. A complete list in table form of all control and indication points for the local annunciation and the SCADA/RTU unit inclusive of all spare points.

C. Local Annunciation:

1. Provide and install a local annunciator panel for each new TPSS, provide alarms and status indication as specified herein and as required by the Referenced Standards. The minimum circuits shall be as indicated herein and on the Contract Drawings.

2. Each annunciator shall have a 17 inch High-Brightness TFT LCD touch-screen annunciator panel with speakers to visually annunciate TPSS equipment status and alarms and audibly annunciate alarms: Provide Technoland TL-PPC 170S478 or an Authority approved equal.

3. General Requirements:

   a. Provide an annunciator system designed to provide status information of discrete signal contacts and provide interface and monitoring of analog devices. Annunciator window arrangement and designations shall be per the approved Contractor’s annunciator drawings and submittals. Annunciator’s internal clock shall be synchronized with the SCADA/RTU’s internal clock.

   b. The basic annunciation system shall comprise of:

      1) Chassis or cabinet.
      2) Point cards.
      3) Light box displays.
      4) Flasher box displays.
      5) Digital time display.
      6) Push-buttons.
      7) Audible devices.
8) Power supply.

c. Factory tests shall be performed on each complete annunciator panel assembly in accordance with the application requirements given in the Referenced Standards and these Specifications.

d. Annunciator visual display assembly shall be flush mounted on a metal enclosure and shall be front accessible.

e. Annunciator point requirements and configuration shall be as indicated on the Contract Documents and as required by the final design.

f. Annunciators shall be of the integral logic type to include visual displays solid-state logic circuits in one assembly.

g. Annunciator shall have screen saver capability, which automatically shows the annunciator windows when the light switch is on.

h. Sequence logic circuits shall be of the plug-in type and may be combined with the visual display windows and lamps.

i. Annunciator shall be designed for an ISA sequence designation "A", without audible alarm device.

j. Annunciator and accessories shall be housed in a metal enclosure complying with NEMA ICS 6, Type 12 enclosure and shall be provided with a hinged front panel with lockable handle and 2-point latches minimum.

4. Annunciator Operation:

a. Each annunciator point as indicated herein and as indicated on the drawings, shall be designed for operation from either a normally open or normally closed field contact.

b. When a field contact operates from a relay function (trip condition), the associated annunciator point logic sequence shall assume lock-in alarm or indication state and initiate a flashing visual display if this status is other than normal. If the field contact is closed by normal operating procedure, the associated annunciator point shall be indicated by a steady display.

c. When the trouble signal is "Acknowledged" at the local annunciator panel, the visual display shall assume an "On" state. Then the field contact self-resets or is manually returned to its normal condition, the visual display shall automatically return to an "Off" status, and the logic sequence reset to a "Normal" state.

d. Annunciator logic sequence shall be capable of accepting and displaying multiple trouble signals simultaneously or in sequence.

e. Operation of the "Lamp Test" feature shall initiate an operational test of the logic sequence and visual display of all annunciator points. Operation of the "Lamp Test" shall not activate alarms to the SCADA system.

5. Relays:

a. Annunciator sequence logic relays shall be hermetically sealed plug-in type.

b. Coordinate the annunciator field contact voltage and logic relay minimum operating current with the type of field contact that is furnished.

c. Each annunciator point logic device shall be provided with an electrically isolated normally open and normally closed repeater contacts, rated at not less than 100 milliamperes resistive current at 125 VDC. Contacts shall be used for initiating equipment trouble signals to the SCADA/RTU equipment through the communication interface terminal cabinet if duplicate alarms are specified.

d. Power removal to the annunciator cabinet shall not result in repeater alarms being reported to the RTU.

6. Display Windows:

a. Separate inscribed display windows shall be furnished for each annunciator point. Windows shall be sized to accommodate 4 lines of
inscription with a 1/4-inch character height.

b. Windows shall be snap-on type, fabricated from translucent plastic and back illuminated by 2 lamps.

c. Annunciator points that indicate substation alarms resulting from a tripped condition shall have a red lens; all other lenses shall be white.

d. Verify individual circuit window designations with the Authority prior to fabrication. DC circuit feeder designations shall be provided by the Authority.

7. Power Supply:

a. Annunciator shall be designed to operate on a 125 VDC control power. Power shall be provided from the Substation DC power panel.

b. Power supply shall be supervised by a voltage detector, which shall initiate remote supervisory annunciation on loss of supply, by a circuit to the supervisory control interface terminal cabinet.

8. Accessories:

a. Push buttons:

1) Annunciator assembly shall be furnished with push buttons for "Acknowledge" and "Test" initiation of the logic sequences.

2) Push buttons shall be flush mounted, color black, heavy-duty and oil tight complete with identifying nameplates of black-face, white-core, engraved laminated plastic.

b. Power Disconnect Switch: Panel shall be furnished with a control power disconnect switch and a "Power On" indicating light. Indicator shall be flush mounted with white translucent lens.

c. Terminal Blocks: Panel shall be furnished with sufficient terminal blocks for wiring to every annunciator field contact and annunciator point logic relay repeater contact, plus 20 percent spare terminals.

d. Four spare windows and I/O cards shall be provided with each annunciator panel.

D. SCADA:

1. Each TPSS shall contain a SCADA that shall interface with the Authority’s existing SCADA/RTU system.

2. The AC switchgear assembly, TRU, and DC switchgear assembly shall be equipped with the necessary devices to provide control, status and alarm indications to the SCADA.

3. Contractor shall install and test all wiring from the rectifier control panel, switchgear assemblies and TPSS accessories to the CIC, SCADA RTU.

4. Additionally, provide a minimum of two (52a) and two (52b) auxiliary contacts, wired to the CIC, for each circuit breaker for future use.

5. Each Substation assembly control circuit status indication circuits and alarms shall be equipped with 24VDC interposing relays for SCADA control and indication.

6. The control, alarm points and status indication requirements shall be as indicated herein and on the Contract Drawings.

E. Remote Terminal Unit (RTU):

1. Contractor shall furnish for each TPSS a RTU to interface the Substation and the existing DART SCS. The existing SCS is based on PC equipment operating in a TCP/IP LAN environment under Windows 2003. The middle-ware is Tecnomatix's Factory Link (version 7.1).

2. General:

a. Provide a PLC system to control, protect, and monitor the operation of the Substation equipment and establish an interface with the SCS. Include in the PLC system all the necessary hardware, software, and diagnostic equipment to ensure an operational and coordinated system. The RTU shall be a self-contained PLC type.
b. Program the RTU specifically for the TPSS application. Use the RTU's to integrate the following functions into a single, high-speed Central Processing Unit (CPU):

1) Relaying logic including:
   a) Reclosing.
   b) Transfer trip (all adjacent Substations).
   c) Other associated logic.

2) Electrical interlocks.

3) Substation annunciation.

4) Substation control.

5) SCADA.

c. RTU shall be fully compatible with Allen-Bradley, SLC 5/05 series or better (model numbers 1747-L553, 1747-M13, 1746-B32, 1746-A10 and all required ancillaries and adaptor socket).

d. RTU's shall have the manufacturer's latest stable firmware revision compatible with the existing system. Future firmware upgrades shall be required if the manufacturer corrects known issues, or defects which are relevant to the Authority's operational system.

e. RTU shall be self-contained units capable of collecting data through dry relay contacts from Substation equipment and devices, and reporting that status to the master station by using the "polled report-by-exception" method.

f. RTU shall be capable of carry out the commands it receives from the Master Station and provide control outputs through interposing relays of momentary and timed duration.

g. If the 86-lockout relay is activated, the RTU shall not accept any closing commands from OCC. Only after the lockout relay is reset, may the RTU accept a closing command. The AC main breaker shall not immediately close after the 86-lockout relay is reset.

h. Contractor shall be responsible for ensuring that the RTU programmable instruction set, character transmission format, protocol and command set are compatible with the existing Authority's SCADA/RTU system.

i. RTU shall be of programmable design with stand-alone restarting capability.

j. Contractor shall install and activate codes and programs as necessary for the RTU to boot and establish communications with the Authority's SCS. Field interface with the existing Authority's OCC is the responsibility of the Contractor. All IP addresses for the SCADA interface will be provided by the Authority.

k. All program/data table memory information shall be resident in non-volatile type memory (i.e. EEPROM).

l. All information shall be coordinated with the Communications Central Contract to ensure compatibility with the SCS.

m. RTU configuration, database definition, algorithms, and program parameters shall be downloadable from the SCS. RTU's shall be capable of being initialized by a single command from the SCS.

n. A power failure restart indication shall be reported to the SCS after recovery from a power failure so that any necessary initializing and downloading may be initiated by the SCS.

3. Bitmap Delivery Dates:

a. Provide TPSS RTU software programming information "bitmap" to include the status of each control and indication point. Bit nomenclature shall be consistent with that of the local CIC. Spare or unassigned bits shall be labeled as spare. Additionally, provide ladder-logic programming and information of any functions provided by the RTU, e.g. transfer trip function, or safety related functions.
b. For all Substations in each Line Section listed below, the Contractor shall furnish to the Authority the Substation RTU “bitmap” data, in accordance with Specification Section 16868 SCADA RTU Subsystem – Communications System.

4. Processor:
   a. RTU processor shall support the following communications options:
      1) Ethernet (10Base-T).
         a) 10 Mbps communication rate.
      b) ISO/IEC 8802-STD 802.3(RJ-45) connector for 10Base-T media.
      c) TCP/IP Communication protocol and built in isolation.
      d) SNMP support Optional dynamic configuration using BOOTP utility.

b. Program Memory Modules:
   1) The CPU user configurable memory shall be used to store program. The size of the CPU memory shall be minimum of 64K with battery backup on the circuit board.
   2) Each RTU shall be equipped with Flash EPROM, with minimum memory of 64K, for memory backup.

5. Components:
   a. All electronic components shall be mounted on a chassis with plug-in printed circuit cards or modular subassemblies. All printed circuit boards of the same model number shall be identical.
   b. Printed circuit boards shall not include or require tack-soldered components (i.e. not mounted in locations with plated through holes or in sockets) on the boards for “tuning” or “timing” purposes.
   c. Printed circuit cards and modules, which contain modifications accomplished by the removal of printed circuit leads and corrected with wired replacements, are not acceptable.
   d. All interconnecting cables shall have keyed housings or contact pins to ensure correct mating of connectors and prevent damage from improper connection. All connectors shall be clearly marked for reconnection (P1-J1, P2-J2, etc.).
   e. Gold-plated contacts shall be provided for all printed circuit cards and multi-pin connectors.
   f. Each printed circuit card and subassembly shall be model and serial numbered to uniquely identify it.
   g. All point inputs and outputs, communication inputs, and power supply inputs shall pass the tests as required by the Referenced Standards.

6. Discrete I/O Modules:
   a. RTU shall be equipped with minimum of 3 input modules and a minimum of 2 output modules with a density of 32 points each. Contractor shall leave a minimum of 40 percent spare points on the modules.

7. Design Requirements:
   a. Logic functions shall be implemented to receive data from and transmit data to the interface device or modem, perform address decoding and error checks, and transfer data to and from the point input/output logic.
   b. To allow for future changes in communication channel configuration, all RTU’s shall have strapable or switch selectable hardware addresses.
   c. In conjunction with the other RTU logic elements, the following functions shall be performed:
      1) Respond to commands for retrieving data.
2) Provide select-acknowledge-execute logic sequence for relay control commands. After a point is selected, a check shall be made from the final stage of the output circuitry for the re-encoded check back message. Merely transmitting the received point selection code will not be acceptable.

3) An acknowledgment of receipt and activation of the relay execute command shall be sent to the SCS after a control operation is performed.

4) Prevent selection of more than 1 control point in a command sequence by:
   a) Inhibiting interposing relays from inadvertently being energized during the initial power up period of the logic, because of failed communication, or any other anomaly.
   b) Protecting against a missing or failed logic card or assembly from causing an invalid operation, damage to other logic, or false transmission to the SCS.
   c) Protecting against over/under voltage conditions from the Authority's power source and the Contractor's power subsystem from causing an invalid operation, damage to logic, or false transmissions to the SCS.

5) Scan intended logic for data in 50 milliseconds or less.

6) Respond to request from the OCC within 50 milliseconds (i.e. from the receipt of the first bit in the request word until the acknowledged message is complete).

7) Respond to a change in an external device such that the time from the recognition of the change to the transmission of the first bit in the RTU-OCC packet shall be 100 milliseconds or less.

8. Operation:
   a. RTU shall operate continuously with specified performance and without reduction in equipment life under the operating temperatures and humidity as specified in the Contract Documents.

9. Communications Interface:
   a. Traction Electrification System (TES) shall be interfaced to the existing SCS via the TPSS RTUs. RTUs shall be interconnected to the Ethernet port via fiber optic cable and associated media converters. RTU shall communicate with the SCS through one of the supported Factory Link protocols. Contractor shall verify with the Authority and the Communications Contractor the interface protocol and hardware requirements for communications interface.
   b. Furnish and install media converter(s) or Ethernet switch to link the RTU(s) with the nearest communication facility. Provide 24VDC or other backed-up power to power the media converters or switch.

10. RTU Communication Logic:
   a. RTU communication logic shall perform the following functions:
      1) Synchronization pattern recognition and generation.
      2) Serial-to-parallel and parallel-to-serial conversions.
      3) Error-check encode and decode.
      4) Decoding and processing of incoming messages.
5) Assembling reply messages.

b. RTU communications to Central shall be over TCP/IP.

c. RTU shall be configured for data error check (CRC or BCC) and retransmission.

11. Communication Line Interface:

a. After delivery of the TPSS to the job site, the TPSS Installation Contractor will furnish and install a fiber optics patch panel, a SCADA Media Converter will link the RTU(s) with the nearest Communication facility. Contractor shall interface with the SCADA system.

b. Contractor shall provide space in the TPSS for the Communication furnished equipment. Contractor shall also provide conduit and raceways as indicated on the Contract Drawings for connection of the equipment to the RTU’s.

12. Indication Inputs:

a. Both form “a” (N.O.) and form “b” (N.C.) relay contacts shall be provided to represent status and alarm indications to the RTU’s. The RTU’s shall detect the states of these contacts by applying a contact sensing voltage generated in the RTU and isolated from the logic voltage. A logic output representing either a 1 or 2 bit word shall be provided according to the requirements identified herein and on the contract drawings.

b. The minimum current through closed contacts shall be 2 milliamperes. The maximum allowable contact sensing current shall be 20 milliamperes. The maximum resistance of the external indication circuit, when closed, shall be 1000 ohms. The minimum resistance of the indication circuit, when open, shall be 50,000 ohms. Contact wetting voltage shall be provided by an isolated power supply in the RTU.

c. RTU shall provide optical isolation between the field contacts and the RTU electronics. Contractor shall provide 2 terminals per point for connection of the field wiring. Common termination points for field-wiring inputs are not acceptable.

d. Each indication input shall include hardware input filtering to eliminate contact bounce or voltage transient signals of less than 8 milliseconds from being detected and processed by the RTU as a valid alarm or change of state. Additional input signal processing and verification shall be provided by the RTU firmware, which combines the detection of more than a single input sample to confirm the state of the input contacts.

e. The number of sample counts used to determine a valid input shall be changeable in firmware as one number for all indication inputs and shall be set to guarantee that an on or off signal that is present for a minimum of 10 milliseconds is detected as a valid alarm or change of state.

f. Each RTU shall have the capability to interface to either of 2 types of indication inputs to be monitored and processed by the RTU, as follows:

1) Two-State: consists of inputs which change state at a rate slower than the SCS poll intervals. The state of the input at the time of the SCS poll shall be reported to the SCS.

2) Two-State with Momentary Change Detection: consists of inputs which may change state more than once between the SCS polling scans. Therefore, a buffer shall be provided which is set when any changes are detected between scans. The condition of this buffer, plus the on/off state of the input at the completion of input processing, shall be reported to the SCS. The change- detect buffer shall not be reset until the SCS has confirmed the receipt of the reported changes by sending an acknowledge message to the RTU.
13. Control Output Requirements:

a. All control outputs from the RTU shall follow the check back-before-operate procedure wherein a selection message is sent to an RTU, stored and decoded down to the drive circuits or interposing relay, re-encoded from those same drive circuits or point select relay, transmitted back to the SCS, and verified at the SCS before any command of execution ("open", "close", "execute", etc.) is sent.

b. Two full transactions shall be required for a control output to occur under this check back-before-operate requirement. Any control scheme, in which a single message with undetected errors can cause a false command, shall be unacceptable. All logic and point selection shall be reset with the reception of a "reset" function, receipt of any command other than an execute command following a valid point selection, time out of the control function timer, or power failure restart.

c. Control outputs shall have individually adjustable time duration for closure, with time ranging from 0.1 seconds to 15 seconds.

d. Control output drive circuitry shall be designed such that a single component failure in the RTU does not cause an invalid operation (uncommanded or wrong operation).

e. A front panel mounted “Master” local/remote selector switch with a white LED indication lamp shall be provided with each RTU.

   1) Switch shall inhibit the remote close and trip control of all AC and DC circuit breakers when the switch is in the local position.

   2) A normally open contact of the switch shall be wired to the RTU to initiate remote supervisory indication when the switch is transferred from remote position to local position.

f. Contractor shall supply interposing relays with single isolated, form "C" contacts rated to make and carry 2 amps at 24 VDC or 5 amps at 120 VAC (1/3 H.P.). Coil surge suppression diodes shall be provided as required. All control output relays shall be plug-in type, general purpose with clear polycarbonate dust covers or solid-state devices. Hold-down devices or springs shall be provided for all relays.

14. Coordination:

a. Contractor shall be responsible for the transmittal of RTU program/data table memory assignments, character transmission formats and the RTU data port configuration to the Authority in strict accordance with the submittal requirements to allow adequate time to coordinate with the Communications SCADA software design.

b. Contractor shall ensure that the RTU is fully addressable to/from the Authority's SCS.

   1) If a software/firmware mismatch is discovered by field testing during or after factory testing of the RTU's, the Contractor shall be responsible for modifying the program/data memory assignments, point address assignment and or data port configuration, necessary to establish 2-way addressable communication with the SCS.

   2) Contractor shall be responsible for coordinating the transmittal of program/data table memory assignments and character transmission formats.

15. Terminal Blocks and Wiring:

a. In order to accept substation field wiring, terminal blocks shall be provided within the RTU enclosure. These terminal blocks (and all interposing relays) shall be stationary within the enclosure and not mounted on swing-racks or doors. Terminal blocks shall be sized to accommodate No.22 - No.24 AWG field wiring.
b. Terminal blocks shall be Allen-Bradley, Finger-Safe type 1492-HM2V24 with voltage indicating LED's or an Authority approved equal, and shall be grouped by like point type within the RTU enclosure.

c. Each terminal block and each terminal shall be uniquely identified and readable by the Authority's maintenance personnel. All terminals to which the power supply voltage is connected shall be provided with protective covers.

d. All wire connections between any moving part such as a swinging door and a stationary part or object shall be stranded wire wrapped with a cable harness protector.

e. All wiring shall be of suitable gauge and insulation to meet the intended use. Installation of this wiring shall be such that no tension is exerted when moving parts are exercised.

f. Input and output signal wiring and power wiring shall be kept physically separate from RTU logic wiring. Low voltage field wiring shall also be separate from control wires and AC power wiring. Internal wiring shall be installed in wire harnesses or wire duct.

g. Wires and cables (signal and power), shall be color-coded and suitably labeled for identification. All wire and cable connectors and terminations shall be permanently labeled for identification and shall be mechanically keyed to prevent improper connection.

h. All connection points for external cables and wires shall be easily accessible for connection/disconnection and shall be permanently labeled.

i. All wires shall be appropriately terminated.

16. Internal Layout:

a. All components including the programmable controller, terminal blocks, power supply, etc., shall be fixed mounted on a nonconductive back plate.

b. Nameplate: Cabinet shall be labeled "SCADA / RTU" using a 4 inch high, blackface, white-core, engraved laminated plastic nameplate. Lettering shall be 2 inch high Gothic font.

17. RTU Mounting Requirements:

a. All RTU's shall be wall mounted and accessible by maintenance personnel.

b. RTU shall be mounted in a chassis (such as the Allen Bradley model number 1746-A10 or an Authority approved equal) with minimum of 10 slots or larger to provide a minimum of 2 slots for future additions.

18. Power Subsystem:

a. RTU shall operate from the 125 VDC Substation battery power panel. Internal DC-DC converters shall be supplied to provide reliable, filtered 24 VDC power.

1) Provide a dedicated 24VDC power supply and terminal block.

b. RTU power subsystem shall convert power as necessary to operate the RTU and distribute it to the sub-assemblies as required. The RTU's power subsystem shall conform to the following requirements:

1) Indicating lamps shall be provided which light only if the rated output of each voltage is present.

2) Provide over-voltage and under-voltage protection on the power supply outputs to prevent the RTU logic from being damaged due to component failure in the power supply, or from becoming unstable and causing invalid operations.

3) When the protection operates under normal conditions (no component failure) the output shall go into a current limiting mode and no source or output circuit breakers shall trip
4) Short circuit protection shall also be provided on the outputs. When the cause of the short circuit is removed, the output voltage shall return to normal.

5) Failure of the DC input source shall not cause any damage to the power subsystem.

6) Provide isolated power sources to interrogate status contacts.

c. Power distribution shall include disconnect switches or breakers such that all external power entering the RTU can be interrupted before it is distributed in the RTU. It shall be possible to repair/replace any of the RTU modules in a completely powered down state by interrupting power at these switches or breakers.

19. Battery Operation:

a. When the RTU is operating on substation battery power, all RTU functions shall continue to operate normally as the battery voltage deteriorates.

b. Before the battery voltage falls below the threshold of error free RTU operation, the RTU shall terminate all application functions, set a battery fail flag on the next reply to a scan from the SCS, followed by a complete power down of the RTU.

20. Grounding:

a. All equipment shall be adequately grounded to safeguard all personnel from shock hazards, and to provide noise elimination.

b. RTU assembly shall be grounded in accordance with the Contract Drawings and vendor recommendations to limit impact of possible EMI noise.

21. Equipment Replacement and Backup:

a. Provide a safe means for maintenance personnel to disable power to input/output circuits. The power –disabled state shall be indicated locally.

b. RTU shall provide for safe I/O card and communication module replacement. Upon replacement and power-up, self-tests shall automatically be initiated, and the RTU shall notify the SCS of the replacement. Self-testing shall include verification that the I/O configuration of the replacement card matches the previous I/O configuration.

c. Training:

1) Contractor shall provide training for the SCADA and RTU systems, this training shall be in addition to the training specified elsewhere in the Contract Documents. Provide:

a) Four 8-9 hour training sessions for RTU procedures.

b) Training booklets and materials for 8 personnel per session.

c) Training will be at the Authority’s facilities.

F. Thyristor Rectifier Alarms:

1. Visual and electronic relay alarms shall be provided to indicate failure of any element critical to the operation of the system.

2. Rectifier:

a. In addition to the control functions and alarm points as specified elsewhere in this Contract, the Contractor shall design the thyristor control system to provide fault signal control and indication logic which belong to one of the following fault and failure groups, provide both local and remote indication:

1) Thyristor Rectifier Fault 1: Rectifier not ready for operation, Cathode Breaker not closed, invalid test mode - electronics, TPSS air
2) Thyristor Rectifier Fault 2: Rectifier trip resulting in opening of AC and DC main breaker; all DC feeder breakers remain closed. AC main breaker may be reclosed or reset from SCADA if required. Rectifier control panel must be evaluated and the problem corrected to restart thyristor. Alarm conditions consist of TPSS air overtemp trip, emergency stop, low battery, blower failure, low air pressure, blower overtemp, bridge overcurrent, ripple fault, regulation fault, thyristor overtemp, AC line under voltage, DC current unbalance, DC short circuit – load, DC voltage unbalance, ON sequence time-out.

3) Thyristor Rectifier Fault 3: Opens AC and DC Main breakers. Feeder breakers remain closed. Rectifier over-temperature trip (Dev 26RH), Transformer over-temperature Trip (Dev 49th), Rectifier door open (Dev 33) and thyristor failure relay (Dev 98T).

4) Thyristor Failure Stage 1: (98A), No more than 1 thyristor per bridge fails.

5) Thyristor Failure Stage 2: (98T), More than 1 thyristor per bridge fails. The 86H lockout trips, 52 AC circuit breaker opens, and 72 DC main circuit breaker opens.


7) Thyristor Rectifier Overtemp Stage 1 (26R1): Annunciation point is activated when the thyristor temperature is higher than 85 degrees C.

8) Thyristor Rectifier Overtemp Stage 2 (26RH): Annunciation point is activated when the thyristor temperature is higher than 95 degrees C. The 86H lockout trips, 52 AC circuit breaker opens, and 72 DC circuit breaker opens.

9) Thyristor Rectifier Control Power Loss: Loss of DC control power or computer fault within thyristor rectifier - A trip signal is sent to the 86H lockout relay in an attempt to trip the incoming AC breaker and DC main breaker. If there is 125 VDC control power available, the lockout relay and circuit breakers will trip.

10) Thyristor Door Open (33): One of the thyristor compartment door limit switches has operated or failed. The 86H lockout relay trips, 52 AC breaker and 72 DC main breaker opens.

11) Negative Disconnect Switch Open: Negative disconnect switch open, local annunciation provided and initiates thyristor rectifier Fault 1.

12) DC Negative Over Voltage: DC negative over voltage annunciates when the running rail voltage increases above the set point of the negative rail-monitoring device.

13) NRGU Lockout (Closed): If the running rail potential rises above the set point (50 to 100 V) and the potential rise is not static, the pursuing current flow closes a contactor, grounding the running rail to earth ground and requires manual reset.

Test points for measuring DC current, voltage and other programmable analog signals shall be provided on the front control panel of the thyristor.
4. All functions in the control cubicle shall be integrated in a microprocessor based control system such as a PLC.

5. Thyristor control system shall incorporate control and indication points as necessary for a fully operation system.

6. Digital control system shall be equipped with enough memory and processor speed to store electronic data for annunciation and retrieval of up to a minimum of 100 past faults, each date and time stamped, which could be downloaded to a customer printer or computer. Time and date data shall be received by the OCC via SCADA once each day. In addition, the memory shall store the negative rail max voltage and max current and for the last 25 times the NRGU activated with time and date stamp. In addition, the memory shall store 24 hours of negative drainage current values at 10 second intervals with time and date stamp, then start re-writing the data.

7. For communicating with the thyristor digital control system, RTU’s, protection relays, and DPM, provide 4 new commercially available, personal notebook type computers (latest Intel processor, or equal,) with:
   a. Latest MS operating software (operating and equipment specific).
   b. 256 MB of RAM and 20 GB hard-drive.
   c. All required application programs to communicate with, download/upload, and check status of parameters of the above listed devices.
   d. Printed instruction manuals and electronic instruction manuals installed in all computers for all above listed devices.
   e. Leather carrying cases with space for computer accessories and cables.
   f. 3-1/4 inch floppy drive.
   g. CD drive.
   h. Optical mouse.
   i. Extra battery.
   j. All required interface cables.
   k. Ink jet type portable printers with extra ink cartridge.

8. Computers shall be used for programming and downloading programs, checking parameters and signal values, etc.

9. Units shall be supplied with the shipment of the first unit.

10. Training:
   a. Contractor shall provide in addition to the Training specified elsewhere in the Contract Documents the following training directly related to the thyristor control system:
      1) Four 8-hour training sessions for the thyristor control system procedures.
      2) Training booklets and materials for 8 personnel per session.
      3) Training will be at the Authority’s facilities.

G. Communication Interface Cabinet (CIC):

1. A CIC shall be provided in each TPSS. The CIC shall permit interface between the SCADA System via the RTU and the:
   1) AC breaker.
   2) DC breakers.
   3) Alarm and status indications.
   4) TRU.
   5) Substation auxiliary systems.

2. CIC shall be the primary enclosure for the Annunciator Cabinet, and shall be a NEMA 12 ventilated enclosure with hinged, gasketed cover/door; the enclosure shall be a padlockable cabinet with a 3-point latch.

3. General:
   a. CIC cabinet shall be sized to house the annunciator panel with enough depth and back panel space to accommodate the required number of SCADA and annunciator points with 20 percent spare capacity. Terminal block layouts shall be
vertical with wire troughs to prevent uncluttered wiring.

b. All substation SCADA control and status indication points shall be terminated in the CIC cabinet, and a 125 VDC to 24 VDC converter power supply shall be provided for power distribution to the SCADA, and communications equipment. Provide a dedicated circuit from the DC distribution panel.

c. Contractor shall provide internal and external wiring from the power supply, indication contacts, control functions, etc., to the status indication and control terminal blocks points.

d. SCADA points existing or entering the substation shall be terminated on protected or non-protected terminal blocks as approved by the final design.

e. In each TPSS CIC enclosure, the Contractor shall provide a permanent mounted wiring diagram for all SCADA point designations.

f. CIC enclosures shall have the following properties and characteristics:

1) Cutouts shall be provided as required for cable entrance.

2) Cable entrances shall be provided with bushings and shall be sealed.

3) Padlocks for all CIC’s shall be keyed identically.
   a) A master and slave key shall be provided with each substation. Verify keying with the Authority prior to installation.

4) A 3/8-inch high strength grounding stud and a No. 6 AWG stranded green insulated ground wire shall be used to ground the CIC.

4. Terminal and Terminations:

a. Unprotected terminal blocks shall be Weidmuller Test terminal or approved equal.

b. Provide assembly rail and modular terminals, Weidmuller Terminations, Incorporated, or equal.

c. Furnish modular test terminals, melamine plastic, and screw clamp connections, with socket screws, with the following requirements:

1) Amperes: 25

2) Volts: 300

3) Wire gauge range: 22 AWG to 12 AWG

4) Thickness: 0.256 inch

5) Terminal and terminations shall be UL Listed

d. Standard accessories: Compatible with the terminal, with the following additional requirements:

1) End Section: Type AP, No. 1179.2

2) End Bracket: Type EWK1, No. 2061.6

3) Test Plug: Type PS, No. 1804.0

4) Jumpering combination: Type QB, No.91455.0

5) Disconnect plug for SAKC4 terminal: Type TST, No. 413074

6) Locking Pin: Type SST#, No. 1527.0

7) Assembly rail: Type TS 32 steel

8) Marking tags: FW, No. 4681.6 white thermoplastic

e. Group marking carrier with paper marking strip and transparent cover:

1) Type SCHT5, Catalog No. 2924.6

2) Type ES05, Catalog No. 2937.0

3) SST, Catalog No. 2940.0
f. Two Weidmuller terminal block screwdrivers shall be provided with each TPSS CIC.

g. Provide protected terminal blocks for any power or data communication cabling and wiring, which either enters or exits the substation.

h. As required, terminal block surge protectors shall be provided in accordance with the referenced standards and these specifications.

2.13 BATTERY SYSTEM (125 VDC)

A. Contractor shall furnish and install with each TPSS, a battery, battery charger, battery rack, battery enclosure, battery disconnect switch and accessories to provide DC power for the Substation equipment.

B. General:

1. Contractor shall be responsible for determining the sizing requirements for the battery system. Contractor shall submit for approval, battery calculations indicating sizing and capacity.

2. Battery shall be nickel cadmium, ALCAD Vantage Valve Regulated, Type VN, Ultra Low Maintenance or an Authority approved equal.

3. Battery shall include all necessary vent caps, inter-cell, and inter-rack connectors for a complete and finished installation.

4. Battery system shall be sized to supply the high discharge rates necessary to close and trip each electrically operated AC and DC circuit breakers after the battery has supplied, without assistance from a charging source, the lower discharge rates required for the indicating lights and relay coil loads with the AC bus dead for 8 hours.

C. Warranty:

1. Battery capacity shall be sized in accordance with the Referenced Standards and the final design.

2. Battery shall have a 5 year full replacement warranty from date of acceptance and a 20 year prorated warranty to deliver not less than 80 percent of its rated capacity.

D. Operation:

1. The charger, in addition to float and equalize charging the battery, shall be designed to carry the full continuous and momentary connected DC loads without the station battery connected.

2. Sufficient filtering shall be provided to minimize the effects on the connected load with the battery disconnected.

3. When the AC supply to the charger is interrupted, the battery shall supply the required power for the load duty cycle for 8 hours.

4. A standard duty, DC rated, fused service disconnect switch shall be provided to isolate the battery for maintenance purposes without interrupting the control power load.

E. Assembly:

1. Battery shall have no requirement for water refurbishment over the 20-year warranty period.

2. Battery shall deliver a nominal 125 VDC at full charge to all substation equipment with an operating range from 95 VDC minimums to 130 VDC maximum.

3. Battery shall be designed for float service at 1.42 Volts per cell.

4. Battery shall consist of a sufficient number of cells with a maximum equalize voltage of 1.47 Volts per cell and provide 80 percent rated capacity after 10s hour of applied equalize charge.

5. Contractor shall establish the required capacity in rated ampere-hours for an 8-hour discharge rate to a terminal voltage of 1.04 V per cell at 77 degrees F.

6. Battery capacities and battery charger shall be adequate for the following load duty cycle over a period of 8 hours from a fully charged state with the battery charger out of service:

a. Normal continuous demand of all substation DC ancillary loads including relays, indicating lamps, meters, local annunciator panel, RTUs, fire and intrusion alarm, emergency lighting and all other supervisory control or power supply circuits.
b. After 8 hours, close and trip 1 high-voltage AC circuit breaker.

c. After 8 hours, close sequentially, all the 750 VDC switchgear circuit breakers.

7. Each positive and negative plate assembly shall be designed for the required battery duty cycle, within the specified substation operating temperatures ranges.

8. Each cell of the battery assembly shall be hermetically sealed and leak proof. Polarity of cell terminal posts shall be clearly and permanently identified.

9. Battery shall not be capable of explosion under any condition, including a short circuit discharge.

10. Battery cells shall be provided with inter-cell connectors. Connectors, plates, and lugs shall be lead-plated solid copper.

11. Battery Cabinet and Battery Rack:

a. Battery shall be installed in a full size, ventilated, fiberglass, multiple door cabinet, and in accordance with the battery manufacturer recommendations.

b. Cabinet shall be a NEMA type 1, painted ANSI 61 light grey and shall provide adequate ventilation at the top and bottom to dispense gas given off during charge and shall also minimize condensation.

c. Provide sufficiently ventilated (either passive or active) to provide sufficient air changes for projected hydrogen emission under worst-case conditions in accordance with battery manufacturers recommendations.

d. Cabinet shall be provided with multiple-tier and or multiple-step structural steel or fiberglass support racks with sufficient space above each rack to perform battery servicing as recommended by the battery manufacturer.

e. Battery rack shall be provided with insulating plastic strips to cover all supports, hold-downs, and restraining rails that are in contact with the battery cells.

f. Cabinet and racks shall be treated with corrosion-resistant finish paint coat.

g. Cabinet doors shall be constructed with sufficient structural support, with full size viewing windows made from perforated Lexan or approved equal.

F. Electrical Connections:

1. Overall layout should be as simple as possible with minimum cable lengths to reduce voltage drop.

2. The main positive and main negative take-off points should always be arranged well apart. The cables must be well secured and of ample length to avoid chafing and strain on the terminal sockets.

3. To maintain electrical integrity apply a light protective coating of NO-OX-ID non-corrosive grease or similar mineral jelly to each connection.

G. Insulating Mat:

1. An electrolyte resistant plastic mat shall be provided under each battery rack.

2. Battery mounting racks and enclosures should be solidly mounted for shipment.

H. Nameplates:

1. Each battery cell container shall be marked with the following information:

   a. Manufacturer's name.

   b. Month and year of manufacture.

   c. Cell type.

   d. Amp-hour capacity.

I. Accessories. One set of the following accessories shall be provided for each battery:


2. Battery maintenance logbook with standard test forms.

3. Quart of No-Co terminal grease.

4. Set of special tools, including torque wrench.

5. Set of cell identification numbers.
6. Main battery fuses and holders:
   a. Fuses shall comply with NEMA FU 1 and shall provide short circuit protection for the battery and main cables to the DC distribution panel.
   b. A general duty, fused disconnect switch or circuit breaker, 250 VDC, shall be mounted adjacent to the battery rack to provide service isolation of the battery.

7. Pegboard:
   a. Provide hardboard, AHA IS 1, tempered, SIS, 1/2-inch nominal thickness, perforated, sized to accommodate all products specified, framed with 1-inch by 1-inch hardwood.
   b. Paint frame and hardboard a color selected by the Authority.
   c. Include hardware for wall mounting and pegboard accessories suited to the products to be mounted.
   d. Provide nameplates as specified, 1-inch high by length as required, with accessory names inscribed in 1/2-inch high vertical letters.

J. Battery Charger:
   1. Battery charger shall be silicon-controlled rectifier, convection cooled, and constant voltage, current limited, complying with the referenced standards.
   2. Battery charger shall be designed to float charge nickel cadmium batteries.
   3. Charger shall be designed to provide a system life expectancy of 20 years.
   4. Battery charger enclosure shall be NEMA 1, ventilated.
   5. Enclosure shall be floor or wall mounted provided with a hinged front panel complete with lockable handle and 2-point latch, and equipped with knockouts for conduit entrance.
   6. Paint color shall be ASA 61 Grey.
   7. Battery charger shall be rated as follows:
      a. Capacity: Capable of float and equalize charging for the specified battery and simultaneously supplying continuous and short time DC loads.
      b. Recharging: Shall be designed to recharge the battery from a terminal discharge voltage of 1.04 V per cell to 80 percent of the battery recharge capacity in 10 hours, using 1.47 V per cell, minimum.
      c. Contractor shall provide certification tests to show battery charger is capable of supplying 80 percent of the ampere-hours required to recharge a fully discharged battery within 10 hours, in addition to maintaining substation continuous and short time loads.
      d. Input Voltage: 240 VAC, 60 Hz, single phase.
      e. Output Voltage: In accordance with specified battery float and equalize voltage requirements.
      f. Output Current: Appropriately rated for charging battery from discharged state, (i.e., 1.04 V per cell), while simultaneously supplying substation continuous and short-time DC loads.
      g. Charger shall be designed to operate as a DC power supply without batteries connected.
      h. Regulation: within plus or minus 1 percent of output DC voltage over its complete load range with within plus or minus 10 percent variation of input AC voltage.
      i. Current Limiting: Adjustable from 80-120 percent; factory set at 110 percent of output nominal current rating.
      j. Ripple: Output ripple voltage shall be 30mVrms or 0.06 percent of nominal output voltage, whichever is higher.
      k. Conversion Efficiency: 0 to 100 percent load; 80 percent (minimum).

K. Charger Accessories.
   1. Each battery charger shall be furnished with the following accessories:
a. One DC voltmeter, 0 to 200 V, 2 percent accuracy.
b. One DC ammeter, battery charge/discharge current, range as applicable, 2 percent accuracy.
c. One AC input pilot light (green LED) marked AC POWER ON.
d. One selector switch, 2 position or push-buttons marked FLOAT and EQUALIZE. LED indicator light provided when Equalize mode activated.
e. One AC input molded-case circuit breaker, NEMA AB 1.
f. One DC output molded-case circuit breaker, NEMA AB 1.
g. One 10 hour plus Current Limit Auto-Equalize Timer with “Equalize” indicating light Charger shall be switched to equalize mode for a set time interval after charger is in current limiting for 36 seconds or more. Equipped with "Float Reset" and "Equalize" override switch.
h. One combined status charger monitor alarm board provided with appropriately rated and quantity of relay contacts for local annunciation and remote status indication.
i. Red LED indicating lamps shall be provided for all alarms on the charger front panel. A “Lamp Test Reset” switch shall be provided for verifying lamp operation and resetting alarm lights.

2. The alarm monitor board shall include the following:
   a. AC failure alarm relay.
   b. High DC voltage alarm relay.
   c. Low DC voltage alarm relay.
   d. Charger failure alarm relay.
   e. Ground detection alarm relay.
   f. Common alarm relay.

3. Nameplates shall be provided for all battery charger devices, meters, etc.

L. Eye Wash Station:

1. Provide self-contained gravity fed eyewash for each TPSS. Unit shall be wall mounted, easily accessible and require no maintenance. Unit shall meet all ANSI and OSHA standard,

2. Be able to deliver fluid to both eyes simultaneously at a volume of not less than 0.4 gallons/minute for 15 minutes.

3. Velocity of fluid should not be high enough to cause eye injury.

4. Mounted 33 to 45 inches from the floor.

5. Mounted a minimum of 6 inches away from the wall or obstructions.

6. Activation time of 1 second or less and the unit should remain in operation without the need for continued activation.

7. Actuating valve or lever should be in an easily located area and be highly visible.

8. Must have nozzle caps to prevent foreign matter from accumulating in the nozzle area.

9. Nozzle caps should automatically separate from the nozzles when activated.

10. Highly visible signs must be posted in the area of the emergency eyewash. The location should be well lighted.

11. Provide with 2 spare re-fill kits for each Substation.

2.14 GROUNDING

A. General

1. Provide all grounding as required by the Referenced Standards and as specified herein.

2. All electrical equipment shall be bonded in accordance with the latest edition of the NEC. All interior-grounding conductors shall be green in color; tape wrap for indication will not be accepted.

3. Ground connections to cabinets, busses or equipment frames shall be made utilizing a compression NEMA type configuration lug, which shall be silver or tin plated copper. The lug shall be attached to the item being grounded with stainless steel or silicon bronze bolting hardware.
4. All connections shall be made in accordance with the manufacturer’s recommendations and with the use of a torque wrench.

B. Raceway and Cable Tray Grounding:

1. All metallic raceway and cable tray systems shall be bonded together to provide a continuous electrical ground path and connected to the overall grounding system.

2. Metallic cable trays shall be bonded to other cable tray components and conduits using a No. 4 AWG insulated green ground cable and NEMA 2-hole, compression type, tin or silver-plated copper lugs. Grounding shall comply with NEC and NEMA, and as otherwise shown.

3. Ground conductors shall be provided in non-metallic raceways systems.

C. DC Grounding:

1. Rectifier and DC switchgear equipment enclosures should be insulated from ground (6 feet minimum) and connected to a DC ground grid through a high-resistance device.

2. TPSS Installation Contractor will provide at each TPSS site an AC ground grid, DC ground grid, and utility ground as required.

3. DC surge arrester ground should be isolated from the AC ground mat and connected to DC ground grid.

4. AC ground mat and DC ground mat should be kept physically separated to limit the voltage on the DC ground mat due to transfer of potential from the AC ground mat.

D. Stray Current Monitoring:

1. Each substation shall be equipped with provisions to monitor stray currents. Each substation shall contain a negative switch cubicle with a shunt and disconnect switch.

2. Provide means to connect the shunt to a chart recorder or voltmeter to monitor and record stray currents.

2.15 CABLES AND WIRE

A. Control Wiring: Secondary and control wiring (low voltage) shall be minimum No. 14 AWG, stranded copper conductors, Type SIS insulation.

B. 600 Volt:

1. All conductors shall be 98 percent conductivity copper with insulation rated 194 degree F.

2. For size No. 1/0 AWG and smaller, NEC Type XHHW-2, Cross-linked-thermosetting-polyethylene-insulated or NEC Type THW-2 ethylene-propylene-rubber-insulated conductors are approved for use.

3. For size No/ 2/0 AWG or larger, NEC Type THW-2, Ethylene-Propylene-Rubber-Insulated conductors are approved for use.

2.16 EQUIPMENT IDENTIFICATION NAMEPLATES

A. General:

1. Size and legends of all nameplates shall be submitted to the Authority for approval. Each switchgear assembly, rectifier unit, transformer unit, circuit breaker auxiliary unit, control panel, panel-mounted and auxiliary device shall be provided with a nameplate for proper identification.

2. Similarly, nameplates shall be provided for all internally mounted devices such as fuse, capacitors, and resistors. Nameplates identifying major equipment shall have lettering 1-inch high (minimum). Where rear access is provided, 2 nameplates shall be furnished, 1 on the front and 1 on the rear of the equipment.

3. Nameplates identifying AC and DC circuit breakers shall have lettering 1-inch high (minimum). The inscription shall include circuit breaker number and service.

4. Nameplates for relays, meters, control and instrument switches, fuses and auxiliary devices shall have 0.125 inch (minimum) lettering. For protective and auxiliary relays, the nameplate inscription shall include the device number and function. Nameplates for fuse shall indicate fuse rating, polarity, and circuit identification.

5. Nameplates identifying each Substation shall be mounted next to each entry door. Nameplate shall have 3-inch high lettering with the inscription “TPSS #1, TPSS #2, etc. Below the Substation number, provide a separate nameplate with the name of the Substation, such as “Victory”, “Walnut”, etc.

6. All nameplates shall be laminated, 3-ply plastic with a dull white surface and black core. All exposed edges shall be beveled.
Nameplates shall be fastened with stainless steel screw.

2.17 INDICATION LIGHTS
A. General: Indicating lights on equipment enclosures shall be LEDs. The LEDs shall be suitable for operating over the range of control voltages as specified by the final design. The LEDs shall be mounted in compact, rugged sockets, and shall be of the bayonet base design. Lenses and bezels shall be rectangular in design. The design shall permit ready replacement of the LEDs from the front. Lenses shall emit convenient reading of the LEDs from oblique angles. Overall dimensions of the lens and bezel shall not exceed 1–3/8 inch in width and height.

2.18 OTHER EQUIPMENT AND MATERIALS
A. Electrical Insulation:
1. Floor insulation thickness shall be determined by the final design calculations, but not less than 1/3 inch.
2. The extent of floor insulation shall be as required to maintain the integrity of the high resistance grounding system.
3. Substation walls behind and to the sides of the DC equipment enclosure shall be insulated with fire resistant insulating material that meets Class 1 flame spread requirements of UBC.
4. Insulation system design shall protect against any accidental contact between the DC equipment enclosure and grounded metal surfaces.
B. Telephone Cabinet and Equipment:
1. Provide a 1-hour fire rated, 4’x8’ plywood backboard for mounting telephone equipment. The rating of the plywood shall be stamped on both sides of the backboard.
2. Telephone cable will be provided from the CIC. Provide a conduit raceway from the CIC to the telephone location. Refer to Communications Specifications for cabling requirements.
3. Telephone, telephone cabinet and telephone equipment shall be provided in accordance with Specification 16851, Telephone Subsystem – Communications System.

C. Safety and Maintenance Equipment:
1. First Aid Kit: Provide a complete first aid kit for each Substation in accordance with the requirements of OSHA and the local ordinances. Provide Elmridge Protection Products 11 Pack First Aid System item 100-ARBBP or Authority approved equal.
2. Emergency Eyewash: Provide portable eye wash system that utilizes plastic bottles that maintain their sterilization unless used.
3. Personal Protective Equipment (PPE): Contractor shall furnish a complete set of PPE as required by the manufacturer and OSHA for each Substation. The PPE shall include at least:
   a. Arch flash protection suit.
   b. Eye protection.
   c. Acid/electrolyte resistant gloves and apron.
D. Table: Provide a fold down table. The location of the table may be changed to fit the final design and layout of the equipment.
E. Single Line Diagram: A Substation condensed single line diagram, 22 inch by 34 inch, in polyvinyl frame, shall be provided for each Substation. Provide complete with legend and symbols on a single sheet

2.19 ANCILLARY
A. This Section provides the requirements for Special Tools and Spare Parts for the Substations that shall be part of this Contract. In addition, requirements as outlined in this Section and the Contract Pricing Schedule shall provide for the provision of a recommended additional spare parts list to be used by the Authority in maintaining a complete spare parts inventory.
B. Special Tools: All special tools, lifting hardware, templates and gauges required to operate and maintain the TPSS shall be provided at each Substation. All special gauges and templates necessary for field erection shall be included. Equipment shall be included in the contract price, no additional compensation will be allowed.
C. Submittal: A detailed Spare Parts and Special Tools Listing. Provide a list (120 days prior to shipment) of all spare parts, special tools and test equipment for each piece of equipment, assembly, or sub-assembly. List by equipment and include tools and equipment designated specifically for use with the TPSS, or usual tools and equipment
required for operation and maintenance of the TPSS but not normally available to maintenance journeyman.

D. Lock-Out-Tag-Out Devices: A lock-out-tag-out device shall be provided for each circuit breaker. The device shall be capable of being secured by up to 6 padlocks.

E. Padlocks: A padlock shall be provided for each circuit breaker and disconnection switch. Two keys shall be provided for each padlock. Master lock or an Authority approved equal, verify keying with the Authority.

F. Keys: Two keys shall be provided for each door and removable panel.

G. First Aid and PPE Cabinet: Cabinet shall be provided for storage of the first aid kit and PPE equipment.

H. Document Cabinet: Install a wall-mounted cabinet with shelves for storage of instruction books, records, log books, switching tags, and other pertinent documents. Furnish the cabinet with doors and closing and latching mechanism. Select cabinet with dimensions 15 inches deep, 24 inches wide and 24 inches high, minimum.

I. Spare Parts Cabinet: Install a wall-mounted cabinet to store small spare parts. Furnish the cabinet with doors and closing and latching mechanism. Select cabinet with internal dimensions 14 inches deep, 24 inches wide and 24 inches high, minimum.

J. Work Desk:
   1. Each Substation shall contain a wall-mounted worktable with sliding drawer, storage cabinet and doors.
   2. Provide a replaceable, non-conducting composition board worktable surface.
   3. Provide table surface approximately 48 inches by 30 inches, minimum.

K. Drawing storage: Provide a hanging “plan holder”, wall mounted with a minimum capacity of 100 full size sheets.

L. Required Spare Parts (System Wide): In addition to any special tools and spare parts required elsewhere in this Specification, the Authority may choose from the following list based on the allocated spare parts budget. Contractor shall deliver the selected spare parts prior to delivery of the first TPSS.
   1. Main AC 15KV circuit breaker, truck mounted – Quantity: 1
   2. Main DC circuit breaker, truck mounted – Quantity: 1
   3. DC feeder breakers, truck mounted – Quantity: 2
   4. One complete set of all devices and components for a thyristor-rectifier assembly including control unit, circuit boards, protective devices, etc.
   5. Complete rectifier transformer of each type – Quantity: 1
   6. Station Service Transformer – Quantity: 1
   7. Signal Service Transformer – Quantity: 1
   8. Spare control relays of each size and type – Quantity: 5
   9. Spare relay of each type furnished – Quantity: 1
   10. Spare CT of each size and type – Quantity: 1
   11. Protective over-current relays of each size and type – Quantity: 5
   12. DPM of each size and type – Quantity: 2
   13. Interposing relays of each type – Quantity: 2
   14. PT of each size and type – Quantity: 1
   15. Instrument and control switches (each type) – Quantity: 2
   16. LA of each size and type – Quantity: 2
   17. Fuses of each size and type – Quantity: 10
   18. LV circuit breakers of each size and type – Quantity: 5
   19. LED indicator lights (each color) – Quantity: 5
   20. Terminal blocks of each type – Quantity: 5
   21. Unit space heaters – Quantity: 2
   22. One set of battery charger spare parts as recommended by the manufacturer.
   23. Ionization smoke detectors – Quantity: 2
   24. Photoelectric smoke detectors – Quantity: 2
25. Thermal detectors – Quantity: 2

26. Load measuring resistors – Quantity: 2

27. Complete set of opening and closing coils for each type of DC breaker and AC breaker – Quantity: 2

28. Complete set of main and arching contacts for each type of DC breaker and AC breaker – Quantity: 2

29. Spring charging motor for 15kv AC circuit breaker, main DC circuit breaker and DC feeder circuit breaker – Quantity: 1

30. Individual power thyristors of each type – Quantity: 12

31. Individual power diodes of each type – Quantity: 12

32. Air filters for HVAC system – Quantity: 160

33. Fifth wheel device for moving DC Feeder breakers, one for each Substation.

M. TPSS Spare Parts (for each TPSS):

1. Provide, for approval by the Authority, a complete list of spare parts that will be provided for each TPSS

2. Provide for each TPSS, spare parts as specified herein, and as recommended by the manufacturer of each TPSS assembly and sub-assembly.

3. Spare parts shall be delivered prior to or upon delivery of each TPSS.

4. For each TPSS include such items as required for normal and emergency use.

N. Recommended Spare Parts List:

1. In addition to the spare parts provided above and elsewhere in this Contract, the Contractor shall develop a list of recommended spare parts for the TPSS(s). The quantities in the list shall be as recommended by the fabricator for 2 years of revenue service. The list shall include current prices for all parts. Contractor shall certify that prices are the current prices for spare parts and are offered to others for the same quantity purchase. The Spare Parts List shall include the following information for each part:

a. Nomenclature.

b. Purpose.

c. Manufacturer's part number or drawing number.

d. Manufacturer's name and address.

e. Quantity recommended by manufacturer.

f. Recommended source of supply.

g. Estimated lead time.

h. Contractor's stock number.

i. Supplier and manufacturer's part number.

j. Name and address of supplier or manufacturer.

k. Assignment (type of assembly).

l. Drawing reference number.

m. Lead time for reorder.

n. Frequency and reasons for replacement based on records.

o. Each part or component shall be identified as being part of next larger assembly or subassembly.

PART 3 - EXECUTION

3.1 GENERAL

A. Contractor shall diligently pursue the execution of this Contract by:

B. Provide the final design, submittals, fabricate, manufacture, and testing for the new Substations as specified herein.

C. Coordinate with the Authority and other Agencies, Contractors to provide a complete and operational Traction Electrical System.

D. Provide factory testing and certification. Perform all phases of design, fabrication manufacturing by qualified and experienced personnel using proper tools and equipment under competent supervision.

E. Provide factory QC procedures and measures that will assure a complete and quality product. Use only products and materials free of asbestos and other potentially harmful substances.
F. Provide field acceptance and verification field-testing procedures, field testing and final certification for each Substation.

G. Using the specified guidelines and references, perform the design, production and conformance tests for each type and rating of transformer/rectifier; AC switchgear, DC switchgear and associated assemblies.

H. Provide on-site support for interface, troubleshooting and system integration with other Authority Contractors and system integration for each Substation.

3.2 DESIGN CONFERENCE

A. Contractor shall attend all meetings and conferences as specified in the Contract Documents.

B. During the first design conference the Contractor shall provide the following information:
   1. Certify overall dimensions and weights.
   2. Submit an initial drawing submittal list.
   3. Submit an initial production schedule.

3.3 FACTORY FABRICATION

A. General:
   1. Furnish, install and test all electrical equipment, equipment assemblies, conduit, cable tray, cables in accordance with the requirements of all Federal, State and Local codes and standards, manufacturer’s instructions and the Contract Documents.
   2. Unless approved otherwise by the Authority, the construction of all TPSSs shall be uniform and comply with the requirements as specified herein and elsewhere in the Contract Documents.

B. Cable and Wire: Control and power wiring shall be as specified herein and shall be neatly laced and properly supported. No splices will be permitted in any wiring. Control and instrument wiring shall be isolated from high-voltage compartments and shall be readily accessible. Wiring shall be protected as required from mechanical injury.

C. Connections:
   1. Connections shall be made only at terminals on the devices, on terminal blocks, or the ground bus. No splices or taps shall be made between these terminals points. Junction boxes shall not be used.
   2. Connections for wiring shall be made using ring-type compression connectors with insulated compression sleeves.
   3. Insulated sleeve shall firmly grip the wire insulation, and the metallic portion shall firmly grip the strands of the conductors.
   4. All control, metering and relay circuits requiring external connections and all unused terminals on auxiliary contacts, devices, relays, instrument transformers, and control switches shall be wired to conveniently located terminal blocks having washer head screw-type terminals, circuit marking strips, and phenolic-laminated dust covers.

D. Terminal Blocks:
   1. Terminal blocks shall have marking strips for wire identification.
   2. All internal wiring shall be identified with Contractor’s wire number at each terminal by means of a suitable plastic sleeve of yellow or white PVC with machine-printed black marking on a matte surface.
   3. Adequate identification for reconnection of control circuits, disconnected to meet shipping requirements, shall be provided on terminal blocks.
   4. Marking strips shall be an approved type.
   5. Shorting type terminals blocks shall be provided for CT connections. A minimum of 10 percent spare terminals but no less than 4 terminals shall be provided on each terminal block.

E. Surge Protection:
   1. Install the AC and DC surge suppressors and surge arrestors as required by the Contract Documents, the NEC and standard industrial practices, install as close as possible to the protected Circuit Breaker.
   2. Install the individual electronic equipment and transient voltage suppressors as close as possible to the protected equipment.
   3. For interior equipment grounding, use insulated green copper cable sized per the manufacturer recommendations for all live connections. Connections between surge
arresters and ground busbar or ground grid may be by bare copper conductors.

F. Substation Grounding:

1. Contractor shall make provisions for grounding of the Substation at the site by providing means to:
   a. Connect the rectifier transformer grounding pads to the Substation AC grounding grid.
   b. Connect the Substation housing grounding pads to the Substation AC grounding grid.
   c. Solidly connect the AC equipment grounding busbar to the Substation grounding grid by 4 corner connections.
   d. Connect the DC equipment grounding busbar to the SubstationDC grounding grid by 2 connections.
   e. Connect the utility surge protection to the utility Substation grounding point.
   f. Connect the DC surge protection to the DC grounding grid.
   g. Connect electronics equipment, such as the SCADA and PLC equipment, to the AC ground grid.

G. Protective Device Settings: Factory set and test all protective devices in accordance with the results of the approved Protective Device Coordination Study.

3.4 TESTING GENERAL REQUIREMENTS

A. General:

1. This section specifies the tests that shall be performed to demonstrate conformance of the TPSS to this Specifications, industrial standards and the Referenced Standards. The testing shall demonstrate that the TPSS conforms to the ratings as specified and meets the mechanical and electrical performance requirements of these Specifications.

2. These tests are defined as:
   a. Design Tests.
   b. Production Tests.
   c. Conformance Tests.
   d. Field Acceptance and Verification Tests.
   e. System Integration Tests.

3. Contractor shall be responsible for the design tests, production tests and conformance tests and field acceptance tests. Contractor shall support the final System Integration Testing.

4. Contractor shall perform the Field Acceptance tests for each TPSS and shall field certify each Substation to comply with these Specifications and to be ready for energization and service.
modifications of a previous design and to ensure that performance has not been adversely affected. The data from previous similar designs may also be used for current designs, where appropriate.

7. If requested by the Contractor, the Authority may waive the requirements for design tests on standard equipment and materials that are to be used in the fabrication of the TPSS. Contractor shall:

   a. Using the submittal process in the Contract Documents, the Contractor shall submit to the Authority the materials or equipment to be furnished that the Contractor is requesting a test waiver on.

   b. State the reason and basis for the waiver request.

   c. If required by the Authority, the Contractor shall submit to the Authority for review the test procedures, test results, and certified documentation of like equipment.

C. Production Tests:

1. Production tests shall be defined by the following:

   a. Production tests shall be made by the manufacturer or fabricator at the production facility as part of the process of producing the equipment, assembly or sub-assembly.

   b. Contractor shall provide confirmation that all required factory tests of systems, subsystems, assemblies and sub-assemblies supplied under this Contract have been successfully performed. These tests shall verify design, nameplate ratings, and adequate and proper performance.

   c. Production tests may be performed in association with other testing requirements if approved by the Authority. Production tests may be made on devices or representative samples, to verify the product meets the design specifications and applicable standards.

   d. The equipment specified in this Contract shall be completely assembled and tested prior to shipment, production tests may be made during assembly and prior to final assembly, but other tests can often be made more effectively on components and sub-assemblies after assembly.

   e. Production tests shall be made and shall include the following as appropriate for the type of equipment concerned:

      1) Current and linear coupler transformer tests.
      2) Bushing tests.
      3) Dielectric withstand tests.
      4) Pressure tests.
      5) Nameplate check.
      6) Leakage tests.
      7) Resistors, heaters, and coils check tests.
      8) Power frequency tests.
      9) Maximum voltage tests.

D. Conformance Tests. Conformance tests shall be defined in this Contract as:

1. Tests performed on the completed TPSS unit, assembly or sub-assembly to demonstrate that the unit will perform in compliance with the Contract Specifications. Conformance testing will be performed to show compliance with the basic requirements of these Specifications and the Referenced Standards. Conformance testing may be performed in association with other testing requirements if approved by the Authority.

2. Conformance tests shall be made on each TPSS unit and testing results shall be submitted to the Authority for approval.

3. In addition to the tests required herein and in the Referenced Standards, if requested by the Authority, additional conformance tests may be required to demonstrate compliance with the applicable standards. Note that prior to initiation of the conformance test all planned production tests will be performed.

4. The conformance tests may be similar to certain design tests. If approved by the Authority individual conformance tests may
be certified as completed upon successful performance as Design tests.

E. Field Testing:

1. General:
   a. After the TPSS has been completely assembled and installed at the job site, field energization testing and acceptance tests shall be performed by this Contract,
   b. System Start-up and commissioning support shall be provided by this Contract.
   c. Coordinate with each TPSS Installation Contractor for startup and testing coordination.
   d. This Contract shall coordinate with each TPSS Installation Contractor to perform the testing and acceptance in as timely a manner as possible. Contractor shall, without delay, test and energize each TPSS unit as it is placed on the site foundation.

2. Pre-Energization Testing:
   a. Each TPSS shall be received, off-loaded and placed on the foundation by the Line Section Contractor. This Contract shall witness the off-loading and utility service installation.
   b. After each Unit is installed on the site foundation and the service utility cables are installed, this Contract shall perform those tests required to verify that the Substation is ready for energization. This Contract shall energize the Substation. This Contract shall then certify that the Unit is ready for the TPSS Installation Contractor to connect the OCS feeder circuits, negative return cables, grounding cables and all other communications and external wiring and conduits.
   c. After completion of the Substation, installation the Section TPSS Installation Contractor shall notify the Procurement Contractor that the Unit is ready for “Acceptance” testing.

3. Acceptance Testing:
   a. TPSS Procurement Contractor shall complete all field-testing as required to “accept” the Substation and verify that the Substation conforms to the design and specifications. Substation energization may be performed prior to all incoming circuits being terminated. Coordinate each TPSS testing and energization with the TPSS Installation Contractor to minimize field-testing requirements.
   b. Testing procedures shall be designed to duplicate as nearly as possible all conditions of operations, and shall be carefully selected to ensure that the equipment is not damaged.
   c. Field acceptance testing shall not commence until all design affecting the respective equipment has been reviewed and accepted by the Authority.
   d. When the acceptance testing has been completed, the Substation has been energized, and all circuitry has been verified and documented, the Contractor shall notify the TPSS Installation Contractor that the Substation is ready for System Integration Testing.

4. Integrated System Tests:
   a. Integrated testing shall be performed during the Line Section start up. The startup and integrated testing of the Authority’s Light Rail System will be implemented in Sections with separate completion milestones as indicated in the Construction Schedule.
   b. TPSS Procurement Contractor shall be present during the startup period to assist in system integration, troubleshoot system failures, and assist in any problems that might arise. Contractor shall provide
support personnel to perform the integrated system tests for all line segments.

c. When a piece of mechanical or electrical equipment is found to be in conflict with specific criteria, an adjustment shall be made to the item by an experienced representative of the manufacturer.

d. If adjustments fail to correct the operation of a piece of equipment or fixture, the Contractor shall remove the equipment or fixture from the project site and replace it with a workable replacement that will meet the specification requirements.

e. Test support shall be provided for the following tests:

1) Train Starting Tests: Proper operation and coordination (i.e. no nuisance tripping) of the DC feeder circuit breaker relaying shall be verified during starting of two 3-car trains at the substation and at the midpoint between each substation. The weight of the vehicle to be simulated during this test shall be based on the worst loading condition of approximately 142 kips.

2) Load Sharing Tests: Proper load sharing between two TPSS shall be verified during starting of two 3-car trains halfway between the 2 substations.

3) Rectifier Short Circuit: (testing on 1 Substation only).

a) A short-circuit fault test shall be conducted to 1 Substation to prove the protective devices for the TPSS design. At a substation, to be selected by the Authority, the TPSS Installation Contractor shall apply a direct fault between 1 contact wire of the OCS and the associated running rail at the following approximate distances from the selected Substation DC feeder circuit breaker:

   (1) At the point of connection of the feeder positive circuit to the OCS.

   (2) A distance of 1/10 mile from the Substation.

   (3) A distance of 1/2 mile from the Substation.

   (4) A distance of 3/4 miles from the Substation.

b) Field Test Monitoring:

   (1) AC circuit breaker, DC main breaker, and DC feeder of each substation shall all be monitored simultaneously by a high-speed chart recorder to show the current, voltage and status of each circuit breaker during and after each short circuit application. In addition, current in each phase of the AC circuit breaker shall be monitored. Test results, such as total inrush current, steady-state fault current, impulse time of the faulted unit, clearing time of the faulted unit, and primary system capacity shall be recorded on oscillograph. All data recorded
on oscillograph shall be properly labeled and identified.

(2) All equipment, including the Substation enclosure, shall be inspected for damage including loose bolts after each short-circuit test. In addition, all breakers subjected to fault conditions shall be production tested in accordance with their applicable ANSI standards. Any reconditioning required returning these circuit breakers to original condition shall be at the Contractor's cost. Failure of the equipment to withstand these tests or to coordinate or meet specified requirements should be grounds for rejection of the equipment.

f. Remote control, indication and alarm functions for each Substation equipment and switching equipment through the SCADA interface shall be verified to demonstrate proper operation.

g. A report shall document the results obtained from the integrated system tests. Report format shall be similar to that specified herein.

5. Testing Plan:

a. TPSS Procurement Contractor shall prepare a “test plan” for each Substation. The most current edition of the NETA Acceptance Specifications shall be used as a guide. The “test plan” shall document the history of each Substation from assembly, factory testing to delivery and final acceptance by the Authority.

b. Provide a complete bound document for each Substation with the following sections:

1) Factory design tests.

2) Factory production tests.

3) Factory conformance tests.

4) Pre-energization testing.

5) Acceptance testing.

6) Integration testing.

7) Acceptance certification.

c. Maintain a record of the testing for all mechanical and electrical equipment specified, including interface with the supervisory and communication system and all alarm and operating modes for each piece of equipment (circuit breakers, rectifier, battery/charger, etc.).

d. Testing Plan shall outline in detail the test requirements and testing procedures that the Contractor shall complete to certify the Substation has been manufactured in accordance with these Specifications and the Referenced Standards.

e. Include detailed descriptions and operations of all electrical, mechanical and instrumentation equipment.

f. Testing Procedures shall address each control device, all mechanical, electrical, and control circuits. Present the Testing Plan in a stepwise, logical sequence to ensure that all equipment has been properly serviced, aligned, connected, calibrated and adjusted prior to operation.

g. Testing Plan shall identify:

1) The approach to be used for accomplishing each of the required tests.

2) The projected schedule and sequence for tests.
h. Field tests shall be conducted on the Substation equipment preceding Substation energization. Include as part of the Testing Plan a section that will list in detail the "steps" required for energization of the Substation. List in a systematic format or block diagram.

i. Testing Procedures shall be bound, containing all the forms, testing data, Referenced Standards, and other related items that will become a record document, provide 1 bound "Testing Plan" for use at each Substation.

6. Acceptance Testing Plan:

a. All Substations shall be factory tested prior to shipment. However, the Substations shall be Field (Acceptance) tested after each Substation has been placed on site.

b. Include in the Acceptance Testing Plan as a minimum the following:

1) Enclosure. Visual Inspection for:
   a) Painting conformance.
   b) Frame or metal deformation.
   c) Access doors operation.
   d) Locks and access.
   e) Equipment movement.
   f) Verify equipment with bill of material.

2) AC Switchgear:
   a) Visual Inspection.
   b) Mechanical functional operations test.
   c) Electrical functional operations test.
   d) Bus Insulation Test.
   e) Ground Continuity test.
   f) Perform Relay Calibration settings and tests.
   g) Verify instruments at 25, 50 and 100 percent scales.

3) Rectifier Transformer:
   a) Visual inspection.
   b) Megger tests.
   c) High-potential test on HV winding.
   d) High-potential test on LV winding.
   e) High-potential test HV to LV, HV & LV to ground.
   f) Verify winding temperature indication.

4) Rectifier:
   a) Visual inspection.
   b) High-potential test of AC and DC Bus.
   c) Rectifier frame insulation test.
   d) Rectifier start-up and calibration.

5) Transformer – Thyristor Controlled Rectifier Unit:
   a) Visual Inspection.
   b) Test and verify all control functions.
   c) Cabinet door operator interface and indicating lights.
   d) Verify rectifier bridge(s).
   e) Verify fan control.
   f) Annunciator interface.
   g) Temperature control.
6) DC Switchgear:
   a) Visual Inspection for each breaker section.
   b) Verify all field connections (control & power).
   c) Verify all ground connections.
   d) Verify that all similar breakers are interchangeable.
   e) Mechanical functional operations test.
   f) Electrical functional operations test.
   g) Ground continuity test.
   h) Relay calibration tests.
   i) Perform relay calibration settings and tests.
   j) High-potential test on DC bus.
   k) High-potential test on each DC circuit breaker.
   l) Verify instruments at 25, 50 and 100 percent scales.
   m) Test all load measuring devices.

7) DC Negative Switch:
   a) Visual Inspection.
   b) Verify mechanical operation.
   c) Verify interlock key operation.
   d) Contact resistance test.

8) Structural Ground (Device 64):

9) NRGU (Device 57NR):
   a) Test forward and reverse voltage detection pickup and drop off.
   b) Test forward and reverse current detection pickup and drop-off.
   c) Inject voltage between rail and earth ground to measure and record pickup voltages at 1/10, 1/4, 1/2, 3/4 miles from the TPSS. Then inject 845vdc in earth ground at 1/10, 1/4, 1/2, 3/4 miles from the TPSS to determine if the NRGU picks up.

10) Battery and Battery Charger
    Perform all tests as recommended by the manufacture including:
    a) Visual inspection.
    b) Check for proper polarity.
    c) Verify supply voltage.
    d) Verify and record cell voltages.

11) Annunciator:
    a) Visual inspection.
    b) Operational test for each alarm circuit.
    c) Operational test for each control circuit.

12) AC and DC Test Cabinets:
    a) Visual inspection.
    b) Verify polarity of DC supply.
c) Test "Close" and "Open" function.

d) Test plug/receptacle interlock.

13) Busways:
   a) Visual inspection.
   b) Verify all bus connections and insulation.
   c) High-Potential tests.

14) Distribution (Auxiliary Power) Transformers:
   a) Visual inspection.
   b) Verify fuse size and ratings.

15) Distribution Panels:
   a) Visual Inspection.
   b) Verify circuit breakers size and ratings with drawings.
   c) Verify input and output voltages.

16) Relays, Meters, and Instrument Transformers:
   a) Visual inspection.
   b) Calibrate, set and test each relay and relay function.
   c) Operational test of each relay by signal injection.

17) TPSS:
   a) Visual inspection.
   b) Verify correct operation of all interlocks.
   c) Verify correct operation of all Annunciator functions.
   d) Verify correct operation of all PLC functions.
   e) Test all lighting and AC power operations.
   f) Insulation to ground tests on the busses with circuit breakers and fused interrupter switches "racked" and "closed."
   g) Test for proper operation of all protective, control and annunciation devices.
   h) Functional test for all auxiliary equipment and alarms, such as air conditioning units, "house" wiring, SCADA, etc.
   i) Test all equipment grounding.
   j) Test all structure grounding.

18) Fire Detection System.  Perform all tests as recommended by the manufacturer including:
   a) Visual inspection.
   b) Functional test for each alarm point.
   c) Functional test for emergency trip scheme.
   d) After the smoke sensing fire detection system is completely installed, it shall be tested for continuity and correct operation in accordance with NFPA 72H.

19) Cooling equipment:
   a) Visual inspection.
   b) Perform functional tests of all cooling
20) Continuity and Control Function Tests. Perform control function tests of all circuits including relays, annunciation, indication circuits, shutdown circuit functions and alarms. As a minimum test:

a) For control circuits, include all equipment, devices, interconnecting wiring and cabling.

b) Control wiring shall be tested prior to the operational test with the controls energized, but with the controlled equipment and devices disconnected or otherwise made inoperable.

c) For these tests, the control functions shall be checked for proper operation by actuating each contact that initiates a control operation and then following the control sequence through the various affiliated devices to ascertain that the correct results are obtained with each condition of interlocking.

d) The actuating of contacts as required to initiate an operation and to set up the interlocking conditions should be performed by simulating operating conditions.

e) The minimum voltage required to operate breakers and the tap and time dial settings of all relays shall be verified in accordance with the relay coordination study.

f) All relays shall be bench tested in accordance with the relay manufacturers data and curves.

g) Minimum pickup and dropout of under-voltage relays.

h) Check interlocks on rectifier doors for proper functioning and operation of Substation shutdown circuits.

i) Check required setting of heater thermostats.

21) Rated Voltage Test:

a) The entire Substation shall be energized at rated voltage to verify functionality of all components, devices, relays, etc. including lighting, heating, battery chargers, RTUs, fire alarm panels, station service panels, AC breakers, thyristor rectifier, DC breakers, annunciator and any other installed hardware.

b) Contractor shall develop a check sheet and procedure for completing this function.

c) The test procedure shall be approved by the Authority prior to energization.

22) Grounding:

a) Perform insulation test on structure to ground and operation of ground relays.
b) Test all equipment grounds for continuity and resistance.

23) RTU's: Complete field functional, interface and performance testing shall be performed for all RTU software/firmware developed under this Contract.

24) SCADA RTUs. Perform all tests as recommended by the manufacturer including:
   a) Visual inspection.
   b) Operational test for each input signal.
   c) Operational test for each output signal.
   d) Operational test for each transfer trip point.
   e) Operational test for the Emergency Trip Scheme.

25) Negative Return and Drainage Assembly:
   a) Visual inspection.
   b) Verify connections and insulation.

26) Insulating Floor:
   a) Test the floor resistance using high voltage megger.
   b) Take 1 resistance reading for each 3 feet by 3 feet area of insulated floor. The average of all the resistance readings shall be at least 10 megohms.

2) Test Procedures shall include the following as a minimum:
   a) Objective and scope.
   b) A description of the required test set up, including diagrams, schematics.
   c) Illustrated drawings showing test equipment connection set.
   d) Test equipment to be used.
   e) Personnel required for the test.
   f) Estimated duration of test.
   g) Data sheets to be used.
   h) Step by step instructions for performing the test, identifying the points where data is to be recorded and the limits for acceptable data.
   i) Instructions for recording data on data sheets or verifying that individual procedure steps have been completed.
   j) Pass/fail criteria.
   k) Test results will be reviewed by the Authority and accepted, as submitted or additional tests may be required.
   l) If additional tests are required because test results submitted do not comply with the requirements of the Specifications, the Contractor will be requested to retest.
at no expense to Authority.

d) Test Reports. Test reports shall document the results obtained and be certified by the testing technician and the CQCR. Reports shall include the following:

1) Equipment tested, including model and serial numbers.

2) Title of test.

3) Objective of test and pass/fail criteria.

4) Summary and conclusions.

5) Location and date of test.

6) Test method and equipment used for test.

7) Results, including calculations, curves, photographs, and other supporting data.

8) Abbreviations and references.

9) Signature of CQCR.

7. Special Tests:

a) At the discretion of the Authority, on equipment provided under this Contract and in addition to the specified Acceptance tests and integrated system tests, special tests may be required.

b) Special tests shall be performed to verify compliance of the equipment and components with the Specifications.

c) The cost of such special tests required by the Authority on any equipment or component that is proven to comply with the Specifications will be at the expense of the Authority. The cost of special tests on any equipment or component that is proven not to comply with the Specifications shall be at the expense of the Contractor.

3.5 FACTORY FABRICATION, TESTING AND INSPECTION

A. Scope. The work described in this Section consists of tests and inspections to be performed to demonstrate that systems, subsystems, assemblies, subassemblies and components supplied under this Contract comply with the Specifications. Provide:

1. Provide complete fabrication services as specified herein and elsewhere in the Contract Documents.

2. Contractor shall supply complete testing, and operator training services to ensure operability of all equipment supplied.

3. This Section describes methods for performing tests specified (herein and in the Referenced Standards) for testing the Substation at the Contractors facilities. It is intended for use as a basis for performance, safety, and the proper testing of each Substation, the Contractor shall submit to the Authority for approval a “Factory Testing Plan and Procedures” for testing per these specifications.

4. All equipment, assemblies, and sub-assemblies supplied by the Contractor shall be installed in accordance with the manufacturer’s recommendations and instructions.

5. Each assembly and system shall operate as specified and to the Authority’s satisfaction.

6. Contractor shall be responsible for, and shall correct by repair or replacement, at its own expense, any system or assembly, which in the opinion of the Authority does not operate as specified.

7. Contractor shall correct by repair or replacement, at its own expense, any system or assembly that has been damaged by testing or by faulty mechanical or electrical assembly by…..

B. Shipment:

1. Prior to shipment from the factory, each Substation shall be completely assembled in its final field configuration and completely factory (conformance) tested. These tests shall be documented and signed by the testing technician and certified by the Contract Project Quality
Control Representative. Submit test procedure and test results to the Authority.

2. Upon completion of conformance factory tests and system verification, the substation assemblies shall be disassembled as required to provide shipping packages of size and weight compatible with the transportation modes selected and for compliance with traffic regulations. If site re-assembly is required, the re-assembly is the responsibility of the Contractor.

C. Delivery and Storage:

1. Delivery of each TPSS shall be by the Contractor. Receiving, off-loading and inspection of all equipment (including impact recorders) upon delivery shall be performed in accordance with Specification 16312, Traction Power System Substation Installation. All scratches or defects shall be recorded giving the nature and location of all scratches and defects. This record shall then be signed by the Contractor and witnessed by the Authority, each party shall retain a copy.

2. All scratches or defects noted shall be repaired by this Contractor.

3. Scratches or defects in the finish shall be repaired by painting, after properly preparing the surface. Only identical painting furnished by the manufacturer shall be used for such purposes.

4. Failure of the Contractor to protect the materials as outlined herein shall be grounds for rejection of the work.

5. Care shall be exercised during fabrication and delivery to avoid damage or disfigurement of any kind.

6. All equipment, parts and assemblies shall be protected from dust and moisture prior to and during fabrication.

7. Equipment stored in an outdoor environment shall be covered during delivery and during storage. All equipment stored over 10 days shall have heaters to prevent moisture.

D. Factory Test Program:

1. Provide to the Authority a Factory Testing Program for all mechanical and electrical equipment including the interfaces with the supervisory and communication system and all alarm and operating modes for each piece of equipment (circuit breakers, rectifier, battery/charger, etc.).

2. Tests shall be as specified herein or in the Referenced Standards and shall determine whether the equipment has been properly assembled, aligned and connected. Any changes, adjustments or replacements required to make the equipment operate as specified shall be carried out by the Contractor as part of the work.

3. Contractor shall submit a flow diagram indicating the logical sequence of the factory testing; however, this plan shall include for record information all testing, starting with design tests through the integrated testing. Provide this documentation for each Substation.

4. Submit a list of test procedures (by test procedure number) and a brief description of each test.

5. Submit with the Program a preliminary schedule of tests.
   a. Schedule shall show each test for each location with start and finish dates.
   b. Schedule portion of the Plan shall be a dynamic document to be updated as the fabrication progresses.
   c. Provide an organization chart and description of the Contractor's in-house and acceptance field-test organization.

E. Factory Test Procedures:

1. Contractor shall prepare and document a test procedure for each type of test. Test procedures shall be submitted to the Authority for review and approval per the submittal schedule and prior to the start of the tests.

2. Test procedures shall be structured in a systematic, building block manner with check points at critical functions. The procedures shall facilitate the reporting of test results and the re-creation of error conditions. Each procedure shall:
   a. Be submitted and identified as a separate and independent document for approval.
   b. Each test procedure shall be stapled or bound.
c. Each procedure shall be individually numbered in a logical sequence with all pages numbered.

d. First sheet of the procedure shall contain the title, date, and name of individuals who prepared and approved the procedure.

3. Based upon the results of the first items tested, the Contractor may initiate revisions to the test procedures if approved by the Authority. The modified test procedures shall be resubmitted to the Authority for approval.

F. Testing Format: As a minimum, the following information shall be included in the procedures for each function tested:

1. Title of test.

2. A test identification number and name.

3. A statement of test objective, scope and pass/fail criteria.


5. Location and date of test.

6. A list of equipment required to perform the test, including model and serial numbers.

7. A list of prerequisite tests that shall be completed before the test can be performed.

8. Abbreviations and references.

9. A description of the required test setup including diagrams illustrating test equipment connections identifying test points, where applicable.

10. Step by step instructions for performing the test, identifying the points where data are to be recorded and the limits for acceptable data.

11. Instructions for recording data on data sheets or verifying that individual procedure steps have been completed.

12. All test data sheets on which all results of testing are to be recorded.

13. Results, including calculations, curves, photographs, and other supporting data.

14. Pass or Fail indication with summary and conclusions for each test.

15. Provide signature of the Tester, Contractor's Project Manager and Quality Control representative.

G. Test Results:

1. Test results shall include all of the test procedure forms for the test, with all fields complete. Fields that are not applicable shall be so indicated.

2. Test results shall be submitted with a Test Summary Sheet that includes, as a minimum, the following:

   a. Test number and revision.
   
   b. Test completion date.
   
   c. Narrative summary of the test results.
   
   d. Listing of any procedure failures, observations and procedure field modifications.
   
   e. Signature of the Contractor's Testing Manager.
   
   f. Additional comments.
   
   g. Unless otherwise approved by the Authority, tests in which 1 or more procedures have failed shall be repeated in its entirety.

3. Regression Testing:

   a. Contractor shall identify and be responsible for any regression testing required due to software changes after the test program has started.
   
   b. Prior to commencement of regression testing, the Contractor shall submit a list of tests and procedures that require re-testing. Contractor shall also submit a revised test schedule for approval.

4. Qualification Tests:

   a. Contractor shall perform Qualification Testing (as part of the Production tests) on all equipment to verify that the equipment complies with the specified design and environmental requirements.
b. Qualification tests shall ensure that component(s) that are designated as vital will function in a manner necessary for fail-safe operation. Testing shall include a full range of known failures of interfaces to the tested equipment.

c. Qualification tests shall ensure proper operation over the temperature, humidity, vibration and shock ranges expected for a rail application in the Dallas area.

d. Qualification tests may not be required for unmodified equipment, which has a proven service in a similar operating environment. In lieu of qualification testing, the Contractor shall submit documentation of prior qualification testing.

H. Records and Reports:

1. Reports:
   a. Contractor shall develop, maintain, and update a test report for each test. This report shall include listings of all test deficiencies and their resolutions.
   b. If required by component failure, list system retesting requirements, and system design changes.
   c. Contractor shall submit final test reports for each TPSS 15 days after completion of testing. This report shall include all testing requirements as submitted in the test plan, including listings of all test deficiencies and their resolutions, and system retesting.

2. Records:
   a. Test data sheets shall be used to record applicable drawing numbers, test equipment, including serial numbers and calibration dates where applicable, discrepancies, corrective action required, and test data.
   b. Data entries shall be referenced to the applicable procedures and allowable limits for each entry and shall be indicated on the data sheets.
   c. The test data sheets shall be arranged in tabular form.

3.6 INDIVIDUAL EQUIPMENT TESTING REQUIREMENTS

A. Contractor shall perform design tests, production tests, and conformance tests as specified herein and in the Referenced Standards. Tests indicated herein are for reference only; the Contractor shall prepare and submit tests and testing procedure specific to the equipment furnished and standard industrial practices.

B. AC Switchgear: The following tests shall be performed on each class and rating of AC circuit breaker, fused load interrupted switch and switchgear assembly. For each AC circuit breaker and switchgear assembly all applicable tests as identified in these specifications and the Referenced Standards including but not limited to:

1. Design Tests:
   a. Maximum voltage.
   b. Power frequency.
   c. Continuous current.
   d. Short circuit rating.
   e. Rated operated duty.
   f. Rated permissible tripping delay.
   g. Rated interrupting time.
   h. Rated reclosing time.
   i. Rated control voltage.
   j. Load current switching.
   k. Mechanical life.
   l. Dielectric withstand.
   m. Radio influence voltage tests.

2. Production Tests:
   a. Current tests.
   b. Bushing tests.
   c. Leakage tests.
   d. Resistors, heaters, and coils check tests.
   e. Control and secondary wiring check tests.
f. Clearance and mechanical adjustment check tests.
g. Mechanical operation tests.
h. Timing tests.
i. Stored energy system tests.
j. Conductivity of current path test.
k. Power frequency withstand voltage tests on primary insulation components.
l. Power frequency withstand voltage tests on control, secondary wiring, and components, to include motors, release coils, etc.
m. Electrical resistance of current path.
n. Low-frequency withstand voltage.
o. Enclosures interchangeability test.
p. Nameplate check.

3. Conformation Tests:
   a. Lightning impulse withstand tests.
b. Continuous current carrying tests.
c. Mechanical endurance tests.
d. Load current switching tests.
e. Short-time current carrying tests.
f. Short-circuit current tests.
g. Conductivity of current path tests.
h. Power frequency withstand voltage tests.

C. Rectifier Transformer:

   1. Transformer, rectifier (thyristor) and TRU shall be subjected to design, production and acceptances tests as required by these Specifications, and the Referenced Standards. All testing shall meet or exceed the requirements for “Heavy-Traction Service”.

   2. General:
      a. Contractor shall perform the following tests to determine the “Performance Characteristics” for each type and rating for each transformer/rectifier specified, determine by test the:

         1) Rated output in KW.
         2) Voltage regulation.
         3) Efficiency.
         4) Power factor.
         5) Harmonic content.

b. Design tests shall be made on a single transformer, rectifier of each type and rating to be provided under this Contract.

c. Production and conformance tests shall be made on each transformer and rectifier to be provided under this Contract.

d. Design, Production and conformance tests shall be made on each Transformer-Rectifier Unit of each type and rating.

e. Testing may be accomplished at the manufacturer’s facilities if appropriately equipped to perform tests, or upon approval by the Authority at an independent testing facility.

f. Design and conformance tests for transformers and rectifiers may be combined with transformer-rectifier unit tests where feasible and approved in advance.

g. The Authority reserves the right to witness all tests, and shall have access to all test facilities.

1) Acceptance of the TRU shall be contingent upon successful completion of all test described herein and in the Referenced Standards.

2) Data from all tests shall be submitted to Authority for review and approval.

3) Test plans; procedures and scheduled test dates shall be submitted for approval at least 90 working days in advance of scheduled test dates.
4) No test results will be accepted prior to receipt and approval of test plans and procedures.

h. Mechanical repairs on transformers, coils, or magnetic circuits will not be accepted:

1) In the event of a test failure, within 30 days from the failed test date, the Contractor shall submit a detailed report describing the design deficiency and their corrective action including any drawings changes.

2) Failure of the transformer, rectifier and TRU to meet the design parameters as required by these Specifications, shall necessitate rejection of the transformer rectifier design in total, requiring the Contractor to redesign and remanufacture the unit to meet Contract specified parameters.

3. Design Tests:

a. Dielectric impulse.

b. Loss measurement.

c. Commutating reactance.

d. Low frequency dielectric.

e. Temperature rise (heat run).

f. Short circuit tests.

g. Rated voltage.

h. Rated current.

i. Rated load.

j. Harmonic load test:

1) Perform at loads of 25, 50, 100, 150, 200 and 300 percent.

2) Record and measure the harmonic voltages and currents though the 61st harmonic in 6-pulse mode and 12-pulse mode.

k. Phase control.

l. Excitation loss at rated voltage on the rated voltage connection.

m. Excitation current at rated voltage on the rated voltage connection.

n. Noise level:

1) Test at 50 percent, 75 percent, 100 percent, 150 percent, 200 percent, 250 percent and 300 percent load. The substation transformer shall have a maximum sound pressure level of 60dBA at 200 percent full load and 50dBA at normal load when tested in accordance with NEMA TR-1. Acoustical insulation, vibration isolation, and structural design techniques shall be used to minimize the continuous noise level of the assembled Substation.

o. Perform partial discharge test:

1) To certify the transformer has a minimum partial discharge-free voltage of 120 percent of rated voltage. Provide oscillograph recordings with the detailed report of the measured test.

2) Partial discharge tests shall be performed in accordance with the Referenced Standards for the detection of partial discharge and measurement of apparent charge in dry-type transformers, except as modified herein.

3) Measure partial discharge inception and extinction voltage during induced voltage test in accordance with the Referenced Standards and the following requirements:

a) Transformer shall be subjected to an induced voltage of 1.5 times the rated voltage at a frequency between 100Hz and 400 Hz.
b) Partial discharge measurements shall be performed with a selected instrument operating at a frequency of 1.9 MHz.

c) Partial discharge extinction level shall be reached at an induced voltage of higher than 1.2 times rated voltage.

d) Partial discharge extinction level will be considered to have been reached when the reading at 1.9 MHz is less than 10 microvolts or 13 picocoulombs.

p. Temperature test or tests shall be made on 1 unit when 1 or more units of a given rating are produced by one manufacturer at the same time, except that these tests shall be omitted when a record of a temperature test, made in accordance with these standards, on a duplicate or essentially duplicate unit, is available. The temperature test is a design test, not a conformance test.

q. Temperature loading cycle test to verify the temperature limits specified.

r. Perform equivalent RMS Heavy Duty overload cycle test to record temperature rise at end of overload cycle.

4. Production Tests:

a. Resistance measurements (windings): Resistance measurements of all windings on the rated voltage connection of each identical unit and in case of a production run, at the tap extremes of 1 unit of a given rating when produced by one manufacturer at the same time.

b. Ratio tests: Ratio tests on the rated voltage connection and on all tap connections.


d. No load loss.

e. Impedance voltage and load loss: Impedance and load loss at rated current on the rated voltage connections of each unit and on the tap extremes of one unit of a given rating when produced by one manufacturer at the same time.

f. Applied potential.

g. Induced potential.

h. Reduced, chopped and full-wave impulse test.

i. Dielectric low-frequency withstand.

5. Conformance tests:

a. Resistance measurement.

b. Transformer Turns Ratio (TTR) test.

c. Polarity and phase relation test.

d. No-load loss test and excitation current test.

e. Impedance voltage and load loss test.


g. Induced potential test.

h. Reduced, chopped and full-wave impulse tests.

i. Partial discharge test.

j. Efficiency.

k. Voltage regulation.

l. Power factor.

D. Thyristor Controlled Rectifier:

1. Perform rectifier tests in accordance with these Specifications and the Referenced Standards, and as follows.
2. Design Tests:
   a. Reduced voltage load test: Including specified overloads, after temperature stabilization at rated load. Test shall be conducted without exceeding safe junction temperature on the silicon-controlled rectifiers (SCR).
   b. Current balance test: Demonstrate proportional sharing between parallel thyristors, within plus or minus 10 percent at the 100 percent and specified overload rating.
   c. Loss measurement:
      1) Test in accordance with the Referenced Standards for 100 percent rated load.
      2) Efficiency, voltage regulation and power factor in 6-pulse mode and in 12-pulse mode.
      3) At loads of 1, 25, 50, 100, 150, and 300 percent of rated load, determine efficiency, voltage regulation and power factor in 6-pulse mode and 12-pulse mode.

3. Production Tests:
   a. Dielectric strength test.
   b. Rated voltage test.


E. Transformer/Rectifier Unit:

1. The following tests shall be completed on a complete TRU:
   a. Design Tests
   b. Rated Temperature Load Test:
      1) Contractor shall perform a Load Test as outlined in the Referenced Standards.
      2) Tests shall prove that the average temperature rise on the windings of the transformer does not exceed the design values or the Referenced Standards.

3) In addition, the test shall prove that the rectifier SCR temperature does not exceed 149 degree F for the copper bus and 104 degree F for the enclosure.

   c. Harmonic Spectrum Load Test:
      1) At loads of 25 percent, 50 percent, 100 percent, 150 percent, 200 percent and 300 percent of rated load, measure and record the harmonic voltages and currents though the 61st harmonic that would be sent back into the utility system in 6-pulse and 12-pulse mode to verify the rectifier-transformer harmonic limits comply with standard IEEE 519.

   d. DC fault relay testing: DC switchgear enclosure-to-positive bus fault detection relaying system shall be tested to prove that it can withstand the maximum available positive-to-ground short circuit current (including contribution from adjacent TPSS) for the duration of time to clear the fault.

   e. Test Acceptance Criteria:
      1) Transformers:
         a) Successfully pass all specified design, routine and TRU tests with no physical damage and meet all temperature limits, including the duty cycle.
         b) Satisfy all design criteria as demonstrated by measured test results.

      2) Rectifiers:
         a) Successfully pass all specified design, routine and TRU tests with no physical damage and meet all temperature limits.
         b) Satisfy all design criteria as
3) Transformer-rectifier units: Successfully pass all specified design, routine and transformer-rectifier unit tests with no physical damage and meet all temperature limits.

4) Satisfy all design criteria as demonstrated by measured test results.

2. Production Tests: Test per the Referenced Standards.

3. Conformance Tests:
   a. Functional test protective devices.
   b. Functional test TCR control system.

F. DC Switchgear:

   1. Design Tests: All applicable tests identified as design tests in the Referenced Standards for 1 DC circuit breaker and switchgear assembly of each size and rating. If tests are made outside the enclosure, a separate design test shall be made to verify that trip devices calibrated outside the circuit breaker enclosure maintain calibration within the enclosure. Design tests on the circuit breakers shall include the following, as indicated below:
      a. Short-time current test.
      b. Continuous current test.
      c. Load (low) current switching tests.
      d. Endurance test.
      e. AC dielectric withstand test.
      f. Trip device calibration check test.
      g. AC dielectric.
      h. Peak current test.
      i. Short-circuit current test.
      j. Production tests.
tested using 2,500 VDC megohms meter for 1 minute.

s. Proper operation and setting of all relays in accordance with approved relay coordination curves.

t. Check all operations and interlock functions.

G. Negative Bus Boxes:
1. Design Tests: None Required.
3. Conformance Tests: Shunts calibrated and tests in accordance with the Referenced Standards.

H. Annunciator. The following tests shall be performed in accordance with the control schematics and wiring diagrams:
1. Design Tests: None Required.
2. Production Tests: Manufacturer's standard production tests shall be performed on the Annunciator and the Annunciator components.
3. Conformance Tests: By means of insulation resistance, 100 percent point-to-point continuity, and operation tests, each local annunciator panel shall be checked for proper operation.

I. Busways:
1. Design Tests:
   a. Dielectric tests.
   b. Power frequency withstand.
   c. Lighting impulse withstand.
   d. Continuation current.
   e. Temperature rise tests.
   f. Momentary tests.
   g. Bus Bar Insulation.
2. Production Tests:
   a. Power frequency withstand voltage tests.
   b. Mechanical operation tests.
   c. Grounding of instrument transformer case tests.

3. Conformance Tests:
   a. Enclosure security tests.
   b. Dielectric test.
   c. Mechanical performance test.
   d. Continuous current test.
   e. Short-circuit current carrying test.
   f. Momentary current withstand test.
   g. Electrical operation and control wiring tests.
      1) Control wiring continuity.
      2) Control wiring insulation.

J. Distribution (Auxiliary Power) Transformers:
1. All applicable tests identified in the Referenced Standard shall be performed on one of the 15 kV class distribution transformers.
2. Design Tests:
   a. Temperature rise.
   b. No-load losses and excitation current.
   c. Dielectric tests.
   d. Short-circuit tests.
   e. Audible sound-level measurement.
   f. Mechanical design tests.
   g. Calculated data:
      1) Total losses.
      2) Efficiency.
      3) Voltage regulation.
3. Production Tests:
   a. Resistance measurements.
   b. Ratio tests.
   c. Polarity and phase-relation tests.
d. Load losses and impedance voltage.
e. Impedance voltage and load loss.
f. Dielectric.

4. Conformation Tests:
   a. Impulse.
   b. Insulation power factor.
   c. Insulation resistance.
   d. Partial discharge.

K. DC Control Power System (Battery and Battery Charger):
   1. All applicable tests identified in the Referenced Standard shall be performed on the DC Power Supply.
   2. Design Tests:
      a. Dielectric test.
      b. Voltage adjustment test.
      c. Temperature rise test.
      d. Current-limit test.
      e. Short-circuit test.
      f. Voltage deviation (Regulation) test.
      g. Efficiency measurement.
      h. Power factor measurement.
      i. Ripple voltage measurement.
      j. Audible noise test.
      k. Dynamic response test.
      l. Input and output surge test.
   3. Production Tests:
      a. Dielectric test.
      b. Voltage adjustment test.
      d. Ripple voltage measurement.

L. Distribution Panels: In addition to the following this Contract shall certify or perform all standard-manufacturing tests for panelboards as required by Industry Standards and the Referenced Specifications.
   1. Design Tests:
      a. Temperature rise test.
      b. Dielectric test.
      c. Short-circuit test.
      d. Environmental test.
      e. Applicable enclosure design tests.
   2. Production Tests: Manufacturer's standard production tests shall be performed on all AC and DC distribution panels.
   3. Conformation Tests:
      a. Energy distribution tests shall include the following:
         1) Verify size, type and ratings for all fuses and circuit breakers.
         2) Verify each circuit breaker size with that on approved circuit plans.
         3) All branch wiring shall be checked using resistance test instruments acceptable to the Authority to verify agreement with approved plans.
         4) Verify wire gauge with that on approved circuit drawings. All discrepancies in wire sizes shall be replaced with proper size wire.
         5) Each wiring circuit shall be tested against all other energy busses to ground to ensure that no shorts or faults exist.
b. Wiring verification test. All circuitry shall be checked for accuracy against approved circuit drawings. Tests may be done with energy on or off and shall verify the following:

1) Point-to-point wiring.

2) During wire verification test a wire count on each terminal, relay contact, etc. shall be taken to ensure that only the number of wires called for on the approved circuit plans is present at each terminal, relay contact, etc. Any discrepancies found shall be corrected.

3) Verify wiring tags and panel board nomenclature where applicable.

4) Verify that all components are as shown on approved circuit drawings and located in proper positions.

M. Relays, Meters, and Instrument Transformers: In addition to the following, the Contractor shall certify or perform all standard Design, Production and Conformance tests for relays, meters and instrument transformers as required by Industry Standards and the Referenced Specifications.


2. Production Tests: Manufacturer’s standard production tests shall be performed on all relays, meters and instrument transformers.

3. Conformance Tests:

   a. All relays, meters, and instrument transformers shall be checked for accuracy, performance, operation, proper setting, and calibration. Set and calibrate relays per the coordination study performed under this Contract.

   b. Relay checking, setting, and calibration shall be performed as a separate test element from the overall inspection and testing procedures. Tests shall include:

      1) Test Current: Test current shall be injected into the current circuits at the current transformer terminals to ensure protective relays operate properly by tripping their respective breakers and are polarized correctly, and to ensure that instruments read correctly and that meters are calibrated.

      2) Checking:

         a) Instruments shall be checked for accuracy at quarter, half, and full-scale points.

         b) Telemeter transducers shall be checked for accuracy at quarter, half, and full-scale points.

      3) Indicating Setting and Date: After relays have been set, a small white card stating the setting and date shall be placed within the relay case.

N. Traction Power Substation. Each individual Substation shall be tested unless otherwise approved by the Authority. The Authority or designated representative shall witness these tests; notify the Authority 30 days prior to testing. After all equipment is installed in the Substation Enclosure and prior to delivery, perform the following tests and checks on all completely assembled substations:

1. Design Tests:

   a. DC Short Circuit Tests:

      1) DC short circuit tests shall be performed on 1 Substation to verify proper calibration, function, and coordination of all protective devices, and to confirm adequate short-time capability of DC circuit breakers. One bolted fault shall be applied at each of the following locations:

         a) Load side of 1 DC feeder breaker.

         b) DC positive bus.

         c) Output of rectifier terminals.

      2) AC circuit breaker, DC main breaker and DC feeder
breaker of the Substation shall all be monitored and recorded simultaneously by a high-speed chart recorder to show the status of each circuit breaker during and after each short circuit application. In addition, each phase of the AC circuit breaker shall be monitored. Test results, such as total inrush current, steady-state fault current, impulse time of faulted unit, and primary system capacity shall be recorded on oscillograph. All data recorded on oscillograph shall be properly labeled and identified.

3) All equipment including the Substation Enclosure shall be inspected for damage including loose bolts after each short-circuit test. In addition, all breakers subjected to fault conditions shall be production tested in accordance with their applicable ANSI standards. Any reconditioning required returning these circuit breakers to original condition shall be at the Contractor's cost.

4) Equipment and the Substation Enclosure shall be inspected for damage after the test. Failure of the equipment either to withstand these tests or to coordinate or meet the specified requirements shall be grounds for rejection of the equipment. Contractor shall make repairs and retest failed components until units pass all tests.

5) This test may be performed as part of the Integrated Systems Tests as specified herein.

b. Noise Level Test:

1) Noise level tests shall be performed on 1 Substation at the factory or in the field.

2) The noise level measured at a distance of 50 feet from any point of the Substation Enclosure shall not exceed 45 dBA when the maximum load equivalent to 2 trains accelerating simultaneously is being drawn and with the Substation cooling equipment running.

3) The weight of the LRV to be simulated during this test shall be based on the worst loading condition.

c. Temperature Rise Test:

1) Contractor shall perform a temperature rise test to verify that the temperature rise inside the Substation Enclosure is maintained within operating limits of all Substation equipment.

2) The test shall be designated a design test, performed on the first Substation.

3) The test shall take place in direct sunlight at an equivalent ambient temperature of 115 degree F, plus and minus 20 degree F, doors closed, with the TRU operated at 100 percent full-load, with all auxiliary equipment energized and under load, ventilation fans thermostatically controlled, until inside temperature is stabilized, but not less than 6 hours.

4) This test may be performed as part of the transformer rectifier load cycle test.

5) Stabilized temperature is considered to have been reached when the temperature rise inside the Substation Enclosure changes no more than 35.6 degrees F in 1 hour. Measurements of temperature shall be from multiple locations as approved by the Authority.

6) Contractor shall provide a listing of all installed equipment with the manufacturer's specified
operating temperature limits along with a test procedure.

7) The test is considered successful if the inside temperature of the Substation Enclosure properly reflects the HVAC design required in Section 13121.

d. Production Tests: During construction, fabrication and assembly of the TPSS, perform testing as required to assure all components are comparable to assure a complete and operational unit.

2. Conformation Tests:

a. General Tests: Each Substation shall be energized and functional/operational tests performed on all devices, assemblies and circuits. The following tests shall be performed after installation of all switchgear assemblies in the Substation Enclosure, perform all tests after each unit is completely assembled and point to point wiring is complete.

1) Installation Tests:

a) Inspect and certify that each piece of equipment is installed according to approved installation drawings within acceptable physical tolerances.

b) Provide certification that “Quality of Installation” has been demonstrated by field tests for continuity, insulation resistance, resistance of ground connections, circuit breakdown, visual inspection and any other tests required by this Specification.

c) Prior to any work that conceals another installation, the installation shall be witnessed and certified by the CQCR unless otherwise directed by the Authority.

2) Verification of protective relay settings and trip circuits.

a) All relays shall be set in accordance with the approved protective device coordination study.

b) Each AC and DC switchgear and circuit breaker protective system shall be checked using primary injection.

c) The test shall simultaneously verify the current transformer, voltage transformer or shut ratio, secondary wiring, polarity, relay operation, tripping circuit, and circuit breaker operation.

d) Verify correct operation of auto-reclosing and transfer trip device operation.

3) Verify correct operation of all interlocks.

4) Verify correct operation of all Annunciator functions.

5) Verify correct operation of all PLC functions.

6) Verify all lighting and AC power operations.

7) Test for continuity and insulation of all busses and wiring.

8) Insulation to ground tests on the busses with circuit breakers and fused interrupter switches "racked" and "closed."
9) Test for proper operation of all protective, control and annunciation devices.

10) Functional test for all auxiliary equipment and alarms, such as air conditioning units, “house” wiring, SCADA, etc.

11) Test all equipment grounding.

12) Test all structure grounding.

b. Fire Detection System: After the smoke sensing fire detection system is completely installed, it shall be tested for continuity and correct operation in accordance with NFPA 72H.

c. Cooling Equipment: Perform functional tests of all cooling equipment and its control circuitry.

d. Continuity and Control Function Tests:

1) As a minimum, perform continuity and control function tests of all circuits including relays, annunciation, indication circuits, shutdown circuit functions and alarms.

2) For control circuits, include all equipment, devices, interconnecting wire and cable.

3) Control wiring shall be tested prior to the operational test with the controls energized, but with the controlled equipment and devices disconnected or otherwise made inoperable.

4) For these tests, the control functions shall be checked for proper operation by actuating each contact that initiates a control operation and then following the control sequence through the various affiliated devices to ascertain that the correct results are obtained with each condition of interlocking.

5) The actuating of contacts as required to initiate an operation and to set up the interlocking conditions should be performed by simulating operating conditions.

6) Minimum voltage required to operate breakers and the tap and time dial settings of all relays shall be verified in accordance with the relay coordination study.

7) All relays shall be bench tested in accordance with the relay manufacturer’s data and curves.

8) Minimum pickup and dropout of under-voltage relays.

9) Check interlocks on rectifier doors for proper functioning and operation of Substation shutdown circuits.

10) Check required setting of heater thermostats.

e. Rated Voltage Test:

1) The entire TPSS shall be energized at rated voltage to verify functionality of all components, devices, relays, etc., including lighting, heating, battery chargers, RTUs, fire alarm panels, station service panels, AC breakers, thyristor rectifier, DC breakers, annunciator and any other installed hardware.

2) Contractor shall develop a check sheet and procedure for completing this test.

3) Test procedure shall be approved by the Authority prior to commencement of test.

f. Grounding:

1) Perform insulation test on structure to ground and operation of ground relays.
2) Test all equipment grounds for continuity and resistance.

**g. RTU’s:**

1) Complete functional and performance testing shall be performed for all RTU software/firmware developed under this contract.

2) Burn-In: RTU equipment shall undergo a factory burn-in for at least 72 hours. Comprehensive diagnostics shall be performed on each RTU after the burn-in period.

3) Functional Tests:

   a) In conjunction with the System Factory Acceptance Test, complete functional tests shall be performed for each type of RTU subsystem. A full RTU factory functional test shall be performed for at least 2 RTUs per type.

   b) Tests shall include, as a minimum.

      (1) All I/O cables shall be checked for continuity at the factory.

      (2) All I/O addressable status points shall be verified for correct status reporting and address location.

      (3) All addressable control points shall be verified for correct output and point address.

      (4) A complete protocol command set test shall be performed verifying that each command and reply is executed as requested.

4) Physical Inventory: Physical inventory data shall be provided with each RTU.

**h. SCADA RTUs:**

1) Functional Input/Output Check.

2) Communications Verification Test.

**i. Software/Firmware Tests:** Complete functional and performance testing shall be performed for all RTU software/firmware developed under this Contract in accordance with the validation and verification plan.

1) Burn-In: RTU equipment shall undergo a factory burn-in for at least 72 hours. Comprehensive diagnostics shall be performed on each RTU after the burn-in period.

2) Functional Tests:

   a) In conjunction with the System Factory Acceptance Test, complete functional tests shall be performed for each type of RTU subsystem. A full RTU factory functional test shall be performed for at least 2 RTU’s per type.

   b) Tests shall include, as a minimum.

      (1) All I/O cables shall be checked for continuity at the factory.

      (2) All I/O addressable status points shall be verified for correct status reporting and address location.
status points shall be verified for correct status reporting and address location.

(3) All addressable control points shall be verified for correct output and point address.

(4) A complete DF-1 protocol command set test shall be performed verifying that each command and reply is executed as requested.

3) Physical Inventory: Physical inventory data shall be provided with each RTU.

j. Negative Return and Drainage Assembly:

1) Design Tests: Test the negative grounding unit to confirm that its operation is in accordance with the system Specification.

2) Production Tests:
   a) Dielectric test.
   b) Electrical operation test.

k. Insulating Floor:

1) Test the floor resistance using high voltage megger prior to switchgear installation.

2) Take 1 resistance reading for each 3 feet by 3 feet area of insulated floor. The average of all the resistance readings shall be at least 10 megohms.

l. Other Equipment: Perform applicable tests on the following Substation equipment.

   1) Indicating instruments.
   2) Relays and Transducers.
   3) Instrument transformers.
   4) Annunciators.
   5) PLCs.
   6) Batteries.
   7) Battery Chargers.
   8) Auxiliary Power Transformers.
   9) Insulated Wire and Cable.
   10) Busbars.
   11) Disconnect Switches.
   12) Surge Arresters.
   13) Cable Tray.
   14) Panelboards.
   15) Molded-Case Circuit Breakers.

m. Underwriters Laboratory (UL).

1) Prior to shipment of the Substation, the Contractor shall acquire inspection services from Underwriters Laboratory to perform a "Field Evaluated Product Label" inspection on the entire substation and equipment and provide applied "Field Evaluated Product Labels" on all equipment that does not bear the UL Listing Mark.

2) Any equipment found during the inspection requiring changes in order to meet the UL inspector's requirements, shall be made or corrected and re-inspected to acquire the UL Field Evaluated Product Label, at no additional cost to the Authority.
PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment will be per the Contract Bid Schedule and shall be measured separately for each Traction Power Substation.

4.2 PAYMENT

A. Payment for the various TPSSs will be made at the respective lump sum prices quoted in the Pricing Bid Schedule; which prices shall include full compensation for all costs incurred in the complete fabrication, assembly, factory testing and delivery to the job site.

END OF SECTION 16311
Addendum “A” - CONTRACT DELIVERABLES REQUIREMENTS LIST (CDRL)

<table>
<thead>
<tr>
<th>Specification Section</th>
<th>Brief Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fault and Coordination Study:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16045</td>
<td>Fault &amp; Coordination Study (each site)</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td>16045</td>
<td>Equipment Arc Study</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td><strong>Basic Electrical Materials:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16050</td>
<td>Manufacturer's Equipment Drawings and Installation Instructions</td>
<td>(120 days after NTP)</td>
</tr>
<tr>
<td><strong>Mainline TPSS:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16311</td>
<td>Product and Equipment literature</td>
<td>(120 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Equipment Arrangement</td>
<td>(120 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Lighting and Low Voltage AC Wiring</td>
<td>(120 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Fire Alarm and Telephone Layout</td>
<td>(120 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>SCADA RTU Points Listing</td>
<td>(120 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>TPSS One Line Diagram</td>
<td>(150 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Equipment Control Schematics</td>
<td>(150 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Battery and Battery Charger Sizing Calculations</td>
<td>(150 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Heating and Air Conditioning Load Calculations</td>
<td>(150 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>TPSS Equipment Arrangement</td>
<td>(150 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Rectifier/Transformer Design Calculations</td>
<td>(180 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Internal Wiring Diagrams</td>
<td>(180 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Interconnection Wiring Diagrams</td>
<td>(180 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Operation and Maintenance Spare Parts</td>
<td>(180 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Calculations</td>
<td>(240 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Software Requirements Specification (SRS)</td>
<td>(240 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Software Design Description (SDD)</td>
<td>(240 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Software Verification and Validation Document (SVVD)</td>
<td>(240 days after NTP)</td>
</tr>
<tr>
<td>16311</td>
<td>Utility Coordination Study</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td>16311</td>
<td>Utility Three Phase Harmonics Study</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td>16311</td>
<td>Utility AC Power Factor Study</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td>16311</td>
<td>Utility Voltage Distortion</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td>16311</td>
<td>Protective Relay Study and Settings</td>
<td>(30 days prior to shipment)</td>
</tr>
<tr>
<td>16311</td>
<td>Factory Test Procedures</td>
<td>(90 days prior to testing)</td>
</tr>
<tr>
<td>16311</td>
<td>Installation Acceptance and Verification Test Plan</td>
<td>(90 days prior to testing)</td>
</tr>
<tr>
<td>Document Type</td>
<td>Required Time Frame</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>--------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Installation Acceptance and Verification Tests</td>
<td>90 days prior to testing</td>
<td></td>
</tr>
<tr>
<td>Reports</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated Systems Tests Forms</td>
<td>120 days prior to shipment</td>
<td></td>
</tr>
<tr>
<td>Factory Certified Test Reports</td>
<td>10 Days after Testing</td>
<td></td>
</tr>
<tr>
<td>RTU I/O Memory Address Assignments</td>
<td>120 days prior to shipment</td>
<td></td>
</tr>
<tr>
<td>Factory Test Results</td>
<td>Prior to Acceptance</td>
<td></td>
</tr>
<tr>
<td>Record Documents</td>
<td>Prior to Acceptance</td>
<td></td>
</tr>
<tr>
<td>Certification of Completion of Work</td>
<td>Prior to Acceptance</td>
<td></td>
</tr>
<tr>
<td>Certificate of Compliance</td>
<td>Prior to Acceptance</td>
<td></td>
</tr>
<tr>
<td>Special Test Plan</td>
<td>As Required</td>
<td></td>
</tr>
<tr>
<td>Special Test Reports</td>
<td>As Required</td>
<td></td>
</tr>
<tr>
<td>Test Equipment Data and Calibration Certificate</td>
<td>As Required</td>
<td></td>
</tr>
<tr>
<td>Spare Parts and Special Tools</td>
<td>with each TPSS</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>FUNCTION</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>AC SWGR:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC Breaker Close</td>
<td>Control function to &quot;Close &quot; the Main AC circuit breaker (device 52).</td>
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</tr>
<tr>
<td>AC Breaker Open</td>
<td>Control function to &quot;Open &quot; the Main AC circuit breaker (device 52).</td>
<td></td>
</tr>
<tr>
<td>AC Breaker Open (52)</td>
<td>Main AC circuit breaker has been tripped either by the 86H Lockout Relay, by a TRC Fault 2 trip.</td>
<td></td>
</tr>
<tr>
<td>AC Breaker Closed</td>
<td>Main AC circuit breaker, device 52 is racked-in and closed.</td>
<td></td>
</tr>
<tr>
<td>AC Breaker Overcurrent trip (51X)</td>
<td>The overcurrent relay (51) has initiated a trip by the 86H lockout relay (Main AC and main DC breakers will trip and lock-out).</td>
<td></td>
</tr>
<tr>
<td>AC Supply Undervoltage (27)</td>
<td>AC supply power has been lost from the Utility.</td>
<td></td>
</tr>
<tr>
<td>AC Breaker-Local</td>
<td>Indication for control status for the main AC circuit breaker (Breaker cannot be closed remotely when in local position).</td>
<td></td>
</tr>
<tr>
<td><strong>Rectifier Transformer:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xfmr Over-Temp Stage #1 (49T)</td>
<td>Rectifier transformer has an over-temperature condition -&quot;alarm&quot; (49T).</td>
<td></td>
</tr>
<tr>
<td>Xfmr Over-Temp Stage #2 (49TH)</td>
<td>Rectifier transformer has tripped the Main AC and DC main breaker, due to over-temperature (49TH).</td>
<td></td>
</tr>
<tr>
<td><strong>DC Rectifier:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectifier Trouble Alarm</td>
<td>The DC Rectifier has experienced a problem and is not ready for energization.</td>
<td></td>
</tr>
<tr>
<td>Rectifier Over-Temp Stage #1 (26R)</td>
<td>Rectifier has an over-temperature condition -&quot;alarm&quot; (26R).</td>
<td></td>
</tr>
<tr>
<td>Rectifier Over-Temp Stage #2 (26RH)</td>
<td>Rectifier has tripped the Rectifier lock-out relay (device 86H), due to over-temp (26RH).</td>
<td></td>
</tr>
<tr>
<td>Thyristor Failure Stage #1 (98A)</td>
<td>The DC rectifier has experience a thyristor failure - &quot;alarm&quot; (98A).</td>
<td></td>
</tr>
<tr>
<td>Thyristor Failure Stage #2 (98T)</td>
<td>The DC rectifier has tripped the rectifier lock-out relay (device 86H,), due to a second thyristor failure - (98T).</td>
<td></td>
</tr>
<tr>
<td>Rectifier Lock-Out (86H)</td>
<td>The AC rectifier Lock-out relay (86H) has operated due to a fault 3 trip, 50/51 fault, 32-1 fault, smoke/fire alarm, or an ETS trip.</td>
<td></td>
</tr>
<tr>
<td>Rectifier Door open (33R)</td>
<td>The rectifier door has been opened (device 33) and has tripped the AC main and DC main circuit breakers (device 86H).</td>
<td></td>
</tr>
<tr>
<td><strong>DC Enclosure &amp; Negative Bus:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Enclosure -&quot;Live&quot; structure (64R)</td>
<td>The DC structure has a potential and has taken the unit off-line by the lock-out relays (86H and 186H). All breakers tripped and locked out.</td>
<td></td>
</tr>
<tr>
<td>DC Enclosure - &quot;Grounded&quot; (64MR)</td>
<td>The DC enclosure has been grounded and has tripped the AC main breaker, DC main breaker and all DC feeder breakers (86H and 186H).</td>
<td></td>
</tr>
<tr>
<td>Neg Rail Grounding Unit Alarm (57NR)</td>
<td>The voltage between the DC negative return and earth ground has exceeded safe value's-&quot;alarm&quot; setting (alarm only).</td>
<td></td>
</tr>
<tr>
<td>Neg Rail Grounding Unit Sw Closed</td>
<td>Negative bus to ground switch closed due to excessive voltage and current from earth ground to the negative return.</td>
<td></td>
</tr>
<tr>
<td>DC Negative Disconnect Switch Open (89N)</td>
<td>DC negative bus disconnect switch is open (Investigate to see if this goes to SCADA).</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>FUNCTION</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td><strong>DC Positive Main Breaker (Cathode Breaker)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main DC Remote Open</td>
<td>Control function to &quot;Open&quot; the main DC circuit breaker (device 72).</td>
<td></td>
</tr>
<tr>
<td>Main DC Remote Close</td>
<td>Control function to &quot;Close&quot; the main DC circuit breaker (device 72).</td>
<td></td>
</tr>
<tr>
<td>Main DC Breaker Open (72)</td>
<td>Substation DC main circuit breaker is in the open position.</td>
<td></td>
</tr>
<tr>
<td>Station Lockout (186H)</td>
<td>A trip has been initiated by the ETSA relay or 64R/64MR relays. Trips and locks out the DC main circuit breaker and all DC feeder breakers.</td>
<td></td>
</tr>
<tr>
<td>Main DC Breaker - Local</td>
<td>Indication for control status for the Main DC circuit breaker.</td>
<td></td>
</tr>
<tr>
<td>Main DC Breaker Closed</td>
<td>Substation DC main circuit breaker is in the closed position.</td>
<td></td>
</tr>
<tr>
<td><strong>DC Feeder Circuit Breakers</strong> #1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder Breaker &quot;XXXX&quot; Remote Open</td>
<td>OCC remote control function to &quot;Open&quot; the DC feeder circuit breaker (device 172).</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Remote Close</td>
<td>OCC remote control function to &quot;Close&quot; the DC feeder circuit breaker (device 172).</td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Receive, &quot;Allow Reclosure&quot; (85RX)</td>
<td>Feeder Breaker &quot;XXXX&quot; receives &quot;Allow Reclosure&quot; signal from adjoining TPSS. <em>(RTU Output to the 85RX)</em></td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Receive, &quot;Disallow Reclosure&quot; (85NX)</td>
<td>Feeder Breaker &quot;XXXX&quot; receives &quot;Disallow Reclosure&quot; signal from adjoining TPSS. <em>(RTU Output to the 85NX)</em></td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Transmit, &quot;Allow Reclosure&quot; (85R)</td>
<td>Feeder breaker &quot;XXXX&quot; tripped by 176 or 150 device and transmits a Transfer trip &quot;allow reclosure&quot; signal to adjoining TPSS.</td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Transmit, &quot;Disallow Reclosure&quot; (85N)</td>
<td>Feeder breaker &quot;XXXX&quot; tripped by ETSA device and transmits a transfer trip &quot;disallow reclosure&quot; signal to adjoining TPSS.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Breaker Open</td>
<td>Feeder breaker is in the open position.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; in &quot;Local&quot;</td>
<td>Indication for control status for Feeder DC circuit breaker.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Reclosure Lock-Out</td>
<td>Feeder breaker has attempted to reclose and has reached its lock-out settings.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Transfer Trip alarm</td>
<td>Feeder breaker has been &quot;tripped&quot; by the transfer-trip from an adjacent Substation.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; is Closed</td>
<td>Feeder breaker is in the closed position.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; line energized</td>
<td>Indication that the load side of the Feeder Breaker is energized.</td>
<td></td>
</tr>
<tr>
<td><strong>DC Feeder Circuit Breakers</strong> #2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder Breaker &quot;XXXX&quot; Remote Open</td>
<td>OCC remote control function to open the DC feeder circuit breaker (device 172).</td>
<td></td>
</tr>
<tr>
<td>Feeder Breaker &quot;XXXX&quot; Remote Close</td>
<td>OCC remote control function to close the DC feeder circuit breaker (device 172).</td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Receive, &quot;Allow Reclosure&quot; (85RX)</td>
<td>Feeder breaker &quot;XXXX&quot; receives &quot;Allow Reclosure&quot; signal from adjoining TPSS. <em>(RTU Output for 85RX)</em></td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Receive, &quot;Disallow Reclosure&quot; (85NX)</td>
<td>Feeder breaker &quot;XXXX&quot; receives &quot;Disallow Reclosure&quot; signal from adjoining TPSS. <em>(RTU Output for 85NX)</em></td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Transmit, &quot;Allow Reclosure&quot; (85R)</td>
<td>Feeder breaker &quot;XXXX&quot; tripped by 176 or 150 device and transmits a Transfer Trip &quot;Allow Reclosure&quot; signal to adjoining TPSS.</td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT</td>
<td>FUNCTION</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Transfer Trip, Transmit, &quot;Disallow Reclosure&quot;</td>
<td>Feeder breaker 'XXXX' tripped by ETSA device and transmits a transfer trip</td>
<td></td>
</tr>
<tr>
<td>(85N)</td>
<td>&quot;Disallow Reclosure&quot; signal to adjoining TPSS.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Breaker Open</td>
<td>Feeder breaker is in the open position.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; in &quot;Local&quot;</td>
<td>Indication for control status for feeder DC circuit breaker.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Reclosure Lock-Out</td>
<td>Feeder breaker has attempted to reclose and has reached its lock-out</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Transfer Trip alarm</td>
<td>settings.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; is Closed</td>
<td>Feeder breaker is in the closed position.</td>
<td></td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; line energized</td>
<td>Indication that the load side of the feeder breaker is energized.</td>
<td></td>
</tr>
</tbody>
</table>

**DC Feeder Circuit Breakers**

### 3:
- Feeder Breaker "XXXX" Remote Open
  - OCC remote control function to open the DC feeder circuit breaker (device 172).
- Feeder Breaker "XXXX" Remote Close
  - OCC remote control function to close the DC feeder circuit breaker (device 172).
- Transfer Trip, Receive, "Allow Reclosure" (85RX)
  - Feeder breaker "XXXX" receives "Allow Reclosure" signal from adjoining TPSS. * (RTU Output for 85RX)
- Transfer Trip, Receive, "Disallow Reclosure" (85NX)
  - Feeder breaker "XXXX" receives "Disallow Reclosure" signal from adjoining TPSS. * (RTU Output for 85NX)
- Transfer Trip, Transmit, "Allow Reclosure" (85R)
  - Feeder breaker 'XXXX' tripped by 176 or 150 device and transmits a transfer trip "Allow Reclosure" signal to adjoining TPSS.
- Transfer Trip, Transmit, "Disallow Reclosure" (85N)
  - Feeder Breaker 'XXXX' tripped by ETSA device and transmits a transfer trip "Disallow Reclosure" signal to adjoining TPSS.
- Feeder Breaker "XXXX" Breaker Open
  - Feeder breaker is in the open position.
- Feeder Breaker "XXXX" in "Local"
  - Indication for control status for Feeder DC circuit breaker.
- Feeder "XXXX" Reclosure Lock-Out
  - Feeder breaker has attempted to reclose and has reached its lock-out settings.
- Feeder "XXXX" Transfer Trip alarm
  - Feeder breaker has been "tripped" by the transfer-trip from an adjacent Substation.
- Feeder "XXXX" is Closed
  - Feeder breaker is in the closed position.
- Feeder "XXXX" line energized
  - Indication that the load side of the feeder breaker is energized.

### 4:
- Feeder Breaker "XXXX" Remote Open
  - OCC remote control function to "open" the DC feeder circuit breaker. (device 172)
- Feeder Breaker "XXXX" Remote Close
  - OCC remote control function to "close" the DC feeder circuit breaker. (device 172)
- Transfer Trip, Receive, "Allow Reclosure" (85RX)
  - Feeder breaker "XXXX" receives "Allow Reclosure" signal from adjoining TPSS. * (RTU Output for 85RX)
<table>
<thead>
<tr>
<th><strong>EQUIPMENT</strong></th>
<th><strong>FUNCTION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer Trip, Receive, &quot;Disallow Reclosure&quot; (85NX)</td>
<td>Feeder breaker &quot;XXXX&quot; receives &quot;Disallow Reclosure&quot; signal from adjoining TPSS. <em>(RTU Output for 85NX)</em></td>
</tr>
<tr>
<td>Transfer Trip, Transmit, &quot;Allow Reclosure&quot; (85R)</td>
<td>Feeder breaker &quot;XXXX&quot; tripped by 176 or 150 device and transmits a transfer trip &quot;Allow Reclosure&quot; signal to adjoining TPSS.</td>
</tr>
<tr>
<td>Transfer Trip, Transmit, &quot;Disallow Reclosure&quot; (85N)</td>
<td>Feeder breaker &quot;XXXX&quot; tripped by ETSA device and transmits a transfer trip &quot;Disallow Reclosure&quot; signal to adjoining TPSS.</td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Breaker Open</td>
<td>Feeder breaker is in the Open position.</td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; in &quot;Local&quot;</td>
<td>Indication for control status for Feeder DC circuit breaker.</td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Reclosure Lockout</td>
<td>Feeder breaker has attempted to reclose and has reached its lock-out settings.</td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; Transfer Trip alarm</td>
<td>Feeder breaker has been tripped by the transfer-trip from an adjacent Substation.</td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; is Closed</td>
<td>Feeder breaker is in the closed position.</td>
</tr>
<tr>
<td>Feeder &quot;XXXX&quot; line energized</td>
<td>Indication that the load side of the Feeder Breaker is energized.</td>
</tr>
</tbody>
</table>

**Addition SCADA Points:**

| **Intrusion Alarm** | Substation has been entered by unauthorized personnel. |
| **Smoke/fire Panel Alarm** | Fire or excessive heat has been detected - Stage 1 (Alarm shall open the main AC and DC circuit breakers). |
| **Smoke/Fire Panel Trouble** | Notification of malfunction in Fire Detection system. |
| **Battery charger failure** | Battery charger has mal-functioned. |
| **Battery Undervoltage** | The battery system has reached a critical condition and needs immediate attention. |
| **Battery Pos/Neg. Ground Fault** | One leg of the battery has grounded. |
| **TPSS ambient high temp** | Ambient temperature "alarm" setting inside the TPSS has been exceeded. |
| **AC Station Service Power Loss (27A)** | AC station service power has been loss. |
| **AC Signal Power Loss (27B)** | AC Power has been loss at the Signal Service Panel. |
| **AC Switchgear Control Power Loss (27DC)** | DC control power to the DC switchgear has been interrupted. |
| **DC Switchgear Control Power Loss (27DCM)** | DC control power to the AC switchgear has been interrupted. |
| **ETS Trip** | One of the ETS pushbuttons has been activated inside the substation. |
| **Signal Power Cable Ground (64SG)** | One of the 480V signal power cables has to be grounded. |

**Notes:**

1. "XXXX" Circuit Numbers to be provided for each Substation.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes in detail the requirements for the receiving, off-loading, placement, site preparation, and testing for the Traction Power Substations (TPSS). The requirements associated with this Specification include but are not limited to:

1. Receiving, off-loading, and placement of each TPSS Substation.
2. Substation final Ground Grid installation and testing.
3. Substation site work including access roads, grading and sub-surface preparation.
4. Substation foundation construction.
7. Support for “Acceptance Testing” performed by the Contractor.
8. Coordinate incoming Utility Primary Power requirements and service locations with the local utility. Provide and install Utility Power Cable and Conduits.
9. Coordinate the final Utility Meter Installation with the Utility Provider. Install wiring and conduit from Utility Meter to the TPSS.
10. Install and terminate all DC Feeder Cables, Negative Return Cables, and Conduits from the TPSS to each Feeder Pole location as indicated on the Contract Drawings.

B. Contractor shall install complete and operational Substations for use by the Authority as an integral part of the Traction Electrification System (TES).

C. Related Section:

1. Section 16110 – Conduit and Raceways

1.2 REFERENCED STANDARDS

A. Publications: The technical documents and publications pertaining to the requirements for the installation of the Substations are listed in this section and elsewhere in the Contract Documents, and are applicable to the extent cited in these Specifications.

B. Note that some references and publications may be “inactive.” However these Standards shall be used as guidelines and reference values, and therefore are considered for reference.

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)


D. American National Standards Institute (ANSI)

1. ANSI C12.1 - Electric Meters
2. ANSI C12.11 - Transformers, Instruments for Metering
3. ANSI C37.1 - Definition, Specification, and Analysis of Systems used for SCADA
4. ANSI C37.2 - Electric Power System Device Function Numbers
5. ANSI C37.32 - HV Air Switches, Buss Bar Supports Application Guide
6. ANSI C37.34 - Test Code for High-Voltage Air Switches
7. ANSI C37.40 - Service Conditions and Definitions for HV Fuses
8. ANSI C37.46 - Specifications for Power Fuse and Fuse Disconnecting Switches
9. ANSI C37.47 - Specifications for Distribution Fuse Disconnecting Switches and Current Limiting Fuses

E. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 100 - The Authoritative Dictionary of IEEE Standards Terms
2. IEEE C57.12.70 - Terminal Markings and Connections for Distribution and Power Transformers

5. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System


7. IEEE 367 - Recommended practice for Electrical Power Station Ground Potential


10. IEEE 837 - Standard for Qualifying Permanent Connections used in Substation Grounding

11. IEEE1100 - Grounding Electronic Systems

12. IEEE 1106 - Recommended Practice For Installation, Maintenance, Testing, And Replacement Of Vended Nickel-Cadmium Batteries For Stationary Applications

13. IEEE 1115 - Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications

F. International Fire Code (IFC)

1. D103 – Fire Apparatus Access Roads - Minimum Specifications

G. International Organization for Standardization (ISO)

1. ISO 9001 - Quality Management Systems - Requirements

H. National Electrical Manufacturers Association (NEMA)

1. NEMA BU 1 - Busways

2. NEMA CC 1 - Electric Power Connection for Substations

3. NEMA WC 7 - Standard to Cross-Linked Thermosetting Polyethylene Wire and Cable

4. NEMA WC 8 - Ethylene-Propylene Rubber-Insulated Wire and Cable (ICEA S-68-516)

I. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)


3. NFPA 78 - Lightning Protection Code

J. Occupational Safety and Health Administration (OSHA)

1. 29 CFR 1910 – Occupational Safety and Health Standards

2. 29 CFR 1926 – Safety and Health Regulations for Construction

K. Underwriters Laboratory (UL)

1. UL 467 - UL Standard for Safety Grounding and Bonding Equipment

1.3 SUBMITTALS

A. Submit the following in accordance with these Specifications and Contract Documents.

B. Not later than (NLT) 180 calendar days prior to receipt of each Substation

1. Installation Work Plan

2. Substation Lifting and placing plan

C. NLT 30 calendar days after Testing

1. Acceptance test reports

2. Integration test reports

1.4 QUALITY ASSURANCE

A. Contractor shall perform the Work included in this section in compliance with the requirements of these Specifications and in strict accordance with the requirements of the Authority approved Contractor Quality Control Program. Contractor shall as a minimum:

1. Perform inspections and tests during Substation installation, site preparation, ground grid design and installation and conduit placement to guarantee proper and safe operation of systems and subsystems installed by the Contractor.
2. Perform on-site testing for the equipment and materials installed by this Contractor that shall assure that the installation is in compliance with these Specifications.

B. The Authority reserves the right to witness all tests, inspections, and test results.

C. In concurrence with the standard quality control functions, the Contractor shall:
   1. Notify the Authority of all testing, testing procedures, and inspection procedures.
   2. Supply and maintain all field test equipment of proper type, capacity, range, and accuracy required to perform the required tests and inspections.
   3. Maintain all testing equipment in good working order and properly calibrated.
   4. Advise the Authority a minimum of 14 calendar days in advance of each test.

D. When tests are to be conducted continuously, the Authority shall be advised at least 21 calendar days in advance of the start of such tests and duration period in which such tests shall be conducted.

E. Contractor shall perform Quality Control and Quality Assurance practices, procedures, methods, and policies in accordance with these Specifications during all phases of installation including:
   1. Foundation Installation
   2. Site Preparation
   3. Ground Grid Installation
   4. Conduit Placement
   5. Utility and Feeder Installation
   6. TPSS Receiving and Off-loading
   7. Storage (if required)
   8. Acceptance testing support
   9. Integration testing support

F. To demonstrate that the installed equipment conforms to the specified design requirement, the Contractor shall perform all tests for the equipment and cables installed by his Work. Tests shall be performed prior to energizing the equipment and cables.

G. All Substation Work and Site Preparation shall be by personnel with proven experience and who have been regularly engaged in this type of Work.

1.5 TPSS SITE INSTALLATION

A. Contractor shall receive and install the Authority provided Substations in accordance with the quantities, specific locations, and scheduled dates in the Contract Exhibits and Contract Drawings.

B. Each Substation shall be fabricated as a complete packaged Substation and shall include all equipment and materials from the utility termination point in the Substation utility service cubicle to the points of connection to positive feeder cables, and negative-return cables.

C. The Substations shall be factory tested and shall be ready for energization upon off-loading at the project site, placement, and connection to the utility feeder. The TPSS Procurement Contractor shall Field Test and energize each Substation.

D. If Substation final design requires shipping “splits,” the Contractor is responsible for on-site reassembly.

E. Each Substation shall be designed for below grade utility service. Contractor shall provide utility service cables, terminations, conduits, raceways, and miscellaneous hardware required for a full and complete utility service installation.

F. Each Substation shall be designed to provide DC positive service via underground conduits to an Overhead Contact System (OCS) with the negative return by the “running” rails. Contractor shall provide DC Positive feeders, Negative return feeders, terminations, conduits, raceways, and miscellaneous hardware required for a full and complete feeder installation.
   1. The TPSS Procurement Contractor shall provide Positive and Negative DC cable termination “lugs” with each TPSS Unit.

G. Fire apparatus access roads shall be provided and maintained in accordance with IFC D103.

1.6 INSTALLATION WORK PLAN

A. Contractor shall prepare and submit for Authority approval an “Installation Work Plan” for each TPSS site. The Work Plan shall be detailed and inclusive of all site activities from site preparation to Authority final acceptance.

B. Contractor shall schedule the Work activities using the Critical Path Method (CPM) and shall include critical path nodes.
C. The Work Plan shall be prepared using Authority approved software and shall include:

1. Tasking “activities” with task identification and description
2. A time line with activity milestone, activity duration, and completion dates
3. Resource requirements including labor, equipment and materials
4. Percent complete
5. Target start and completion dates for each activity
6. Equipment and material delivery dates

D. Upon beginning the first site activity, the Contractor shall provide monthly a revised CPM and flow charts that depict the most current information available.

E. With the Authority approval, the “TPSS Installation Work Plan” can be part of the overall Work Installation plan.

1.7 UTILITY SERVICE

A. Utility service (3-phase, 3-wire, and 12.47/13.2kV) will be provided by the local Utility Power Company(s).

B. Contractor shall coordinate with the Utility Power Company(s) to verify the nominal service voltage for each TPSS site.

C. Contractor shall coordinate with the Utility Power Company(s) to obtain the utility short circuit Megavolt-Ampere (MVA) and other utility data as required.

D. Contractor shall coordinate with the local Utility for the final “service meter” and shall pay all inspection and/or placement fees as required for final utility service. The Utility shall provide an Interval Data Record or (IDR) Power Factor type meter.

1.8 WARNING SIGNS

A. Contractor shall provide warning and identification signs for each site as required by the final site design. Site warning signs, operational warning, designation labels, and other signs shall be provided for all Substation Sites and equipment.

B. Contractor shall also provide “High Voltage” warning signs for all electrical equipment operating over 600 Volts.

C. Contractor shall install warning and identification signs on fences, pull boxes, catenary poles where appropriate, and other Substation site and feeder locations as required for the safe operation, access, and use of related facilities.

1.9 INSTALLATION

A. Contractor shall provide Substation site installations that are identical as much as possible.

1. Substations and site equipment shall be placed and installed per the individual Contract Drawing site plans. Contractor shall verify all equipment locations, conduit routing, and utility locations prior to installation.

2. Penetrations for conduit, grounding and access panels shall be located in a like manner as required by the equipment furnished.

3. Conduit routing, cable trays, and cables between equipment enclosures shall be by the shortest routing possible. Contract Drawings are for routing reference only.

4. Termination and mounting of hardware shall be located in a like manner.

5. Cables and wire terminations shall be located in a like manner.

1.10 SEISMIC DESIGN CONSIDERATIONS

A. Equipment, conduit, foundations, cable tray, and associate mounting hardware/anchors shall be designed to operate in a Seismic Zone 1 and shall comply with the special seismic design requirements as specified in the International Uniform Building Code (IUBC).

1.11 PRODUCT DELIVERY AND STORAGE

A. General:

1. Contractor shall receive and off-load each TPSS.

2. This section is a guide for Substation handling, storage, and installation. Contractor shall emphasize safety aspects and other considerations in working with this type of equipment. This section supplements, but does not replace, the manufacturer’s detailed instructions. The objective is to provide additional guidelines to promote and enhance a reliable installation.

3. Each Substation shall include 2 sets of instruction books and drawings. The
Operation and Maintenance Manuals (O&M) Manuals shall contain detailed recommendations for storage, handling, installation, operation, and maintenance for the Substation.

4. Personnel responsible for the off-loading, placement, and storage shall review these recommendations before handling the equipment. Particular attention shall be given to recommendations for the preparation of the foundation and forms on which the TPSS is to be installed.

5. One set of O&M Manuals shall remain with the Substation at all times, the second set shall be submitted to the Authority.

**B. Receiving**

1. Each completed TPSS shall be delivered to individual site locations as specified herein or to a storage area designated by the Authority.

2. Contractor shall employ a company fully experienced in handling, rigging and placement of this type of equipment. The Company shall be insured, bonded and approved by the Authority.

3. The Substations will have the following general characteristics. Contractor shall verify exact weights and dimensions prior to shipment:
   - **a. Weight:** 90,000 pounds
   - **b. Height:** 15 feet
   - **c. Width:** 16 feet
   - **d. Length:** 45 feet
   - **e. Lifting Points:** 4 or 6 point

4. Only authorized personnel shall be permitted to handle the equipment. Care shall be exercised in handling each piece of equipment (even if crated).

**C. After Receipt:**

1. Substations may be shipped fully assembled or in shipping sections. If shipping sections are required, no more than 2 shipping splits shall be permitted. Cost for reassembly of Substations at the job site shall be by the Contractor.

2. After receipt, each Substation shall be fully assembled (if shipped in shipping sections), placed on the site foundation, connected to the Utility system, feeders and communications installed, tested, energized and certified to be in full compliance with the Referenced Standards and these Specifications.

1.12 **RIGGING**

A. Contractor shall prepare and submit a rigging and lift plan for Authority approval. The Plan shall be consistent with 29 CFR PART 1910 and 29 CFR PART 1926.

B. Instructions for lifting and handling of the TPSS or each shipping section and/or piece of equipment shall be provided in the O&M Manual and drawings.

C. The rigging shall be adequate for the equipment size and weight.

1.13 **STORAGE**

A. Indoor units that cannot be installed immediately shall be stored in a dry, clean location and shall remain in crates and/or packing during the storage period. The longer the period of storage, the greater the care required for protection of the equipment.

B. Outdoor units shall be placed directly on the Substation foundation if possible. If unit is to be stored, the Substation shall be placed on proper cribbing or ties.

C. During storage, the TPSS shall be placed on a level surface to prevent unnecessary strain and possible distortion.

D. During the construction period, protection shall be provided against dust, dirt, falling objects, dripping water, excessive water, excessive moisture, and other possible causes of damage to the equipment.

E. Temporary covering shall not restrict ventilation and shall not be removed until the equipment is ready for installation.

1. Store equipment in a heated building. If this is not possible, special precautions shall be taken to keep the equipment sufficiently warm with adequate ventilation to prevent condensation during the storage period.

2. If required, temporary heating shall be installed in the equipment.

3. If outdoor switchgear cannot be installed and energized, temporary power must be provided for the operation of the space heaters to minimize condensation of moisture within the housing.
PART 2 -PRODUCTS

2.1 GENERAL

A. All Substations shall be factory tested prior to shipment by the Contractor.

2.2 ACCEPTANCE TESTING

A. AC Switchgear:
   1. Ground Continuity test.

B. DC Switchgear:
   1. Verify all field connections (control and power).
   2. Verify all ground connections.

C. Grounding:
   1. Test all equipment grounds for continuity and resistance.

2.3 INTEGRATION TESTING

A. Contractor shall support the Authority’s Systems Integration testing for each Substation.

B. Integrated testing shall be performed after Acceptance Testing has been completed and prior to acceptance by the Authority. The startup and Integrated testing of the Authority’s Light Rail System will be implemented in Line Sections with separate completion milestones as indicated in the Construction Schedule.

C. Contractor shall be present during the Integration testing to assist in performing system integration, troubleshoot system failures, and assist in any problems that might arise.

2.4 GROUNDING

A. Ground Grid Construction:
   1. The ground mats (AC and DC) that shall be contained within the Substation property lines such that the step-and-touch potentials at the rated short circuit current do not exceed the recommended safety limits of the referenced standards.
   2. The ground mats (AC and DC) shall be constructed from an assembly of driven rods and bare copper conductor. All connections shall be thermo welded and capable of carrying the rated short circuit current. The mats shall typically be located a minimum of 3 feet below finished grade, and shall be constructed and tested prior to the Substation installation.

B. Grounding for Personnel Safety:
   1. In substations, where applicable, bond exposed metallic structure, AC equipment enclosure, ductwork, fencing and metallic piping to the AC ground grid, using minimum of No. 6 AWG, 2000v, green insulated copper conductor for indoor connections and 4/0 AWG, 2000v, black insulated copper conductor for outdoor connections.
   2. In manholes, provide grounding to all metallic components except manhole cover, to a maximum of 25 ohms resistance to ground. If manholes are located within the AC ground grid area, then all manhole metallic components shall be connected to the grid.
   3. Bond and ground exposed metallic structures in open areas to separate grounding electrodes.
   4. Weld all grounding and bonding connections exothermically to metallic structures, metal cable troughs, and metal fences.

C. Field Quality Control:
   1. Test ground resistance of each ground grid after installation and before utility cable connection.
   2. Test each ground bus when connected to ground grid using an Authority approved test procedure. Submit results for Authority approval.
   3. At the conclusion of the Fall-Of-Potential Test for each Substation ground grid, a graph shall be plotted of resistance verses distance showing at least 7 test points that are equally spaced between
the ground grid and the current probe. If the graph does not flatten in the middle, then the current probe shall be relocated 150 feet from the current point and the test performed again. The testing shall end when a flattened portion within the graph is achieved.

4. To meet resistance requirements, install additional ground rods or use soldier piles as ground rods where available. Isolate piles used for grounding from those bonded for stray current and cathodic protection.

5. Test metallic conduit and raceways, equipment enclosures, metallic cable troughs, metal fences, metal hand railings, metallic structures, and light fittings for continuity to grounding system as required by each final site design.

6. Test resistance of connections and conductors between ground buses in TPSS(s) for electrical continuity.

7. Prepare and submit testing certifications for each TPSS site, testing shall be signed by the testing technician, and certified by the CQCR and/or a Professional Engineer licensed in the State of Texas.

2.7 TPSS FOUNDATIONS

A. Contractor shall construct Substation foundations for each TPSS site as required by these Specifications and at the locations indicated on the Contract Drawings.

2.8 AC FEEDERS

A. The electric utility company(s) shall provide to each TPSS 3-phase, 60 Hz power circuits as primary service. The utility power is expected to be provided at 13,200 Volts. However, the Contractor shall field verify each site voltage.

B. A single 3-phase feeder shall be provided to serve each substation. Utility feeder cable and installation shall be provided by this Contract and coordinated with the required electric utility for each substation.

C. The electric utility company(s) will provide the metering equipment.

D. Power Cable, service pole terminations and TPSS terminations shall be provided by this Contract. Connection to the Utility System shall be by the Utility Company.

2.9 DC FEEDERS

A. The DC feeder system shall be furnished and installed by this Contract for each Substation Site and shall include the positive DC feeders from the TPSS to the OCS, the negative DC feeders from the Substation to the rails or impedance bonds, and any underground along-track parallel feeders required to locally reinforce the overhead contact system’s electrical capacity.

B. The system shall also include raceways, pull boxes, manholes, and associated appurtenances for the routing of the feeder cables. Feeder conductors shall be insulated, conform to applicable industry standards and shall be suitable for both wet and dry locations. The raceway shall be underground and the design of the ductwork, the embedment depth, and the manhole spacing shall be in accordance
with the NEC requirements. The routing of the raceways and duct banks and locations of manholes and hand holes shall be as indicted on the final site design and coordinated with the civil and track way design.

C. The positive and negative traction power cables shall be installed in separate conduits and where possible separate manholes, however where installed in the same manhole or exposed locations, the positive and negative cables shall be isolated with barriers, and suitably routed and supported on insulated racks or trays to minimize the possibility of incurring physical damage.

D. Flame-resistant jacketed cables or tape shall be used in such installations. Insulated feeder conductors shall be protected against switching surges and lightning. Lightning arrestors for each feeder cable shall be required on all "riser" poles.

E. No cable splices shall be permitted unless specifically approved by the Authority.

PART 3 - EXECUTION

3.1 FIELD TESTING

A. General Field Testing:

1. The TPSS Procurement Contractor shall perform Substation Field Acceptance Testing.

2. Contractor shall test all equipment and materials that was provided and installed by this Contract.

3. Contractor shall receive, off-load, store as required, and place the TPSS on the site foundation. Contractor shall notify the Authority when the Substation is in place. Contractor shall then inspect and test for shipping damage and shall certify that the Substation is ready for cable and conduit installation.

4. Contractor shall install all utility cables, communications cables, feeder cables, conduits, equipment and other items as required to complete the Substation connection to the utility, communication facilities, and the overhead contact system as required in the Contract Drawings.

5. Contractor Final Field Acceptance testing shall not commence until all Substation field wiring, cable installation, and equipment installation has been completed and accepted by the Authority.

6. Contractor shall prepare all test procedures and test report forms for cables and equipment that the Contractor installs. Contractor shall submit procedures and reports for Authority approval. Procedures and report forms shall be Authority approved prior to commencement of testing.

B. Testing Plan for Contractor Installed Equipment:

1. Contractor shall prepare an installation and testing plan that details the testing procedures that the Contractor shall use in testing the Contractor installed equipment and materials.

2. The Testing Procedures shall address field-installed equipment, cables and other equipment. Present the Plan in a stepwise and logical sequence to ensure that all equipment has been properly installed and ready for service.

3. Field Tests shall be conducted on the Substation field installed equipment and cables preceding energization.

4. The Plan shall identify the approach to be used for accomplishing each of the required tests. The projected schedule for test installation verification procedures, test execution, and submittal of test results shall be included.

5. Testing procedures shall be bound, containing all the forms, testing data, referenced standards, and other related items that will become the record document, "Installation Verification and Acceptance Testing Report." Provide one bound "Testing Plan" for each Substation. With the approval of the Authority the "TPSS Installation Work Plan" can be part of the overall Work Installation plan.

C. Field Testing shall include but will not be limited to:

1. General Field Tests:
   a. Visual conformation checks
   b. Ground verification test
   c. Integrated test support
   d. Field wiring verification of all circuitry
   e. Resistance of ground connections
f. Field wire tags, nameplates, and other identification’s shall be verified for proper nomenclature and location.

g. Each field wiring circuit and bus shall be tested against all other energy buses to ensure no short circuits or faults exist.

2. Grounding Systems:
   a. Verify that grounding system at each Substation is installed in accordance with the Grounding Design.
   b. Verify continuity of ground connections to ground grid and to isolated ground rods.
   c. Test each grounding system using the fall-of-potential method to measure the total resistance to remote ground of the system.

3. SCADA Interface:
   a. This Contract shall perform Field Testing of all cables and connectors to the point of interface with the communications system. It shall be the responsibility of the Contractor to coordinate installed equipment with other Authority Contractors to assure that a complete and operational system is installed.
   b. This Contract shall provide onsite personnel to assist in the Authority Systems Interface testing.

D. Test Procedures:
   1. Contractor shall provide Field Test Procedures and report forms. They shall include:
      a. Objective and scope.
      b. A description of the required test setup, including diagrams, schematics, illustrating test equipment connection set.
      c. Test equipment to be used.
      d. Personnel required for the test.
      e. Estimated test duration.
      f. Data sheets to be used.
      g. Step by step instructions for performing the test, identifying the points where data are to be recorded and the limits for acceptable data.
      h. Instructions for recording data on data sheets or verifying that individual procedure steps have been completed.

E. Test Reports:
   1. Test reports shall document the results obtained and shall be certified by the testing technician, and the Contractor Quality Control Representative (CQCR). Reports shall include the following:
      a. Equipment tested, including model and serial numbers.
      b. Title of test.
      c. Objective of test and pass/fail criteria.
      d. Summary and conclusions.
      e. Location and date of test.
      f. Printed names and signatures of the testing and QC personnel.
      g. Test method and equipment used for test including dates of last calibration and calibration due date.
      h. Results, including calculations, curves, photographs, and other supporting data.
      i. Abbreviations and references.
      j. Include minimum and maximum test values for each test and actual test value with a pass/fail statement.
k. The final report shall be signed and certified by a Professional Engineer licensed in the State of Texas.

3.2 SPECIAL TESTS

A. Contractor shall support Authority’s Special Testing Requirements.

B. The Authority may require special tests on equipment provided under this Contract. These tests are in addition to the Acceptance tests and the Authority Integrated system tests.

C. Special tests shall be performed to verify compliance of the equipment and components with these Specifications.

D. The cost of such special tests required by the Authority on any equipment or component that is proven to comply with the Specifications will be at the expense of the Authority. The cost of special tests on any equipment or component that is proven not to comply with these Specifications shall be at the Contractor’s expense except equipment and components that are Authority provided.

PART 4 - MEASUREMENT and PAYMENT

4.1 GENERAL

A. The payment for the Work, as specified, shall be full compensation for the Work described in this Section. The price shall be full compensation for installing the TPSS complete in place including designing and installing ground grids, duct banks, manholes, shop drawings, submittals, testing, and inspection; and for all Work as described in the Contract Drawings and in this Section and related Specification sections; and for all operations, materials, tools, labor, equipment and incidentals required to complete the specified Work.

4.2 PAYMENT

A. The Work described in this Section will be paid as a lump sum.

END OF SECTION 16312
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for the basic materials and methods for electrical work specified in these Specifications. Requirements contained therein shall prevail over this Section 16350, “Overhead Contact System Basic Electrical Materials and Methods”, in cases of conflict.

B. The work of this Section consists of providing the following basic electrical materials and equipment:

1. Conduit Expansion and Deflection Fittings
2. Metal Framing and Wire ways
3. Hangers and Supports
4. Concrete Inserts
5. Grounding and Bonding Materials
6. Insulated Wire, Cable, and Accessories

1.2 REFERENCED STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI/ASME B1.1 – Unified Screw and Pipe Threads
2. ANSI/ASME B1.13M – Metric Screws: M Profile
3. ANSI C29.1 - Test Methods for Electric Insulators
4. ANSI C37.46 - High Voltage Expulsion and Current-Limiting Type Power Class Fuses and Fuse Disconnecting Switches
5. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated
6. ANSI Z55.1 – Gray Finishes for Industrial Apparatus and Equipment

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

1. ASTM A36 - Structural Steel
2. ASTM A48/ A48M - Gray Iron Castings
3. ASTM A108 - Steel Bars, Carbon, Cold-Finished, Standard Quality
4. ASTM A123/A123M - Zinc (Hot-Dip Galvanized) Coatings for Iron and Steel Products
5. ASTM A153/A153M - Zinc Coating (Hot-Dip) on Iron and Steel Hardware
6. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
7. ASTM A569/A569M - Steel, Carbon (0.15 Maximum, Percent) Hot Rolled Sheet and Strip Commercial Quality
8. ASTM A575 - Steel Bars, Carbon, Merchant Quality, M-Grades
9. ASTM A576 REV B - Steel Bars, Carbon, Hot-Wrought, Special Quality
10. ASTM B3 - Soft or Annealed Copper Wire
11. ASTM B8 - Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
12. ASTM B173 REV A - Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors
13. ASTM B187/B187M - Copper Bus Bar, Rod, and Shapes
14. ASTM B33 - Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
15. ASTM B633 - Electrodeposited Coatings of Zinc on Iron and Steel
16. ASTM D570 - Water Absorption of Plastics
17. ASTM D635 - Rate of Burning and/or Extent and Time of Burning of Self-supporting Plastics in a Horizontal Position
18. ASTM D638 - Tensile Properties of Plastics
19. ASTM D695 REV A - Compressive Properties of Rigid Plastics
20. ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
OVERHEAD CONTACT SYSTEM BASIC ELECTRICAL MATERIALS AND METHODS

21. ASTM D2000 - Classification System for Rubber Products in Automotive Applications (SAE J200)

22. ASTM D2240 - Rubber Property - Durometer Hardness

23. ASTM D2802 - Ozone-Resistant Ethylene-Propylene Rubber Insulation for Wire and Cable

C. American Railway Engineering and Maintenance-of-Way Association (AREMA)
   1. AREMA CH 33-7 - Rail Bonding (Manual of Railway Engineering, Volume II)

D. Federal Supply Service
   1. FS FF-B-588 - Bolt, Toggle; and Expansion Sleeve, Screw
   2. FS FF-S-325 - Shield, Expansion; Nail Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)
   3. FS L-P-387 - Plastic Sheet, Laminated, Thermosetting (For Design Plates)

E. Insulated Cable Engineers Association (ICEA)
   1. ICEA S-19-81 - Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy

F. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 81 - Guide for Measuring Ground Impedance of a Ground System
   2. IEEE 383 - IEEE Standards for Quality Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations
   3. IEEE 1202 - IEEE Standards for Flame Testing of Cables for Use in Cable Trays In Industrial and Commercial Occupancies

G. International Conference of Building Officials (ICBO)

H. National Electrical Manufacturers Association (NEMA)
   1. NEMA AB 1 - Molded Case Circuit Breakers

   2. NEMA RN 1 - Polyvinyl-Chloride Externally Coated Galvanized Rigid Steel Conduit
   3. NEMA TC 2 - Electrical Plastic Tubing (EPT) Conduit
   4. NEMA TC 3 - PVC Fittings for use with Rigid PVC Conduit and Tubing
   5. NEMA VE 1 - Metal Cable Tray Systems
   6. NEMA WC 57 - Standard for Control, Thermocouple Extension and Instrumentation Cables
   7. NEMA WC 70 - Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
   8. NEMA WC 71 - Standard for Nonshielded Cables Rated 2001-5000 Volts
   9. NEMA WD 1 - General Color requirements for Wiring Devices

I. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)

J. Underwriters Laboratories (UL)
   1. UL 5 – Standard for Safety Surface Metal Raceways and Fittings
   2. UL 6 - Standard for Safety Electrical Rigid Metal Conduit
   3. UL 83 - Standard for Safety Thermoplastic-Insulated Wires and Cables
   4. UL 467 - Standard for Safety Grounding and Bonding Equipment
   5. UL 651 - Standard for Safety Schedule 40 and 80 Rigid PVC Conduit
   6. UL 870 - Standard for Safety Wire way, Auxiliary Gutter and Associated Fittings
   7. UL 1277 - Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
   8. UL 1479 - Fire Test for Through – Penetration Firestops
1.3 SUBMITTALS

A. Submit the following in accordance with these Specifications:

1. Manufacturer’s descriptions, catalog data, shop drawings, run sheets, and product information, including cut sheets showing model numbers or item identification.

2. Samples of each type of cable.

3. Manufacturer’s installation instructions.

4. Certified test reports demonstrating that materials comply with the specified requirements and the referenced ANSI, AEIC, ASTM, FS, ICEA, IEEE, NEMA, NFPA and UL standards.

5. Shop drawings of warning signs as required herein under Article 3.6.

1.4 QUALITY ASSURANCE

A. Contractor shall perform the work included in this Section in strict accordance with the requirements of the Contractor’s Quality Assurance Program as Authority approved and in compliance with the requirements of these Specifications.

B. Contractor shall perform the following in accordance with these Specifications:

1. Material qualification testing and certification for acceptance of materials, components, and assemblies.

2. Job control testing of in-progress work being performed in shops, factories, and on-site.

3. On-site inspection of specified work elements.

2.3 METAL FRAMING AND WIREWAYS

A. Metal Framing (Continuous Slot Metal Channel System): Comply with the following requirements:

1. Channel:
   a. Steel, ASTM A569, where used as a raceway, channel shall be listed by UL as complying with UL 5 for use as surface raceway.

2. Configuration:
   a. Single channel or 2 single channels welded together. Channels shall accept spring-held steel nuts.

3. Single Channel Dimensions:
   a. 1-5/8 inch by 1-5/8 inch, 12-gauge

4. Double Channel Dimensions:
   a. 1-5/8 inch by 3-1/4 inch, 12-gauge

5. General Fittings Dimensions, for Flat, Angular and U Shapes:
   a. 1/4 inch thick by 1-5/8 inch wide, unless otherwise indicated.

6. Channel, Pipe Clamps, and General Fittings Finish: Hot-dip galvanized after fabrication, ASTM A123 or A153, as applicable.

2.4 HANGERS AND SUPPORTS

A. Hanger Rods:
1. ASTM A575 or ASTM A576. Threaded, hot-rolled steel, 3/8-inch diameter minimum with electro-deposited zinc coating, conforming to ASTM B633, Fe/Zn 5, Type III.

B. Insulated Tie Plate Assemblies:
1. Fabricated of 2 or more galvanized steel hanger rods, a steel channel horizontal member and U-bolts, clamps and other attachments required for securing hanger rods and conduits.
2. Horizontal Member:
   a. Continuous slot galvanized metal channel single or double, as required.

2.5 CONCRETE INSERTS

A. Continuous Insert:
1. Steel single channel with concrete anchors and continuous slot to accept springheld steel nuts. Channel hot-dip galvanized to ASTM A123 or A153 and filled with expanded polystyrene. Nuts and springs electro-deposited zinc coating according to ASTM B633.

B. Expansion Anchors:
1. FS FF-S-325, Interim Amendment 3, Group VIII, Type 1. Metal shall be ASTM A108 steel with electro-deposited zinc coating according to ASTM B633.

C. Equipment Anchorages:
1. Steel leveling plates, angles, and studs shall comply with ASTM A36.

2.6 GROUNDING AND BONDING MATERIALS

A. Grounding and bonding materials shall comply with UL 467.

B. Ground Rods:
1. Medium carbon steel core, copper-clad by the molten weld casting process and have a conductivity of not less than 27 percent of pure copper. Rods shall be not less than 3/4-inch diameter with lengths as indicated in the Contract Drawings.

C. Ground Conductors:
1. ASTM B3, Class B stranded annealed copper and sizes as indicated.

D. Connectors:
1. Exposed ground connections shall be bolted type of high copper alloy. Terminal lugs on cable ends shall be compression or exothermic-weld type.
2. Buried ground connections shall be exothermic-weld type.

2.7 INSULATED WIRE, CABLE, AND ACCESSORIES

A. High-Voltage Alternating Current (AC) Power Cable:
1. Type: Cables shall be single-conductor, shielded, and required for use on 13.2 KV or 12.47 KV, 3-phase, 60 Hz systems. Cables shall comply with NEMA WC70, type MV-90 or MV-105 and AEIC CS6, and shall be suitable for installation in conduit and ducts. Conductor size shall be as required, but not less than No. 2/0 AWG and the maximum continuous operating temperature rating shall be 194 degrees F.
2. Conductors: Shall be uncoated copper wire in compliance with ASTM B3 and Class B stranded conductor conforming to ASTM B8.
3. Strand Screen: Extruded semiconducting ethylene-propylene-rubber (EPR) thermosetting compound, which shall be clean stripping from the conductor and firmly bonded to the overlying insulation.
4. Insulation: The insulation shall be a flame-resistant, EPR thermosetting compound with minimum average insulation thickness for 133 percent insulation level in accordance with the applicable standards.
5. Insulation Screen: An extruded semiconducting, EPR cover shall be applied directly over the insulation. It shall be plainly identified as being conductive.
6. Insulation Shield: Bare 5 mils thick minimum, copper tape shall be helically
applied over the insulation screen with a minimum overlap of 25 percent.

7. The nonmetallic jacket shall consist of a durable lead-free moisture and sunlight resistant low-smoke, zero-halogen polyolefin (LSZH) compound, with a thickness of not less than 80 mils.

8. Cable Identification: The following information shall be printed on the jacket, in contrasting color, at approximately 2-foot intervals:
   a. Manufacturer's name
   b. Year of manufacture
   c. Conductor size
   d. Voltage rating
   e. Insulation type
   f. Jacket type

9. Cable shall have a written warranty of not less than 40 years.

B. Direct Current (DC) Cable:

1. Type: NEC Type RHW-2, 2000-Volt, single-conductor, non-shielded, suitable for wet or dry installation in conduit, underground ducts, and cable trays. Continuous operating temperature rated at 194 or 221 degrees F, wet and dry, with a hot spot temperature of 230 degrees F.

2. Conductors: Shall be coated, D or G stranding, soft copper wire as specified below. The conductor shall be in compliance with ASTM B8 and B189. Conductor size shall be as shown on the plans and as specified:
   a. Main Feeder (TPSS to Disc Switch): Class D
   b. Catenary Feeder (Disconnect Switch to Catenary wire): Class G
   c. Negative Returns: Class D
   d. DC Surge Arrester: Class D

3. Insulation: The insulation shall be a flame-retardant, ozone-resistant, ethylene-propylene-rubber compound in compliance with ASTM D2802 and NEMA Standards. The minimum average insulation thickness shall be 80 to 90 mils.

4. Jacket: The jacket shall be flame-retardant, ozone-resistant, nonhalogen, cross-linked polyethylene compound, meeting the flame test requirements of UL 1581, IEEE 383 and IEEE 1202. Maximum overall diameter shall not be more than 1.47 inches. The jacket shall be tested in accordance with ICEA Standards.

5. Cable Identification: The following information shall be printed on the jacket, in contrasting color, at approximately 2 foot intervals:
   a. Manufacturer's name
   b. Year of manufacture
   c. Conductor size
   d. Voltage rating
   e. Insulation type
   f. Jacket type

C. Low-Voltage Wire and Cable:

1. UL listed for the intended purpose.

2. Conductors: Soft or annealed copper complying with ASTM B3:
   a. Power Circuits
      1) Size No. 12 AWG, minimum, shall be ASTM B8, Class B stranded conductor.
   b. Control Circuits
      1) Size No. 14 AWG, minimum, ASTM B8, Class B stranded, minimum.
   c. Fixture wiring:
      1) Size No. 16 AWG, minimum, ASTM B8, Class C stranded.
   d. Wire that crosses hinge points shall be flexible Class C stranded.
   e. The conductors shall be insulated with a flame retardant dielectric based on an ethylene-propylene type elastomer meeting UL 1581. The jacket overall shall be mechanically rugged cross-linked polyethylene or thermoplastic.
compound to comply with UL 1277.

D. Color Coding of Conductors:

1. Color code of single-conductor control wires shall be as follows:
   a. 2000 V circuits: black
   b. 480/277 V circuits: blue with yellow tracer
   c. 208/120 V circuits: yellow with blue tracer
   d. Color-coded with base colors and tracers per ICEA and NEMA Standards.

2. Color code of multiple conductor control cables shall conform to NEMA Standards, using colors with stripes on one side and alphanumeric printing on the other side.

3. All external equipment ground wire insulation shall be minimum No. 6 with green insulated jacket.

E. Terminations for Low-Voltage Wire and Cable:

1. Terminal connections shall be UL listed and have capacity and insulation voltage ratings of not less than the ratings of the wire or cable terminated.
   a. Terminals for No. 10 AWG and Smaller Wire:
      1) Except as noted, vinyl-insulated, electro-tin-plated, electrolytic copper locking spade or ring type.
         a) Except as noted, vinyl-insulated, electro-tin-plated, electrolytic copper locking spade or ring type.
      2) Terminals for No. 8 to No. 3/0 wire
         a) Compression-type, tin-plated copper lug.
      3) Terminals for No. 4/0 and Larger Wire
         a) Long-barrel, tin-plated copper,

   4) Connections to the catenary will be by means of parallel clamps with full current carrying capacity.

F. Terminations for 2,000 V Cables:

1. At DC Catenary Disconnect Switches and Feeder Terminations:
   a. Provide cable terminations rated for the maximum current rating of the cable, provide long-barrel, double-indentation, compression-type, non-insulated, tin-plated copper sleeve connectors, with an inspection window.
   b. Provide each connector with 2-hole lug for positive cables and one-hole or 2-hole lugs for negative power circuits. Hole sizes and spacing shall be provided per NEMA standards.
   c. Each connector shall be stamped with the manufacture name, wire size, catalog number and die index number.
   d. The connector shall be color coded so that the proper installing die and crimping tool is selected by matching the die color to the connector color.
   e. All electrical connections shall be cleaned and installed using a compression tool. Connectors shall be installed using an electrical joint compound such as Penetrox or Authority approved equal. Install each connection using a torque wrench. Proper torque shall be per the manufacture recommendations.
   f. Installation hardware shall be as indicated on the Contract Drawings and as recommended by the Manufacturer.

G. Insulation Sleeves:

1. For 2,000 V cable terminations provide heavy-wall, flame-retardant, flexible, heat-shrinkable cable sleeves with thermoplastic adhesive.
H. Wire Identification Markers:

1. Feeder Identification Marker:
   a. Fungus and water-resistant, self-laminating vinyl, with opaque blank write-on section and transparent adhesive section to wrap around the cable and protect printing. Identify cable at both ends.

2. Control Wire Identification Marker:
   a. Fungus and water-resistant, factory-printed, self-adhesive vinyl with printing protected by clear, permanent overcoat. Identify cable at both ends.

I. Wire Tie Wraps:

1. Stainless steel, with stainless steel locking barb and taper, capable of supporting up to three 750 Kcmil insulated feeder cables on cantilever tubes, headspan wires or feeder support wires. A separate, UV resistant, protective cable sleeve shall be provided with each tie wrap for protecting the insulation of the cables against damage from the stainless steel tie wrap.

J. Factory Testing:

1. All UL, ICEA, and NEMA production tests including standard dielectric withstand tests shall be performed on each reel of cable prior to shipment. A certified copy of the design and production test report for each reel of cable shall be provided to the Authority prior to shipment. A copy of the test report shall also be packed with each reel. Test voltage and insulation test requirements shall be in accordance with ICEA and NEMA Standards. Tests may be witnessed by the Authority.

K. Reels and Packing:

1. The cable shall be provided on returnable or non-returnable reels. Reels shall be constructed of rugged materials, and shall afford proper protection to the cable during shipment and handling.

2. A watertight seal shall be applied to each end of the cable to prevent the entrance of moisture during transit or outdoor storage.

3. A durable label shall be securely attached to each flange of each reel. Each label shall indicate the purchase order number, name of manufacturer, reel number, length of cable on reel, description of cable, weight of reel and rolling direction, and source of manufacture.

2.8 SEALING COMPOUND

A. A 2-part silicone foam shall be used to prevent passage of fire, smoke toxic gases and water. Sealing compound shall be rated for 2 hours and UL 1479 listed. Authority approved products include:

1. Dow Corning 3-6548 Silicone RTV Foam, as manufactured by Dow Corning Corporation, Midland, Michigan 48640; or

2. Chase-Foam, CTC PR-855, as manufactured by Chase Technology Corporation, 168 Railroad Street, Huntington Station, New York 11746.

B. Sealing compound shall be installed in accordance with the manufacturer's written instructions.

2.9 CONDUIT CABLE SEALS

A. Provide watertight seal between 750 Kcmil cables and feeder riser conduit on catenary poles and in manholes on all conduits (occupied & empty leading directly to the Traction Power Substation (TPSS).

B. Pressure disc of PVC-coated steel and sealing ring of neoprene.

C. O-Z Gedney type CSBI, CSBE or Authority approved equal. Size as shown, drilled to accommodate cables.

2.10 WORKMANSHIP

A. All equipment surfaces shall be smooth and free of defects, which detract from safe performance and neat appearance. Such defects include, but are not limited to gaps, burrs, sharp edges, wrinkles, waves, and blemishes. Enclosing structures shall possess sufficient reinforcement to maintain structural integrity as well as the safety of their contents through transport, handling, installation and operation.

B. Equipment Metal Enclosures:

1. Enclosures shall be fabricated according to the requirements of the cited references listed in the specifications.

C. Threaded Fasteners:

1. Fasteners shall be Unified-type screw threads with dimensions in inches conforming to ANSI B1.1 (ISO-inch-
Fasteners shall be Authority approved, and the Contractor may use metric fasteners to ANSI B1.13M (ISO-metric) for internal assemblies, or components.

2. Each assembly or component containing ISO-metric threaded fasteners shall be indelibly identified and Authority approved. Additionally, all maintenance manuals shall be conspicuously marked on each page where metric threaded fasteners are used to assemble the component. Spare parts shall contain all required replacement ISO-metric fasteners of the correct size and grade.

D. Surface Treatment:

1. Exposed non-wearing metal surfaces shall be painted. The surface shall first be thoroughly cleaned and treated with an anti-rust coating. The metal finish shall be a semi-gloss paint system that is the manufacturer's standard for the service specified.

2. Unfinished metal surfaces shall be coated with a layer of grease. The grease shall be removable by a petroleum-derived solvent.

E. Finish Color:

1. Enclosures shall have an exterior finish of light gray color No. 61 in accordance with ANSI Z55.1. Interior colors of enclosures shall be the manufacturer's standard for the intended service.

F. Touch-Up:

1. Equipment shall be provided with sufficient finish coat touch-up paint to cover five percent of the metal surfaces.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Installation work shall be in accordance with applicable requirements of NEC, comply with the regulations of International Conference of Building Officials (ICBO) and Public Utility Company (PUC) for electrical service connections.

B. Materials and equipment shall be applied, installed, and connected as recommended by the manufacturer.

3.2 CABLE TRAYS, METAL FRAMING, AND WIREWAYS

A. Trays and wireways shall be supported by cantilever type metal frame support or hangers of sufficient strength to carry combined weights of tray and cable and the dynamic loads imposed during cable pulling.

B. Electrical continuity shall be maintained between sections of steel tray by bolted copper braid and the steel tray connected to local grounding system by green colored insulated wire.

3.3 GROUNDING

A. General:

1. Provide local grounds and connections to DC disconnecting switch enclosures installed at project site.

B. Buried Ground Conductors:

1. Grounding grid conductor shall be as specified. Final design, ground rods, size of conductor, depth of burial, and arrangement of grid shall be by the Contractor and generally conform to the design as indicated on Contract Drawings.

2. Conductor splices, joints, and connections shall be made by the exothermic copper-oxide reduction weld method. Welds shall only be performed by welders experienced in the use of the exothermic welding materials.

3. Finish welds shall be cleaned and coated with an Authority approved cold applied bituminous resin compound. Primer shall be as recommended by the coating manufacturer.

C. Ground Rods:

1. Ground rods shall be driven vertically to a depth required to acquire the calculated ground resistance. Rod point shall be provided with a steel alloy cone and driven end provided with removable driving stud. Problem areas shall be immediately brought to the Authority's attention.

2. For rod lengths greater than 15 feet, sections of standard rod shall be joined with couplings. Top of driven rod shall be at same depth as buried conductor.

3. Ground rods shall be separated from adjacent buried metallic structure or pipe by a minimum of 2 feet.

D. Ground risers shall be fitted with exothermic weld or compression lugs. Lugs shall be 2-hole, attached to equipment by means of bolts.
E. Grounding Grid Resistance Measurement:

1. Ground grid resistance measurement shall be taken by the fall of potential method in accordance with IEEE 81. Contractor shall measure each substation ground resistance to verify that the resistance is as calculated but not more than 2 ohms. If the resistance is greater than 2 ohms, remedial action must be implemented such as adding ground rods to lower the resistance in compliance with this requirement.

2. DC ground grid resistance shall be three ohms or less.

3.4 INSULATED WIRE, CABLE, AND ACCESSORIES

A. General:

1. Wire and cable shall be installed by means of equipment, devices, and methods recommended by manufacturer. High-voltage cable terminations shall be performed by qualified personnel.

2. External wiring and cabling to the TPSS, remote mounted traction power equipment, and other facilities shall be provided in field as indicated. Wiring and cabling shall be terminated and connected, except as indicated, by means of connectors, lugs, and other methods specified.

3. Wire and cable shall be installed, supported and segregated in cable tray, raceway or conduit within manholes and handholes. Contractor shall route cables inside each manhole to allow unobstructed access into manhole. Channel cable supports, racks, an other cable supporting devices shall be used for securing cables to manhole walls. In manholes, cable seals shall be used to seal all occupied or empty conduits that route to the TPSS.

4. Wiring and cabling shall be run end to end without splices, except where indicated otherwise on the Contract Drawings. Each cable shall be identified at each end, and at any intermediate pullbox, by markers as specified in Paragraph 2.7.H in this Section.

5. Interconnecting circuit wiring between equipment panels and cubicles shall be terminated at terminal blocks.

6. Suitable installation equipment shall be provided, to prevent cutting and abrasion of conduit and wire during the pulling of feeders.

7. Masking or other means shall be used to prevent obliteration of cable identifications when solid-color coating or colored tracers are used.

8. Cables to be installed in a single conduit shall be pulled together.

9. The manufacturer’s recommended pulling tension or sidewall pressure shall not be exceeded.

10. Refer to these Specifications for cable testing requirements.

B. Power Cabling:

1. AC and DC circuits consisting of multiple single conductors shall be grouped and pulled together in the designated raceway. Conductors shall be continuous from end to end without splices, except where indicated. Adequate slack shall be provided at terminations and in pullboxes, handholes, and manholes.

2. Bundle circuit conductors neatly and securely to cable trays with specified strap. Cables entering equipment panels and cubicles shall be spaced and tied to supports provided.

3. Cables shall be identified at each end of circuit and at any intermediate pullbox, handhole, or manhole by specified markers. Cables shall also be identified at 10 feet intervals in cable trays.

C. Control Wiring:

1. Unless otherwise specified, multiconductor control wiring with 600 V or 2000 V insulation between equipment panels and cubicles shall be installed in designated conduits and raceways separate from those used for power cables. Multiconductor cables installed in the same conduit shall be pulled together.

2. Control wiring shall be run from end to end without splices. Each multiconductor cable shall be identified at each end, and at any intermediate pullbox, handhole, or manhole by specified markers. Control wiring shall be identified at 50 foot intervals in cable trays.

3. Control cable shall be neatly laid and grouped in cable tray and secured by specified strap. Cable entering
equipment panels or cubicles shall be supported and secured to prevent tension on terminations. Adequate slack cable shall be provided and each wire terminated shall be double looped.

4. Interconnecting circuit wiring between equipment panels and cubicles shall be terminated at terminal blocks.

5. Equipment panel and cubicle wiring shall be run in wireways and each conductor shall be continuous without splices or taps from terminal to terminal.

6. Wiring within DC switchgear and disconnecting switch compartments and cubicles shall be shielded from primary current conductors by flame-resistant insulating barriers.

7. Wiring within high-voltage AC equipment compartments shall be shielded by a grounded metal screen.

8. Interior wiring within equipment panels and cubicles shall be identified at each termination with the equipment manufacturer’s wire number by a marker as specified with imprinted identification.

3.5 WARNING DEVICES

A. Wire Termination:

1. Power wiring shall be terminated with specified connector. Provide adequate slack wire, one loop minimum, to prevent strain on termination.

3.6 WARNING SIGNS

A. Attach specified warning signs to exterior surfaces of DC disconnecting switch enclosure access doors with tamperproof mechanical fasteners.

3.7 FIELD TOUCH-UP

A. Galvanized Metal Surfaces:

1. Coat damaged surfaces, to the strength and finish of the original coating, with polystyrene organic rich compound containing not less than 91 percent by weight metallic zinc powder in dried film.

B. Painted Metal Surfaces:

1. Clean, treat, and coat damaged surfaces with required rust inhibiting undercoating and finish coat paint system in accordance with manufacturer's instructions.

C. Fiberglass:

1. Reinforced Polyester Enclosures: Repair damaged surface with materials and methods recommended by manufacturer.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the Work specified under Section 16371 “Overhead Contact System.”

END OF SECTION 16350
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section includes providing, installing, and testing complete grounding and bonding systems.

B. For related Work specified elsewhere, refer to these Specifications.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
   2. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   3. ASTM B187/187M - Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes

B. Institute of Electrical and Electronics Engineering (IEEE)
   2. IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
   4. IEEE 142 – Grounding of Industrial and Commercial Power Systems
   5. IEEE 367 (R2000) - Recommended Practice for Determining the Electrical Power Station Ground Potential Rise and Induced Voltage from a Power Fault
   6. IEEE 837 – Standard for Qualifying Permanent Connections used in Substation Grounding

C. National Electrical Safety Code (NESC)

D. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (NEC)

E. Underwriters Laboratories (UL)
   1. UL 467 - Standard for Safety Grounding and Bonding Equipment.

F. Source Quality Control
   1. Each Item UL- Listed

1.3 SUBMITTALS

A. Submit the following for approval in accordance with these Specifications, and with the additional requirements as specified for each.

B. Shop Drawings
   1. Thirty days prior to installation, submit procedures and equipment for testing resistances and electrical continuity.

C. Certification
   1. Seven days after testing has been completed, submit certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to the ground grid does not exceed specified values.

D. Traction Power Substation (TPSS) Final Design
   1. Provide site-specific final grounding design for each TPSS Site. Employ the services of a firm experienced in “ground grid” design. The final design shall be developed with grounding analysis software to formulate a design that consists, as a minimum, of the following:
      a. Site testing for soil resistivity
      b. Ground system resistance
      c. Ground potential rise
      d. Step, touch, and absolute potential inside and outside the grid
      e. Installation drawings compatible with the Authority CADD system
      f. Grounding system compliance testing
      g. A complete Bill of Material
2. Provide drawings, calculations, and final design for Authority approval for each TPSS site 90 days prior to beginning site work for each TPSS.

3. All calculations shall be signed and sealed by a Licensed Texas Professional Engineer.

1.4 QUALITY ASSURANCE

A. The following codes, regulations, Reference Standards, and Specifications apply to the Work included in this Section:

1. The codes and regulations of the jurisdictional authorities
2. NEC
3. UL: 467
4. ASTM: B187, A666, B8
5. IEEE 80/81
6. NESC
7. NFPA

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. Grounding and Bonding Equipment:

1. General Requirements: UL 467
2. Ground Rods
   a. Copper clad steel or other material as shown on drawings. Minimum dimensions: 3/4 inch diameter by 15 feet long unless otherwise indicated.
3. Grounding Electrode Conductors
   a. Stainless steel or copper conductor, as shown on drawings.
   b. Size unless otherwise shown:
      1) For use in ground grid and for connecting of ground grid to ground bus and OCS pole base to ground rod: No. 4/0 AWG or as shown on Drawings.
      2) For other grounding electrode conductors: In accordance with NEC Table 250-94.
4. Equipment Grounding Conductor
   a. Sized in accordance with NEC Article 250-95 unless otherwise shown on Drawings.
   b. Equipment grounding insulated conductor.
   c. Equipment grounding bare conductor integral with multiple-conductor cable.
5. Terminal Lugs
   a. For No. 4/0 AWG and Smaller Conductors: Cadweld or copper compression terminal lugs as indicated.
   b. For 250 kcmil and Larger: Long barrel, copper, double-compression terminal lugs.
6. Ground Connector
   a. O-Z Gedney, Type KG or approved equal.
   b. Two-piece, designed for connecting grounding conductor to bus bar.
   c. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.
   d. Exothermic Weld: Size and type per manufacturer’s recommendations.
7. Jumpers
   a. Insulated copper braided or leaf-type flexible jumper, size as required.
8. Coal Tar Epoxy
   a. Polyamide cured coal tar epoxy, Dupont Corlar 823 CTE, Koppers Company No. 300M, PPG Industries 97-640 or 97-641 or approved equal, applied to a dry film thickness of 8 mils. per coat.
9. Epoxy Resin Encapsulation
   a. Two-Component epoxy resin type with plastic snap mold, as manufactured by Duriron Company, 3-M Company or approved equal.
PART 3 - EXECUTION

3.1 GROUNDING

A. Ground Connections:

1. Weld buried ground connections exothermically, in accordance with manufacturer's recommendations. Clean and coat with coal tar epoxy applied with a 32 mils dry film thickness using multiple coats. Allow drying between coats and before backfilling. Encapsulate with epoxy resin, all buried ground connections of grounding electrode conductors running to ground buses as shown.

2. Use two-hole terminal lug to connect grounding conductor to equipment enclosure. Secure connector or terminal lug to the conductor so as to engage all strands equally by using tools and pressure recommended by the manufacturer.

3. Exothermically weld connections for ground rods in manholes and handholes, as shown.

4. Splices shall not be permitted in grounding conductors.

B. Equipment Grounding:

1. Disconnect Switches
   a. Connect continuous equipment ground bus by copper ground wire to building or facility ground bus.
   b. Provide ground wire equal in size to largest conductor in line feeding equipment, but not less than No. 6 AWG, nor larger than No. 4/0 AWG.
   c. Install ground wire in rigid steel conduit bonded at both ends.

2. Wiring, channels, metallic conduit, rigid galvanized steel, flexible conduits, metallic boxes, panelboards, and transformer enclosures: Ground the ground bus with copper ground conductors sized as specified.

3. Overhead Catenary System Surge Arrestors
   a. Surge arrestors shall be installed to protect the OCS system at connection points to feeders, disconnect switches and on each track at interlockings. Ground in accordance with drawings and with requirements of these Specifications. Provide rigid steel conduit from lightning arrester ground connection extending down to the base of the catenary pole for connection to the ground electrode.

4. Grounding for Personnel Safety
   a. In manholes, provide grounding to all metallic components except manhole cover, to a maximum of 25 ohms resistance to ground.
   b. Weld all grounding and bonding connections exothermically to metallic structures, catenary poles, cable troughs, and fences.

3.2 FIELD QUALITY CONTROL

1. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.

2. To meet resistance requirements, install additional ground rods or use soldier piles as ground rods where available. Isolate piles used for grounding from those bonded for stray current and cathodic protection.

3. Test metallic conduit and raceways, equipment enclosures, metallic cable troughs, fences, hand railings, metallic structures, and light standards for continuity to grounding system.

4. Conduct tests in presence of the Authority.

5. Prepare and submit certifications as specified.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the Work specified under Section 16371 "Overhead Contact System."

END OF SECTION 16351
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work specified in this Section includes the final design, providing all labor, materials, tools, equipment, services, and incidentals for the installation, testing and commissioning of the Overhead Contact System (OCS) in conformance with the project requirements as defined in the Contract Documents including Drawings and these Specifications.

B. This OCS Work includes, but is not limited to, the following elements:

1. Final OCS design based on the Drawings and Specifications.
   a. The catenary system shall consist of the conductors, hangers, feeders, jumpers, and other assemblies from which the light rail vehicles collect electrical power.
   b. The physical support system shall consist of steel poles to be installed on concrete foundations, pole bonding, pole bands/attachments, cantilevers, pull offs, cross-spans and headspans and other assemblies and components required to support the OCS.
   c. The OCS feeder system shall consist of the following facilities:
      1) Feeder System: Provide 750 kcmil, 2000 V DC feeder and negative return cables from the substation to the OCS. The Work shall include all connections from the substation to the clamped connections at the OCS. Contractor shall supply 750 kcmil, 2000 V DC cables, lugs, cable supports in manholes, conduits, clamp connectors, tie wraps, and hardware for the performance of the Work.
      2) OCS Sectioning: Provide pole-mounted hand operated disconnect switches, 750 kcmil, 2000 V DC feeder cables, including assemblies, operating mechanism, and components to terminate, connect and support the cables from the pole-mouted hand operated disconnect switches to the OCS.

3) Where indicated, provide motor operated disconnect switches including 125 V DC control cables, 2000 V DC feeder cables including assemblies, conduits and components required to support, terminate and connect the cables from the disconnect switches to the OCS.

C. Contractor shall be responsible for the OCS final engineering details, to include the following:

1. Verification of existing field conditions and location of the OCS pole and anchor foundations shown on the Contract Drawings.
2. Selection and/or design of OCS assemblies and components, meeting the dimensional, loading and performance requirements included in the Contract Documents. Design details of assemblies and components by the Contractor shall conform to the requirements of the North Central Texas Council of Governments (NCTCOG) - Standard Specification for Public Construction. Double insulation shall be required.
3. Pole design modifications, if required, by the Contractor shall comply with the loadings specified on the Contract Drawings.
4. All OCS support attachments.
5. Preparation of Contractor-related designs in support of installation including working drawings, structural erection drawings, checking of installation and technical charts shown on the Contract Documents, and preparation of as-built.
6. Preparation and submittal of shop drawings, calculations and data to verify the adequacy of any designs.
7. Engineering design related to any substitutions requested by the Contractor shall be Authority approved.

D. Contractor shall be responsible for procurement and installation of all materials and components required in the Work, in conformance with the project requirements as defined in the Contract Drawings and Specifications.
E. The Work includes field support for integrated system test and startup, testing and commissioning of the completed OCS, including any modifications and adjustments found required for satisfactory performance.

F. The Work includes training of the Authority staff responsible for operating and maintaining the OCS, including preparation of operation and maintenance manuals, and on-site technical support as required.

G. Related Sections:
1. Section 05124 - Overhead Contact Systems - Steel Pole Wide Flange
2. Section 05125 - Overhead Contact System - Fabricated Metal Supports
3. Section 05126 - Overhead Contact System - Steel Tubular Poles
4. Section 16350 - Overhead Contact System Basic Electrical Materials and Methods
5. Section 16351 - Overhead Contact System Grounding and Bonding

1.2 REFERENCED STANDARDS

A. American Institute of Steel Construction, Inc. (AISC)
1. AISC - "Manual of Steel Construction"
2. AISC - Specifications for Structural Joints Using ASTM A325 or A490 Bolts

B. American Society of Mechanical Engineers (ASME)
1. ASME B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form)
2. ASME B18.2.1 - Square and Hex Bolts and Screws (Inch Series)
3. ASME B18.22.1 - Plain Washers-Reaffirmation and Redesignation of ASA B27.2-1965

C. American Iron and Steel Institute (AISI)
1. AISI C1035 to C1045 SBQ - Forged Steel
2. AISI Types 302 and 304 - Stainless Steel

D. American National Standards Institute (ANSI)
1. ANSI C76.1 - Outdoor Apparatus Bushings, Requirements and Test Code
2. ANSI Z55.1 - Gray Finishes for Industrial apparatus and Equipment

E. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
1. ASTM A27/A 27M - Standard Specification for Steel Castings, Carbon, for General Application
2. ASTM A47/A 47M - Standard Specification for Ferritic Malleable Iron Castings
4. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Hardware
5. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
6. ASTM A313/ A313M - Standard Specification for Stainless Steel Spring Wire
8. ASTM A368 - Standard Specification for Stainless Steel Wire Strand
9. ASTM A475 - Standard Specification for Zinc-Coated Steel Wire Strand
10. ASTM A490 - Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
11. ASTM A492 - Standard Specification for Stainless Steel Rope Wire
12. ASTM A493 - Standard Specification for Stainless Steel Wire and Wire Rods for Cold Heading and ColdForging
15. ASTM A563 REV A - Standard Specification for Carbon and Alloy Steel Nuts
16. ASTM A668/ A 668M - Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
17. ASTM A711 - Standard Specification for Steel Forging Stock
19. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire
20. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
22. ASTM B33 - Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
23. ASTM B47 REV A - Standard Specification for Copper Trolley Wire
25. ASTM B173 REV A - Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors
26. ASTM B179 - Standard Specification for Aluminum Alloys in Ingot and Molten Forms for Castings from All Casting Processes
27. ASTM B187/ B187M - Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes
28. ASTM B248 - Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar
29. ASTM B249/B249M - Standard Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings
30. ASTM B584 - Standard Specification for Copper Alloy Sand Castings for General Applications
33. ASTM D116 - Standard Test Methods for Vitrified Ceramic Materials for Electrical Applications
34. ASTM F436 - Standard Specification for Hardened Steel Washers
35. ASTM F467 REV A - Standard Specification for Nonferrous Nuts for General Use
37. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
38. ASTM F594 - Standard Specification for Stainless Steel Nuts

F. Federal Highway Administration (FHWA)
1. FHWA - Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects

G. Industrial Fastener Institute
1. IFI B18.23.1 - Beveled Washers

H. Insulated Cable Engineering Association (ICEA)
1. ICEA S-19-81 - Rubber Insulated Wire and Cable for Transmission and Distribution of Electrical Energy
2. ICEA S-68-516 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy

I. Institute of Electrical and Electronic Engineers (IEEE)
1. IEEE C37.34 - Test Code for High-Voltage Air Switches
2. IEEE 80 - Guide for Safety in Alternating Current Substation Grounding
4. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems
OVERHEAD CONTACT SYSTEM

5. IEEE 383 - Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations

J. National Electric Manufacturing Association (NEMA)
   1. NEMA C29.1 - Test Methods for Electrical Power Insulators, including Addenda C29.1a and C29.2a
   2. NEMA C29.2 - Wet Process Porcelain Insulators (Suspension Type)
   3. NEMA C29.7 - Wet Process Porcelain Insulators (High-Voltage Line-Post Type), including Supplement C29.7a
   4. NEMA C29.8 - Wet Process Porcelain Insulators (Apparatus, Cap and Pin Type)
   5. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
   6. NEMA ICS 1 - Industrial Control and Systems General Requirements
   7. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts
   8. NEMA SG 5 - Power Switchgear Assemblies
   9. NEMA HV-1 - Insulators, High-Voltage
   10. NEMA WC-7 - Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-66-524)

K. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
   2. NFPA 78 - Lightning Protection Code

L. National Electrical Safety Code (NESC)
   1. Rule 264 - Guying and Bracing

M. North Central Texas Council of Governments (NCTCOG)
   1. Standard Specifications for Public Works Construction (NCTCOG Standard Specifications)

N. Underwriters’ Laboratories, Inc. (UL)
   1. UL 467 - Grounding and Bonding Equipment

2. UL 1581 - UL Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords

1.3 SUBMITTALS

A. Proof of Prior Service of Equipment: All proposed materials, components, equipment, and hardware items shall be service proven, with a record of at least 5 years successful use on similar light rail installations. Submit evidence of said service-proven history as requested by the Authority. A lesser period of service record will be allowed only if satisfactory performance can be guaranteed by the supplier; and, if Authority approved.

B. Shop Drawings: Shop drawings shall be submitted prior to fabrication. Included as a minimum shall be:
   1. Final design and calculations for all OCS assemblies.
   2. Physical and electrical characteristics of conductors.
   3. All OCS Manufacturer's arrangement drawings.
   4. Catalog data.
   5. Erection drawings.

C. Samples:
   1. Samples of conductors from each manufacturing batch shall be provided in lengths and quantities requested by the Authority or specified in the applicable standard.
   2. Samples of nameplates for disconnect switch enclosures.

D. Certification: A certification shall be provided by the manufacturer, verifying that the conductors, cable, wire rope, hardware, switches, insulators, and surge arresters have been designed, manufactured, inspected and tested in accordance with applicable portions of the referenced standards and these Specifications.

E. Test Reports: 6 certified copies of manufacturer's test reports for the specific conductors or equipment provided and any other test reports as may be requested by the Authority.

F. Section Insulators:
   1. Shop drawings shall include as a minimum:
      a. Creepage length (inches)
OVERHEAD CONTACT SYSTEM

b. Insulation level (impulse withstand test voltage, kV)
c. DC test voltage (kV)
d. Attachment centers or overall length (inches)
e. Shed diameters (inches)
f. Core diameters (inches)
g. Breakdown of weights, insulator and fittings (pounds)
h. Tensile withstand load (pounds)
i. Cantilever withstand load (pounds)
j. Recommended Maximum working tensile load (inch-pounds)
k. Recommended Maximum working cantilever load (inch-pounds)
l. Material (including end caps and touch-up insulator sealants)

2. Manufacturer's design safety factors.
3. Drawings of hardware and components.
4. Listing and description of components and hardware.
5. Drawings and specifications required for field forming and setting of contact wire into items, including gliders.
6. For assemblies, list values of BIL, ultimate tensile strengths, ultimate torsional strength, weights (including weight of components), and electrical characteristics.
7. Instruction Manual: Instruction Manuals shall be provided covering complete instructions for installation, maintenance and testing. Complete replacement parts lists shall be included.
8. Test Reports: 6 certified copies of reports of the following tests shall be provided.
   a. Prototype tests
   b. Production tests
   c. Field tests
9. The manufacturer shall submit full information, with supporting documentation, on the in-service history of the section insulators to be provided in accordance with these Specifications.

G. Surge Arresters:
   1. Complete manufacturer's descriptions, catalog data, and information including model number.
   2. Manufacturer's general detail and arrangement drawings, and installation instructions.
   3. Schematic wiring and interconnection diagrams.
   4. Method for attaching surge arrester to the pole and routing of the conduit from the surge arrester to the grounding system.
   5. Operation and Maintenance Manual with list of spare parts.

H. Jumpers
   1. Formulas used to establish the overall jumper lengths
   2. Actual field jumper length measurements

I. Cantilevers
   1. Heel settings for each cantilever and steady arm.
   2. Details of the temporary restraints.

J. Cross-span and Headspan Assemblies: Field changes from the design.

K. Messenger and Contact Wire
   1. Proposed methods of wire stringing installation.
   2. Method of prestressing the conductors.

L. Section Breaks
   1. Proposed procedure for construction of section breaks, including type and installation of the 4 bolt contact wire clamp, insulated hangers and insulation.

M. Disconnect Switches
   1. Test plan, which demonstrates that each switch is correctly wired from the Traction Power Substation (TPSS). Plan shall include continuity, voltage measurement and point-to-point verification.
2. Wiring schematic for motor operated disconnects.

N. Feeder Risers
1. Data describing the proposed riser material.
2. Methods proposed to support and attach the conduit risers to the OCS pole.

O. Insulated Cables: Pull tension calculations.

P. Cable Terminations
1. Data on the termination method, when a special type of termination is recommended by the equipment supplier.
2. Samples and test data for new or untried termination devices, including on-site tests and demonstrations when requested by the Authority.
3. Schedule of proposed wire tagging.

Q. Special Tools for OCS Installation
1. Shop drawings showing details and dimensions of all products and assemblies, together with complete specifications of materials proposed for components.
2. Certified statements verifying that the height/stagger gauges and super-elevation/step gauges conform to the performance requirements.

R. OCS Testing and Commissioning
1. Test Program Plan: Contractor shall submit, a Test Program Plan for Authority approval. The purpose of this plan is to ensure that the Contractor has considered all of the testing requirements contained in this and other sections of the specifications, and has made adequate provisions for testing in his overall program plans and schedules, and to achieve an early mutual understanding on the range, depth and other aspects of tests to be conducted. The Test Program Plan shall contain as a minimum the following data:
   a. A flow diagram indicating the logical sequence of tests, starting with factory tests and continuing on to conclude with field demonstration tests.
   b. A list of test procedures (by test procedure number) to be submitted, preliminary submittal schedule, a preliminary schedule of tests, and a brief description of each factory and field test. The schedule portion of the program plan shall be a dynamic document to be updated as the program progresses.
   c. An outline and format of the procedure and test data sheets for each type of test.
   d. Requirements and recommendations for witnessing by the Authority or designated representative.
   e. A description of the Contractor's in-plant and field test organization.
   f. A detailed Safety Program defining all precautions to be taken, notices, signs and barriers to be posted concerning the safety of the public, work personnel and equipment. The program shall define precautionary measures to be taken prior to, during and following the test until such time as normal Work is resumed.
2. Test Procedures: Test procedures shall be submitted for Authority approval at least 45 days in advance of the scheduled test. The test procedure shall include, as a minimum: Objective and scope; test setup; test equipment to be used; personnel required for the test; estimated duration of the test; pass/fail criteria; and samples of data sheets to be used.
3. Test Reports: 6 certified copies of Test Reports shall be submitted for Authority approval within 15 days after completion of tests. Test reports must contain all the data obtained during tests, an analysis of the data and conclusions relating to the test pass/fail criteria outlined in the test procedure.
4. Insulated Telescoping Height Measuring Sticks: Contractor shall supply a catalog cut of the specified insulated telescoping height measuring stick, or a complete technical description of any proposed alternative.
5. Optical Stagger Gauges: Contractor shall supply complete catalog information on the specified optical stagger gauges, or shop drawings and a working description of any proposed alternative.
6. Mobile Height and Stagger Gauges: Contractor shall supply shop drawings and outline specifications for the mobile height and stagger gauges, fully describing the following:
OVERHEAD CONTACT SYSTEM

a. Materials used
b. Construction
c. Assembly/Disassembly
d. Operation without clearance "ears"
e. Installation of clearance "ears", and safeguards for use
f. Track superelevation compensation
g. Means for keeping gauge in adjustment
h. Proposed spare parts

7. Completed Acceptance Measurements Tables

1.4 QUALITY ASSURANCE

A. Comply with the Codes and regulations of the local jurisdictional authority.

B. Contractor shall perform the Work included in this section in strict accordance with the requirements of the Contractor’s Quality Control Program as Authority approved. Comply with the requirements of the Quality Control Sections of these Specifications.

C. Appearance of OCS: All proposed components, equipment, and hardware items shall have a neat and attractive appearance when installed as part of the OCS. Individual components, equipment, and hardware items shall uniformly blend together in line and color, with a minimum number of fittings and discontinuities, to make up complete, neat and attractive assemblies.

D. Contractor shall perform the following:

1. Material qualification testing and certification for approval of materials, components and assemblies.
2. Job control testing of in-progress Work being performed in shops, factories and on-site.
3. On-site inspection of specified Work elements.

E. Functional tests shall be performed on each component assembly and shall be designed to demonstrate that the equipment will perform correctly for its intended application.

F. Materials and components manufactured to applicable foreign standards, including metric standards, will be Authority approved, provided that the Contractor submits written evidence, in the English language, that they are equal or superior to those complying with the standards listed above, and that written approval is obtained from the Authority. Weights and dimensions shall be converted to English units.

1.5 CONSTRUCTION SEGMENTS AND COORDINATION

A. Contractor shall be responsible for scheduling and construction phasing, including coordination with other contracts. Construction of the OCS shall be performed as shown on the Drawings and specified herein.

B. Interface Control: In addition to the requirements specified in the specifications, the Contractor shall:

1. Manage the physical, functional, and schedule interfaces between the OCS and other light rail transit system element contracts.
2. Verify form, fit and function between and among the subsystems, assemblies, and components comprising this OCS element.
3. Contractor shall verify compatibility of the OCS with other affected system elements.

C. Coordination: Contractor shall interface with other contractors through the office of the Authority. Contractor shall respond in writing to information and data requests from the Authority within 5 days of written receipt. Information and data shall be exchanged freely.

D. Contractor’s Responsibility:

1. Contractor shall design, fabricate, install and commission equipment so that the equipment and their elements perform their intended functions in concert with equipment and facilities provided under other contracts. In addition, the Contractor shall perform coordinating functions to assure compatibility of equipment provided by subcontractors under control of the Contractor.

2. Contractor shall assure that Authority approved changes are correctly implemented.

3. Contractor shall participate in formal reviews of the Work with the Authority. The management and control of interfaces will be agenda items at these reviews.

E. Other Construction Contracts: Contract Drawings and Specifications for other construction contracts, which interface with the OCS construction, will be made available for reference only at a location designated by the Authority.
1.6 TYPES OF OCS

A. Simple Catenary Auto-Tensioned (SCAT) System: The SCAT system used shall be supported from cantilevers or headspans attached to wide flanged or tubular tapered galvanized steel poles anchored to cast-in-place reinforced concrete pier foundations. The catenary shall be tensioned by means of counterweights. SCAT shall be used in the main line open route.

B. Simple Catenary Fixed Termination (SCFT) System: The SCFT system shall be supported from existing and new cross-spans, headspans, new cantilevers and 2 track cantilevers attached to wide flange and tapered tubular poles. The catenary shall have fixed ends and the conductor tensions shall vary with changes in temperature.

C. Single Wire Fixed Termination (SWFT) System: The SWFT system shall be supported from cross-spans, backbones and cantilevers attached to galvanized steel poles, anchored to cast-in-place reinforced concrete pier foundations.

PART 2 - PRODUCTS

2.1 MATERIALS - GENERAL

A. Materials provided for the OCS shall be standard products of manufacturers regularly engaged in the production of the materials specified. Materials specified in the Contract Specification shall be used in the OCS where applicable. In case of conflict between requirements specified in other Contract Specifications and this Contract Specification Section 16371 “Overhead Contact System”, the provisions of this Section shall prevail.

2.2 GROUNDING AND BONDING SYSTEM

A. The Work specified in this Article includes the providing of the grounding and bonding systems for the OCS, as shown on the Contract Drawings and specified herein.

B. Grounding and bonding materials are described in these Specifications and as specified herein.

C. The grounding and bonding systems shall be installed in accordance with the Contract Drawings and Specifications, and shall meet the requirements of the NEC and the technical and safety recommendations of ANSI and IEEE.

D. Connectors and Clamps: Connectors shall be as specified in these Specifications. Bolts, washers, and stop nuts shall be of high-copper alloy, Everdur, Durium, Duronze or silicon bronze. Ferrous hardware will not be Authority approved.


F. Exothermic Welding Materials: All tools, molds and other required materials for exothermic welding shall be manufactured or recommended by one supplier to insure consistent and satisfactory quality of welds.

2.3 BARE CONDUCTORS

A. The Work specified in this Article includes providing conductors used in the OCS as messengers, contact wire, jumpers, bare feeders and ground wire, as shown on the Contract Drawings and specified herein.

B. All material shall be of such composition, quality, and purity, that the finished product will have the properties and characteristics described in this Specification.

C. For installation see Article 3.10 of this Section.

D. Contact Wire: 350 kcmil hard drawn copper cable, solid grooved, conforming to ASTM B47.

E. Messenger Wire: 500 kcmil hard drawn copper cable, 19 strand, conforming to ASTM B1 and B8, Class AA, bare.

F. Messenger Potential Equalizing and In-Span Jumpers: 500 kcmil annealed copper cable, stranded, conforming to ASTM B3 and B8, Class H, bare.

G. Full Section Feeding and Jumpers: 500 kcmil annealed copper cable, stranded, conforming to ASTM B3 and B8, Class H, bare, or as shown on the Contract Drawings.

H. Ground Wire: The following types shall be used as shown on the Contract Drawings:

1. Annealed copper conductor, bare, Class B, stranded, conforming to ASTM B3 and B8.

2. Bare copper conductor cable, No. 4/0 AWG used for grounding catenary poles.

3. No. 2/0 AWG, 2000V insulation for surge arrester to messenger connections and to ground.

I. Bonding Wire: No. 1/0 AWG Copperweld, bare, 40 percent conductivity

J. Performance: The physical, mechanical and electrical properties of the conductors shall conform to the requirements of this Specification and the pertinent provisions of all Standards referenced in this Section.

K. Inspection and Testing:
1. The Authority reserves the right to witness the manufacture, testing and packing of all conductors. The manufacturer shall notify the Authority not less than 30 days in advance of manufacturing and testing operations.

2. All conductors shall be subject to factory quality control tests as required in the applicable standards. Tests shall be performed on each reel prior to shipment. A certified copy of the test report for each reel shall be submitted to the Authority prior to shipment. A copy of the test report shall be packed with each reel.

3. Grooved contact wire provided in accordance with ASTM B47 shall be subject to the ASTM B47 twist test in addition to other required tests. The twist test shall be performed as specified for round wire, except that 6 twists shall be required. Contact wire not meeting this test shall be rejected.

4. Contact wire factory splices shall be free of any kinks and shall be marked with bright orange paint for visual check and identification.

5. Splices shall be made and tested in factory in accordance with the manufacturer's recommendations. In field splicing hardware shall not in any way interfere with or impede the smooth running of the vehicle pantograph.

L. Packaging and Marking:

1. All conductors shall be shipped on reels, suitable for the weight of the conductors and the conductors shall be protected from damage. The diameter of reels shall be sufficiently large to eliminate difficulty with waves or kinks when the conductor is strung.

2. Each reel shall have a strong weatherproof tag securely fastened to it, showing the physical, mechanical, and electrical properties as well as type designation, ASTM designation, the name and mark of the manufacturer, the purchase order number, the component number and the wire run number.

3. Messenger wire and contact wire shall be packed so that no splices are required in the tension sections as installed.

4. Contact wire reels shall be packed with the vertical axis of the wire perpendicular to the axis of the reel, with the contact surfaces facing inward and the top (grooved) side outward.

2.4 INSULATED FEEDER CABLE

A. The Work specified in this Article includes providing insulated feeder cable for the OCS, as shown on the Contract Drawings and specified in this Specification. For installation see Article 3.19 of this Section.

2.5 CABLE TERMINATIONS

A. The Work specified in this Section includes providing and installation of cable terminations for the OCS feeder cables and electrical equipment cables, as shown on the Contract Drawings and specified herein.

B. Basic electrical materials and methods are specified in these Specifications. Feeder cable installation are specified in these Specifications, and specified herein.

C. 2000-Volt Power Cable Terminations:

1. Terminations shall be provided for connecting feeder cables to the electrical equipment terminals or studs.

2. Terminations for connecting feeder cables to messengers and contact wires of the OCS:

   a. Trolley wire clamp, Dossert Type JBCV or Authority approved equal.

   b. Two U-bolt parallel clamps, Dossert Type UP or Authority approved equal.

3. Terminations connecting jumper cables to the contact and messenger wires:

   a. Three bolt feeder trolley clamps, Ohio Brass No. 20618 or Authority approved equal.

   b. Feeder trolley clamp, Dossert Type DTAFU or Authority approved equal.

   c. Messenger parallel clamp, Dossert Type PC or Authority approved equal.

D. Power Cable Splices:

1. These Specifications require that all 2000 V cables shall be installed in continuous runs without splices. Contractor shall not splice 2000 V cables.

2. The Authority may approve 2000 V cable splices. Unless prior approval is granted by the Authority, the Contractor shall not splice 2000 V cables.
3. The following paragraphs apply to Authority approved splices:
   a. Splice connectors for 2000 VDC circuit connections in manholes and splice boxes shall be compression type, UL-listed. Splices shall be made moisture-proof and watertight, covered with a flame retardant, cold shrinkable sleeve complete with sealing adhesive, suitable for installation in locations periodically submerged in water. The cold shrink rubber splicing kit shall be as manufactured by 3M, 5740 Series, or Authority approved equal.
   b. Splices shall be installed with care in order to ensure a watertight fit. The Authority shall be notified of each splice completion that is ready for visual inspection.

E. 600-Volt Wire and Cable Terminations: Terminations for Low-Voltage Wire and Cable: Terminal connections shall conform to these Specifications.

F. Wire and Cable Identification Markers: Markers shall conform to the requirements of these Specifications

2.6 GALVANIZED STEEL WIRE AND WIRE ROPE

A. The Work specified in this Article includes providing all grades of galvanized steel wire, preforms, and wire rope for use as support wires and guys for the OCS, as shown on the Contract Drawings and specified herein. For installation see Article 3.6 of this Section.

B. Components: The zinc-coated stranded wire shall be manufactured and tested in accordance with ASTM A475.

C. Performance: Physical properties of the zinc-coated stranded wire shall conform to the description in Table 1 of ASTM A475.

D. Materials: The material used for stranded steel wire shall conform to ASTM A475.

E. Zinc Coating: The weight of coating for zinc-coated steel wire shall not be less than that specified in Table 4, under Class C of ASTM A475.

F. Types: Galvanized steel wire rope shall be of the following types:
   1. Cantilever Top Ties: 3/8 inch diameter, high strength grade.

G. Delivery and Marking: Materials shall be protected against damage in ordinary handling and shipping. Each reel shall have a strong, weatherproof tag securely fastened to it showing the physical and mechanical properties as well as the steel type designation, ASTM designation and the name and mark of the manufacturer.

2.7 STAINLESS STEEL WIRE AND WIRE ROPE

A. The Work specified in this Article includes providing stainless steel wire and wire rope for use as hangers and support wires for the OCS, as shown on the Contract Drawings and specified herein. For installation see Article 3.6 in this section.

B. Materials: Solid stainless steel wire shall be manufactured and tested in accordance with ASTM A493 and ASTM A555. Stainless steel wire rope shall be composed of a multiplicity of round wires manufactured and tested in accordance with ASTM A555, ASTM A368, and ASTM A492. The physical and mechanical properties of the stainless steel wire rope and solid stainless steel wire shall conform to the required tables of the ASTM standards referenced in Article 1.6 of this Section. Stainless steel wire shall be Type 304.

C. Types: Stainless steel wire, rod and wire rope shall be of the following types:
   1. Hangers: Messenger to Contact Wire 0.19 inch diameter rod. Other hangers 1/4 inch diameter, 7 X 19 construction, 6,600 pounds breaking strength.
   2. Bridle and backbone Cables, headspan and cross spans Wires: 1/2 inch diameter, 7 X 19 construction, 21,600 pounds breaking strength.
   3. Counterweight Support Cables: 1/2 inch diameter, non-spinning cable, 7 X 19 construction, 21,600 pounds breaking strength.
   4. Wire and wire rope shall be non-lubricated.

D. Delivery and Marking: Materials shall be protected against damage in ordinary handling and shipping. Each reel shall have a strong, weatherproof tag securely fastened to it showing the physical and mechanical properties as well as steel type designation, ASTM designation and the name and mark of the manufacturer.
2.8 OCS ASSEMBLIES, FITTINGS AND HARDWARE

A. The Work specified in this Article includes providing of assemblies, fittings and hardware for cantilevers, registration arms, pull offs/push offs, and other components required as part of the OCS hardware, as shown on the Contract Drawings and specified herein. For installation see Article 3.3 of this Section.

B. Contractor shall prepare detailed designs for each of the required assemblies, based on the performance requirements, working loads and basic dimensions as shown on the Contract Drawings and specified herein. Contractor’s designs for the assemblies shall be subject to the Authority review and approval.

C. The OCS assemblies shall comply with the NCTCOG - Standard Specification for Public Construction, particularly the requirement for double insulation. All OCS support assemblies shall clear the pantograph dynamic envelope.

D. General: Material for fittings shall comply with the description in the applicable Standards referenced in these Specifications. Substitutions will be considered if the requirements of the Contract Documents are satisfied.

E. Malleable Iron: Fittings or components made of malleable iron shall be Grade 32510 or better, and shall conform to ASTM A47. All components and fittings shall be galvanized in accordance with ASTM A153.

F. Forged Steel: Material for forged steel shall comply with AISI Types C-1035 to C-1045 SBQ and ASTM A711 or A668. All components and fittings shall be galvanized in accordance with ASTM A123.

G. Cast Iron: Cast iron weights and counterweights, if used, shall be of gray cast iron, in accordance with ASTM A48/A48A. Alternatively, lead or concrete weights and counterweights may be provided by the Contractor, if Authority approved.

H. Ductile Iron: Fittings or components requiring higher yield strength shall be of ductile iron, grade 60.40.18 or better and shall conform to ASTM A536. All fittings and components shall be galvanized in accordance with ASTM A153.

I. Stainless Steel: Stainless Steel hardware shall be AISI Type 302 or 304.

J. Nonferrous Metals: Copper alloys for fittings and components shall comply with ASTM B584 and B148.

K. Copper: All copper components shall conform to ASTM B248 or B249.

L. Copper-Clad: Grounding components shall be the Manufacturer’s standard items and shall conform to the IEEE definition of copper-clad materials.

M. Lead: Lead for balance weights in counterweight assemblies shall be casting grade, conforming to ASTM B29.

N. Manufacture and Performance:

1. The designated metals shall be produced by an Authority approved method that will meet the requirements of the ASTM standards and this Specification.

2. Castings shall be of uniform quality and shall be made in such a manner that the material of the casting conforms to the chemical and mechanical properties prescribed in the applicable ASTM standards.

O. Sampling and Testing:

1. For tension tests, a minimum of 3 test bars shall be poured from each lot of metal.

2. For chemical analysis, each lot of castings shall be analyzed for conformance with the chemical composition specified in the ASTM standards.

3. A lot shall consist of all castings produced from 1 furnace melt.

P. Galvanizing

1. Structural steel and plate, strips and bars, pipes and tubing shall be galvanized in accordance with ASTM A123.

2. Castings, fasteners, rolled, pressed, and forged products, and miscellaneous threaded objects that will be centrifuged, spun, or otherwise handled to remove the excess zinc shall be galvanized in accordance with ASTM A153.

Q. Workmanship, Finish, and Appearance:

1. The castings shall be free of adhering sand, visual cracks, surface porosity and shrinkage.

2. Contractor shall be responsible for the dimensional accuracy of castings and forgings.

3. Casting repairs shall be permitted only to the extent allowed by ASTM standards. If welding or repair of a greater magnitude is required, the Contractor shall obtain the Authority approval prior to proceeding.
OVERHEAD CONTACT SYSTEM

R. Marking and Shipping:

1. The identification mark of the foundry and the pattern numbers assigned by the supplier shall be cast into all castings, of sufficient size, in such a position that they will not interfere with the further processing and serviceability of the casting.

2. Castings shall be packed in accordance with the best commercial practice, adequate to ensure approval and safe delivery.

2.9 FASTENERS FOR OCS ASSEMBLIES

A. The Work specified in this Article includes providing various types of fasteners (bolts, nuts and washers) for general use and structural connections on the OCS, as shown on the Contract Drawings and specified herein.

B. Ferrous Metal Fasteners:

1. Material: The material for ferrous metal fasteners not specifically called out on the Contract Drawings shall comply with the applicable portions of the referenced standards, or where not covered in referenced standards shall be commercial products of proven performance in similar service as this system.

2. Anchor Bolts: Anchor bolts used for anchoring structures to their foundation shall comply with ASTM F1554. Nuts shall comply with ASTM A563, Grade D.

3. Structural Joint and Fitting Connections: Ferrous fasteners used with structural connections and fittings shall comply with ASTM A325.

4. U-bolt and Stud Connections: U-bolts and studs shall comply with ASTM A449. Washers shall comply with ASTM F436, and nuts shall comply with ASTM A563, Grade B.

5. Galvanizing: Ferrous fasteners shall be galvanized in accordance with ASTM A153, Grade C

C. Stainless Steel Fasteners:

1. Stainless steel bolts, screws, studs, and nuts shall be used for connections between ferrous and nonferrous metals, and in other applications where shown on the Contract Drawings.

2. Stainless steel bolts, screws, and studs shall comply with ASTM F593. Stainless steel nuts shall comply with ASTM F594.

D. Nonferrous Metal Fasteners:

1. Nonferrous metal fasteners shall be manufactured from material conforming with the applicable portions of the referenced standards.

2. Nonferrous bolts and studs shall comply with ASTM F468. Nonferrous nuts shall comply with ASTM F467. Nonferrous washers and lock washers shall be the manufacturer's standard product.

E. Bolted Connections:

1. Bolted connections using standard fasteners in accordance with ASTM A307 shall conform to the applicable requirements of AISC specification for structural joints using ASTM A307 bolts.

2. Bolted connections using high tensile strength bolts in accordance with ASTM A325 shall conform to the applicable requirements of AISC specification for structural joints using ASTM A325 or A490 bolts.

F. Galvanizing: Bolts, nuts, washers, anchors and other items of iron or steel hardware shall be hot-dipped galvanized as follows:

1. Structural steel, flat bar, pipe, tubing, and wire shall comply with ASTM A123.

2. Castings, fasteners, rolled, pressed, and forged products, and miscellaneous threaded objects that will be centrifuged, spun, or otherwise handled to remove the excess zinc, shall comply with ASTM A153.

3. Perform galvanizing in accordance with ASTM A153, as applicable. The weight of the zinc coating shall not be less than 1.25 ounces per square foot.

4. Threads of nuts shall be retapped after galvanizing. Bolts and nuts shall be assembled immediately after the retapping of nuts to retard corrosion of uncoated female threads.

5. Hardware items provided already galvanized shall be delivered with the required certificates of conformance with ASTM A153 and the required zinc coating specified.

G. Manufacture and Performance: Fasteners shall be produced by a method of manufacture that will meet the requirements of ASTM standards and this Specification.
OVERHEAD CONTACT SYSTEM

H. Testing: Fasteners shall be tested in accordance with the ASTM mechanical testing requirements for the applicable type, length of product and minimum tensile strength.

I. Marking: Bolts shall be marked according to ASTM standards.

J. Source Quality Control:

1. The fastener manufacturer shall provide a certified copy of the latest test report for each stock size in each shipment.

2. Fasteners shall be shipped in sturdy boxes, which are clearly marked with the manufacturer's name, lot number, purchase order number, size and material.

2.10 GUY GUARDS

A. The Work specified in this Article includes providing and installation of prefabricated single piece, full round, elastomeric snap-on guy guards for pole down guys, as shown on the Contract Drawings and specified herein.

B. The guy guards are required to provide high-visibility protection of pole down guys against accidental contact with persons and vehicles, particularly at night when the pole down guys are hard to see.

C. Guy guards shall be manufactured units, fabricated from UV stabilized high impact polyethylene, 96 inches long by 1-1/2 inch diameter, full round snap-on units for all sizes of guy cable, high-visibility yellow color, provided complete with integral locking straps for installation on guy cables without using special tools. Guy guards shall conform to: NESC Rule 264E - Guy Markers (Guy Guards).

D. Manufacturers: Guy guards shall be as manufactured by Preformed Line Products, Cleveland, Ohio; A. B. Chance No. 96-FRG-YEL as manufactured by A. B. Chance Co., Centralia, Missouri; or Authority approved equal.

2.11 DISCONNECT SWITCHES (NO LOAD BREAK)

A. The Work specified in this Article includes providing of DC manual and motorized disconnect switches and accessories for the OCS as shown on the Contract Drawings and specified herein. For installation, see Article 3.14 of this Section.

B. Contractor shall prepare detailed designs for each of the required assemblies, based on the performance requirements, working loads and basic dimensions as shown on the Contract Drawings and specified herein. Contractor's designs for the assemblies shall be subject to the Authority review and approval.

C. Tests - General: Disconnect switches shall be tested at the factory prior to shipment, as specified herein:

1. Qualification Tests: Qualification tests shall be performed to prove compliance with Specifications. Tests shall be conducted generally in accordance with those described in IEEE C37.34, including the following:
   a. Dielectric withstand voltage tests
   b. Short-time current test
   c. Temperature-rise test

2. Production Tests: Production tests shall be performed on switches to check the quality and uniformity of workmanship and materials used. Tests shall include the following:
   a. Operation of all components
   b. Power frequency dielectric withstand
   c. Electric resistance of current path

3. Submit 6 certified copies of all test reports.

D. Equipment: Each DC disconnect switch shall be an outdoor type, either a single-pole or double pole, single-throw, grounding or non-grounding, and non-fusible air switch, double insulated, with arcing horns, either manual or motor operation as indicated in the Contract Drawings. The switches shall be exposed pole mounted or enclosed pad/wall mounted as indicated on the Contract Drawings. Design shall comply with the applicable requirements given in ANSI and NEMA specifications. The switches shall be capable of breaking load currents under emergency conditions.

E. Ratings: Switches shall be rated for 1500 VDC operation with 3.0kV, rms, minimum insulation level. Continuous current ratings shall be 1200 amps without exceeding 122 degrees F rise above a maximum ambient temperature of 104 degrees F. Switches shall have a momentary current withstand rating of not less than 100kA, rms.

F. Motor Drive Mechanism:

1. The motor operated disconnect switches shall be suitable for pole or pad mounting with a motor drive mechanism connected to the switch by means of an insulated operating rod. The motor drive mechanism shall be mounted at approximately 4 feet above ground level when mounted on poles.
2. Each motor operated disconnect switch shall be locally (electrically and mechanically) and remotely controlled. The motor drive mechanism shall be totally enclosed in a NEMA-3R, fiberglass, aluminum or stainless steel enclosure. The unit shall be equipped with an internal motor starter circuit, motor contactor, motor unit, control power transformer (as required), fuses, relays, overloads, limit switches, pushbuttons, emergency operating handle, surge protectors and terminal blocks for power, control, indication and OCS voltage sensing circuits. Motors shall operate from a 125VDC supply, originating from the traction power substation. Voltage for the motor controls shall be derived from the 125VDC distribution panel source. The motor control shall be equipped with surge protection of 1.5 kV. The motor drive mechanism shall be equipped with a forward and reverse operating mode with enclosed pushbuttons for local electrical operation including stop, forward, and reverse. A slip clutch shall be provided to protect against motor overloads. An integral, insulated, emergency operating handle with motor shaft disengager shall be provided for each switch to operate the switch mechanism manually.

3. Remote Supervisory Control and Indication: Switch operating device shall be provided with 125 VDC auxiliary relays for interface with the substation disconnect switch control panel. Auxiliary switches shall be provided having 2 independent contacts for remote supervisory status indication of switch-blade OPEN and CLOSED positions. Status indication circuits shall be wired to terminal blocks for connection of external wiring.

4. Electrical interlocks: An electrical interlock circuit shall be provided to prevent operation of the motor operated disconnect switch with voltage on either side of the contacts. The interlock shall prevent local and remote electrical operation of the switch motor. Emergency manual operation shall not be prohibited.

5. Permanent weatherproof nameplates shall be attached to the outside of each enclosure. Samples shall be submitted for Authority approval before installation.

a. Switch positions shall be labeled "OPEN" and "CLOSED" in 7/8 inch silver letters. "OPEN" to have a green background and "CLOSED" to have a red background.

b. There shall be a label on the switch operating mechanism reading "DO NOT OPERATE WHILE ENERGIZED" in 3/4 inch black letters on a yellow background.

c. Each switch shall be numbered in accordance with the switch numbers as indicated on the Contract Drawings. The identification label shall indicate the switch number and letters in 7/8 inch, high blue characters on a white background.

G. Switch Contacts:

1. Moving and stationary contact surfaces shall be silver plated copper. All other current-carrying parts shall be of high-conductivity copper. Contacts shall be self-aligning, wear compensating, and with initial wiping action.

2. Switch contacts shall be bolted pressure type, or equal.

H. Manual-Operated Disconnect Switch Assembly:

1. Each switch shall be provided with an insulated operating rod, with operating handle located and an Authority approved height from ground level. Operating handles shall be provided with heavy duty lugs to accept padlocks in the fully open and closed switch positions. Switch positions shall be indicated with "OPEN" and "CLOSED" signs clearly visible from ground level.

2. Each switch shall have a permanent weatherproof identification nameplate attached at a suitable location near the switch handle. The nameplate shall have the switch identification number, as indicated on the Contract Drawing, on 7/8 inch high blue numbers on a white background.

3. All non-current carrying metal parts shall be hot-dip galvanized steel.

I. Cable Termination: The line and load side disconnect switch terminals shall be provided with silver-plated copper buses complying with ASTM B187, to accommodate the number and size of copper cables as indicated on the Contract Drawings. The switch terminals shall have provision for NEMA drilled (2 hole or 4 hole) cable terminal lugs.

2.12 SECTION INSULATORS

A. The Work specified in this Article includes providing section insulators for the OCS, as shown on the Contract Drawings and specified herein. For installation see Article 3.12 of this Section.
B. Contractor shall prepare detailed designs for each of the required assemblies, based on the conductor tensions and electrical stresses shown on the Contract Drawings. The basic dimensions of the section insulators shall be as recommended by the manufacturer. Contractor’s designs for the assemblies shall be subject to the Authority review and approval.

C. Assemblies, insulators, fittings and hardware are specified in Articles 2.8 and 2.13 of this Section.

D. Submittals as indicated in Article 1.3 of this Section.

E. Section insulators shall be as shown on the Contract Drawings and recommended by the manufacturer as service-proven units capable of providing smooth current collection, with minimum interruption, by 1 to 3 pantographs running at a speed of up to 65 miles per hour maximum for simple catenary auto tension (SCAT) and simple catenary fixed termination (SCFT) installations, and 35 miles per hour maximum for single wire fixed terminations (SWFT) installations. The section insulators shall be rated for these speeds in normal and reverse directions. The section insulators shall meet or exceed the following design requirements:

1. The design shall be for the SCAT, SCFT, and SWFT systems as indicated on the Contract Drawings.

2. The design shall ensure that electrical separation between catenary wires of adjacent sections is maintained at all times, electrically isolating one section from the other.

3. Section insulators in service and inspection facility buildings shall be of the non-bridging type.

4. The section insulator shall be designed to remain stable (dynamically and structurally) under sustained crosswinds of 55 miles per hour for SCAT, SCFT, and SWFT installations.

5. The section insulator shall be designed to withstand cross-winds of up to 70 mph without failure, including permanent deformation.

6. The design shall assure smooth passage of the pantograph across the section insulator. Tilting during pantograph passage shall not be so severe as to damage pantograph contact surfaces. The skids shall be set as high as possible, consistent with ensuring that the pantograph does not strike the runners. Allowance shall be made for the springiness of the skids on impact of a fast-moving pantograph. The section insulator shall be free of “hard spots.”

7. The design shall ensure that the moving pantograph is continuously in contact with the section insulator.

8. The section insulator shall be positioned close to a supporting structure, but with sufficient clearance maintained from the section insulator center to allow for registration of the contact wire.

9. The design shall be such that when the section insulator is positioned in span, the central point is directly over the centerline of a static pantograph at normal temperature (70 degrees F, open route). The mid-span offset of the contact wire shall be equal to zero or shall be within limits approved by the Authority.

10. Pantographs drawing current while traversing the section insulator shall not create excessive arcing, which could damage the section insulator, contact wire or pantograph.

11. Where the design does not require continuity, the section insulator shall be fitted with suitable arc traps/extinguishers. Where the section insulator is provided with parallel runners, the continuity jumpers shall be removed to provide a neutral zone between the adjacent electrical sections. The traps/extinguishers shall be placed as recommended by the manufacturer, so as to ensure minimal arc tracking across the insulator surface.

12. The design shall allow for torsional forces resulting from the passage of multiple pantographs combined with lateral wind loads at service speed.

13. Contact wire skids shall provide a smooth transition from one section to another.

14. Design factors of safety shall be consistent with those used in the design of the catenary system, and as specified by NCTCOG - Standard Specification for Public Construction.

15. The design shall comply with the following electrical requirements:

   a. Nominal voltage 750 V DC
   b. Voltage range 525 V to 900 V DC

16. The design shall satisfy the environmental conditions as given in the Special Provisions.
17. The design shall provide full performance within a conductor temperature range of 4 to 165 degrees F.

F. Components: Components shall be provided as shown in the manufacturer's catalog and as follows:

1. Arcing Horns and Arc Traps: Skids shall be designed with each end upturned to form arcing horns. A flashover shall take place across the body unit and not across the insulation.

2. Magnetic Arc Extinguishers: The magnetic arc extinguishers, when required, shall include all components required to fasten the extinguisher to the section insulator, and to protect the section insulator from damage by a pantograph passing through while drawing current.

3. Arc Catcher: The tips of the arc catcher shall be replaceable.

4. Hardware: Hardware shall consist of the manufacturer's recommended items and shall include, but shall not be limited to, bolts, U-bolts, washers, clamps (including contact wire clamps), turnbuckles, support connectors, braces, insulators and insulating beams.

G. Protective Finish: Section insulator components shall have an Authority approved protective finish or shall be inherently self-protecting. Ferrous metal components shall be galvanized as specified in Article 2.8 of this Section.

2.13 SUSPENSION, STRAIN, AND STAND-OFF INSULATORS

A. The Work specified in this Article includes providing and testing of suspension, strain, and stand-off insulators for the OCS, as shown on the Contract Drawings and specified herein. For installation see Article 3.2 of this Section.

B. Contractor shall prepare detailed designs for each of the required assemblies, based on the performance requirements, working loads, and basic dimensions shown on the Contract Drawings and specified herein. Contractor's designs for the assemblies shall be subject to the Authority review and approval.

C. The OCS insulators shall comply with the NCTCOG - Standard Specifications for Public Construction, particularly the requirement for double insulation. All insulators shall clear the vehicle pantograph dynamic envelope.

D. Synthetic insulators shall be used. Porcelain insulators shall be acceptable only if so indicated on the Contract Drawings and/or Authority approved.

E. Submittals: Submittals required pursuant in accordance with these Specifications, and shall include manufacturer's certification provided to show compliance with the applicable requirements of the referenced Standards, and the Contract Drawings as to materials, design, manufacturing and testing of the insulators.

F. Porcelain Insulators:

1. The insulators shall be made of the best commercial-grade wet-process porcelain, in accordance with ASTM D116.

2. The entire porcelain surface of the insulators that will be exposed after assembly shall be glazed in No. 70 light gray color as specified in ANSI Z55.1.

3. The surface shall be free of imperfections. Pieces with imperfections in the glaze, which were repaired by re-coating and re-firing, as well as those pieces repaired by retouching with paint, will be rejected.

G. Synthetic Insulators:

1. General: Synthetic insulators shall be fabricated from any of the following materials, or combinations thereof, depending on type or application:

   a. Molded ethylene propylene copolymer with hydrated alumina filler.

   b. Fiberglass-reinforced epoxy solid rod.

   c. Composite type, with molded ethylene propylene copolymer jackets or skirts formed over a fiberglass-reinforced epoxy core.

2. Insulators shall be provided complete with integral galvanized or stainless steel hardware for connection to supports or catenary hardware. Synthetic insulators shall be products of WABCO (Westinghouse Air Brake Company), ABB (ASEA-Brown Boveri), Siemens, or Authority approved equal.

3. Types and Applications: Specific types and applications of synthetic insulators for use with cantilevers, cross-spans and tunnel or structure ceilings, or for use as strain insulators, shall be as shown on the Contract Drawings.

H. Metal Parts: The metal parts of the insulators shall be made of malleable iron, Grade 35018, to
conform with ASTM A47, or open-hearth or electric furnace steel. All ferrous metal parts shall be galvanized in accordance with ASTM A153. Insulator fittings shall provide for connections as shown.

I. Cementing:
1. Cement used for assembling porcelain to metal shall meet or exceed the requirements of ASTM C150 and C151.
2. Cement for synthetic insulators shall be of the types recommended by the insulator manufacturer for use with its materials.

J. Painting: To protect the galvanizing from harmful chemical action of the cement, the hardware, which is in contact with cement, shall be coated with a bituminous paint, or shall be otherwise finished as recommended by the insulator manufacturer for use with its materials.

K. Performance and Testing:
1. Insulators shall be tested in accordance with ANSI C29.1.
2. The mechanical strength of suspension and strain insulators shall exceed the ultimate strength of the conductor or guy to which it is attached.
3. The insulators shall be suitable for both horizontal and vertical mounting and installation, unless otherwise specified.
4. The manufacturer shall provide a certificate of compliance with the applicable portions of the referenced ANSI Standards, and these Specifications.
5. Types and suggested electrical values and minimum mechanical characteristics for OCS insulators are shown on the Contract Drawings.

L. Marking: Each insulator shall bear the manufacturer's name or trademark and year of manufacture, clearly and permanently imprinted, without affecting the appearance or the function of the item.

M. Electrical Ratings:
1. All insulators shall have the following ratings:
   a. Nominal System Voltage: 750 V DC
   b. Insulation Level: 4.87 kV AC, rms
   c. Creepage Distance: 1.88 inch (min.)
2. Synthetic spool insulators shall withstand a 25 kV flashover across 2-1/2 inch leakage distance.

2.14 SURGE ARRESTERS
A. The Work specified in this Article includes providing of surge arresters for the OCS, as shown on the Contract Drawings and specified herein. For installation see Article 3.15.
B. Each surge arrester shall incorporate an individual grounding system for connection to a ground rod or ground mat.
C. Contractor shall prepare detailed designs for each of the required assemblies. Contractor's designs for the assemblies shall be subject to Authority approval.
D. Submittals as indicated in Article 1.3 of this Specification.
E. Equipment:
1. Surge arresters shall be designed and installed on each substation feeder at its connection point with the OCS, at each disconnect switch at its connection point with the OCS, on each track at low overhead bridges, and on each track at interlockings. Contractor to provide design drawings identifying disconnect switch locations.
2. Surge arresters shall be of the metal oxide varistor type. Each surge arrester shall have an energy discharge capability of 2.6 kJ/kV for currents of 500 A or less, Type MCOV, 1280 V, Model No. 6007-006 as manufactured by SMC, or Authority approved equal.
3. Each surge arrester shall be connected to an individual grounding system, ground rod or ground mat, by means of a No. 2/0 AWG insulated cable installed in a GRS conduit attached to the OCS pole as shown on the Contract Drawings.
4. Each grounding connection shall have a grounding resistance of 5 ohms or less or as specified by the surge arrester manufacturer for the type of unit provided.
5. Each grounding connection shall be tested individually in accordance with the required procedures specified in Article 3.23 of this Specification.
2.15 SPECIAL TOOLS FOR OCS INSTALLATION

A. The Work specified in this Article includes providing special tools required for the OCS installation Work, including height/stagger gauges, super-elevation/step gauges, grounding jumpers, live wire tools, slings, hoists, and ladders.

B. Height/stagger gauges, and super-elevation/step gauges shall be special designs fabricated by the Contractor in accordance with the performance requirements specified herein. All other materials and equipment items shall be standard manufactured items, as specified herein, unless otherwise noted.

C. All special tools specified herein shall be used by the Contractor, and shall remain their property, throughout the construction period of the OCS, and during its subsequent testing and commissioning as specified in Article 3.23 of this Specification. Following acceptance of all segments of the completed system, all gauges and special tools (except for consumable items) shall become the property of the Authority, and shall be delivered to the Authority, in good working condition, as directed by the Authority.

D. Submittals as indicated in Article 1.3 of this Specification.

E. Applicable Standards: Pertinent provisions of the following listed standards shall apply to the Work of this Article, except as they may be modified herein, and are hereby made a part of this Specification to the extent required:

1. NCTCOG - Standard Specification for Public Construction
2. Federal, State and Local Authorities: All applicable codes and regulations

F. Materials, General:

1. All materials proposed for use shall meet the applicable performance requirements, and shall be noncorrosive and durable.
2. Guy ropes shall be of synthetic materials.
3. Height/stagger gauges, and super-elevation/step gauges shall be fabricated from aluminum alloy sections, and shall incorporate 2000 V cross track insulation to maintain track polarity and eliminate interference with track circuits during gauging.

G. Height/Stagger Gauges

1. General: The height/stagger gauges, each including 2 interchangeable gauge heads (stagger gauge and pantograph gauge), shall be used to measure heights and staggerers of the catenary system when the system is not energized.
2. Description: Height/stagger gauges shall be compact, lightweight construction, rigidly mounted on rail vehicles without springs or side play, and shall be designed to simulate the dynamic profile envelope of the pantograph. Contractor shall have the option of providing each gauge with a mechanical tilting and/or linkage system to simulate the dynamic envelope, or providing a simplified fixed profile envelope gauge with attachments which provides an equivalent simulation. Contractor shall submit data on the estimated level of variance from theoretical values for Authority approval. The height/stagger gauges shall be designed to measure the following:
   a. Pantograph sway from top of Light Rail Vehicle (LRV)
   b. Cross-track level tolerance
   c. Cross-track displacement of LRV and cross track level tolerance
   d. Contact wire uplift
   e. Combined mechanical and electrical clearance requirements from pantograph dynamic outline envelope
3. Weight: The height/stagger gauges shall be lightweight, for handling by 2 persons in lifting the gauges off the track or placing them on top of the super-elevation/step gauges.
4. Fabrication: Height/stagger gauges shall be fabricated and assembled in conformance with the reviewed and approval required submittals.
5. Strength: The height/stagger gauges shall be strong enough to withstand light impact loads, normal handling and use procedures, under moderate (30 MPH) wind conditions, without deflection, buckling, or permanent deformation.
6. Adjustability: The height/stagger gauges shall be easily adjustable for calibration purposes.
7. Readability: The calibration shall be in inches and easily readable, with 20-20 vision, within a distance of 30 feet.
8. Vertical Operating Range: The height/stagger gauges shall be capable of measurement over a contact wire height
range of from 13 feet to 24 feet above track level.

H. Super-elevation/Step Gauges

1. General: Super-elevation/step gauges shall be used for purposes of adjusting the inclination of the height/stagger gauge by placing the step gauge on the rail under the height/stagger gauge.

2. Description: Super-elevation/step gauges shall be used to emulate the actual track super-elevation for the purpose of adjusting the position of the contact wires.

3. Adjustability: Super-elevation/step gauges shall be designed for use with a calibrated spirit level system, with the levels placed crosswise on the top surfaces or steps of the gauges for direct reading.

4. Readability: Spirit levels to be used with super-elevation/step gauges shall be calibrated in inches and easily readable, with 20/20 vision, within a distance of 5 feet.

I. Manufactured Items: Contractor shall provide the following manufactured items, or Authority approved equal:

1. Cable Cutters: Manufacturer - H.K. Porter, Model 8690FH; Quantity: 3 each

2. Compression Splicing Tools, with 2 die sets of each type for splicing the following: 500 kcmil messenger cable, 500 kcmil feeder cable, 750 kcmil feeder cable, 1/2 inch diameter steel flexible wire, 3/8 inch diameter steel flexible wire, any additional wire size which may be used and spliced: Manufacturer - Burndy Hypress, Model Y35; Quantity: 2 each

3. Chain Ratchet Hoists, 3 ton capacity: Manufacturer - Tugit, Model R292E; Quantity: 3 each

4. Utility Slings, 3 ton capacity: Manufacturer - A. B. Chance or Rhino; Quantity: 6 each

5. High Voltage Protective Gloves, 1000 V insulating capacity per NSI/ASTM D1050: Manufacturer - Salisbury Rubber Co., Model 480Y/277; Quantity: 6 pairs (various sizes)

6. Grips (line pulling) 8,000 lb. capacity: Manufacturer - Klein "Chicago Grips", Model 1656-50; Quantity: 6 sets

7. Grips (line pulling) 15,000 lb. capacity: Manufacturer - Klein "Chicago Grips", Model 1628-16 BP; Quantity: 6 sets

8. Snap-on Grounding Clamps, complete with applicator: Manufacturer - A. B. Chance, Model T600-0806, HG.3706-1; Quantity: 12 each

9. Flat Face Grounding Clamps: Manufacturer - A. B. Chance, Model C600-2232; Quantity: 3 each

10. Flat Face Grounding Clamps: Manufacturer - A. B. Chance, Model C600-0436; Quantity: 3 each

11. Copper Ferrules (shrouded plain-plug type, 1 unit): Manufacturer - A. B. Chance, Model C600-2633; Quantity: 12 each

12. Copper Ferrules (shrouded threaded plug, 1 unit): Manufacturer - A. B. Chance, Model C600-2625; Quantity: 12 each


14. Grounding Cable, No.4/0 AWG, 2107 strands, clear PVC jacket: Manufacturer - A. B. Chance, Catalog No. S6451; Quantity: 400 linear feet

15. Telescoping Tools, epoxy glass: Manufacturer - A. B. Chance, Model C403-1021; Quantity: 3 each

2.16 COUNTERWEIGHT ASSEMBLY

A. The assembly shall maintain constant tension in the SCAT system conductors notwithstanding changes in ambient, solar or current heating temperatures. Changes in the lengths of conductors shall be compensated for by an equivalent movement of the counterweights (upward or downward). Low and high temperature stop devices shall be provided such that movement of the counterweights due to conductor expansion and/or contraction under temperature conditions below 20 degrees F and above 120 degrees F or an increase in system weight due to ice formation is eliminated. Contractor shall submit, for Authority approval, the methods to be used to restrict the counterweight movements outside of the above referenced temperatures.

B. The counterweight assembly shall operate at a nominal pulley ratio of approximately 3:1.

C. The counterweight assembly shall have pulleys with self-lubricating bearings. The bearings shall be sealed to prevent the ingress of moisture or other contaminants, or the loss of lubricant.
D. The counterweight assembly shall operate freely under all climatic conditions within the limits specified above and shall function freely when a weight differential of plus/minus 25 pound is applied to the counterweight stack.

E. The assembly shall incorporate a safety feature to prevent the weights falling to the ground in the event of a failure of the tensioned wires. It shall also have provisions for continuity to ground under electrical fault conditions.

F. Counterweights shall be fabricated of cast iron, or other Authority approved material, with a vandal-proof assembly.

G. Weight sets may be either 1 casting or made up from individual castings. If individual castings are used they shall be of an interlocking design to prevent slippage. The assembled stack of weights shall be as compact as possible and shall fit between the flanges of the wide flange anchor poles.

H. Tolerance on the complete balance weight set shall be 0 pounds +50 pounds

I. Weights shall be compact allowing for the required vertical movements and shall incorporate a guide tube arrangement to prevent the weights from freely moving in the horizontal direction.

J. The counterweight assembly shall have a minimum design life of 30 years and shall not require maintenance or inspection at intervals of less than 12 months. The design shall permit disassembly and reassembly of an in-place unit by standard maintenance crews.

K. Assemblies and component parts shall be designed for ease of maintenance, replacement, assembly, and disassembly, which shall be accomplished with a minimum of special tools. Component parts shall be properly identified for this purpose.

L. The assembly shall incorporate provisions for adjustment due to wire elongation (stretch).

M. All materials and design shall have been proven by the manufacturer's experience to be suitable for the purpose of which they are intended. They shall be suitable for the loads and climatic conditions existing in the project.

N. All external ferrous parts shall be stainless steel or hot-dip galvanized in accordance with the required ASTM specification. Any ferrous parts that are not stainless steel or cannot be galvanized shall be painted with an Authority approved epoxy coating with color to match ANSI No. 61, light gray.

O. Each tensioning device shall bear the manufacturer's name or trademark and year of manufacture clearly and permanently imprinted.

P. Contractor may offer other alternatives for consideration by Authority at no expense to Authority. Such alternatives may include a differential pulley arrangement.

PART 3 - EXECUTION

3.1 OCS INSTALLATION - GENERAL

A. General Description:

1. The Work specified in this Article includes the installation of the complete OCS, including overhead structure suspension systems, anchor bolts, pole guys, cantilevers, headspans and cross-spans, backbones, door bridges, wiring, surge arresters, insulators, disconnect switches, feeder wire and cable, and other components required to provide a complete operating system.

2. Reference is made to the OCS pole foundations in the Specifications and these shall be closely coordinated with installation of the OCS.

3. Steel poles shall be shipped from the factory as complete assemblies with bases, attachment fittings, nuts, counterweight pulleys and guides, where required, and other accessories included, disassembled as required for shipment, and delivered to the Work site in shipping packages providing adequate protection for contents and including identifying labels and instructions for assembly and installation at the site.

B. Quality Control: Contractor shall perform the installation Work included in this Article in strict accordance with the requirements of the Contractor's Authority approved Quality Control Program and the requirements of these Specifications.

C. Submittals: In addition to shop drawings, erection drawings, samples, and operation and maintenance instructions required by Article 1.3 of this Specification, 6 certified copies of reports of all field tests shall be submitted to the Authority as required or recommended by these Specifications and referenced standards, or as required to establish compliance with the Contract Documents.

D. Applicable Standards:

1. Standards applicable to products covered in this Article have been listed in other articles of this Section, and apply here.

2. All OCS installations shall comply with the requirements of NCTCOG - Standard Specification for Public Construction.
E. Appearance of Completed Installation: The completed OCS shall have a neat and attractive appearance, with minimum adverse impact on fixed facilities and surrounding areas, after all components, equipment, and hardware items are installed in place and final adjustments made. To ensure this, the Contractor shall submit to the Authority, prior to starting on-site Work, information on its proposed components and installation methods, accompanied by photographs of existing overhead contact systems constructed similarly.

F. Location of Structures:

1. Reference points for location of OCS structures and facilities are as shown on the Contract Drawings.

2. Actual locations of OCS structures will be determined by the installer who is responsible for installation of the OCS structure foundations, OCS structure guy anchors, underground ducts, handholes and manholes.

3. Before installing poles the Contractor shall check the pole foundation locations and attachment provisions, and advise the Authority of any deficiencies that could result in an unacceptable OCS installation if not corrected. The Authority will advise the Contractor of remedial action to be taken.

4. Contractor shall measure and record the actual location and elevation of each OCS foundation in relation to the referenced and associated track(s), and the superelevation magnitude and the curve direction of the tracks at each foundation, prior to starting the installation of poles, cantilevers, and other OCS structures and assemblies. The above referenced measurements must be taken to insure that, in all locations, these structures are installed with the correct geometrical relationship to the final track alignment as shown on the Contract Drawings.

5. The reference point for locating structures with respect to the track shall be the design position, as shown on the Contract Drawings together with any allowable tolerances. Any deviations in the actual position of the track from the design position shown on the Contract Drawings shall be referred to the Authority.

6. The setting dimensions for each structure with respect to the reference point shall be as given in the layout plan schedule. Structure offsets shall generally be at right angles to the track centerline.

7. All major structures that might interfere with OCS installation shall be clearly identified in terms of location and elevation, referenced to the adjacent track.

8. Contractor shall notify the Authority of any OCS poles that may obstruct wayside signal equipment from being seen by the train operator.

G. Structure Numbering:

1. All new structures shall be clearly and permanently numbered, using the reference numbers as shown on the Contract Drawings and specifications. The pole numbering characters, letters and numbers, shall be not less than 1-1/2 inch high and shall have a color and be of the type as shown on the Contract Drawings. Steel poles located between tracks shall normally be numbered with the numbers on the sides of the pole facing in the along track direction. At poles which have counterweights installed, the numbers shall be located on the sides of the pole facing the tracks. Numbers shall be installed 8 feet above track level, to the underside of the numbers, as indicated on the Contract Drawings. Side poles shall only have 1 set of numbers and the numbers shall be installed facing normal direction of travel.

2. Elevated poles, wall attachments and OCS supports under bridges, shall be numbered in the same size and style as required for poles and specified in these Specifications. In areas of low illumination, luminous numbers or background shall be employed as required to improve visibility.

3. In locations where it is impractical to number the pole or OCS assembly, numbers may be applied to the adjacent structural wall, as Authority approved, in a manner and order that will clearly identify the item to which the number applies.

4. Center poles shall have 2 sets of numbers, 1 set for each track.

H. Installation Tolerances

1. Installation tolerances shall be as follows:

   a. Bowing effect on pole: Less than 2-1/2 percent of height or 2 inches maximum at contact wire height

   b. Cantilever along track offset: within plus or minus 6 inches

   c. Hanger length: within plus or minus 1/2 inch
OVERHEAD CONTACT SYSTEM

d. Hanger spacing: within plus or minus 6 inches

e. Messenger and contact wire locations:

1) Overbridges: within plus or minus 1 inch Lateral; within plus or minus 1/2 inch Vertical

2) Overlap Locations (between parallel wires): within plus or minus 1 inch Lateral; within plus or minus 2 inches Vertical

3) All Other Locations: within plus or minus 1 inch Lateral; within plus or minus 2 inches Vertical

2. The tolerance given at the conductor height is only applicable provided the conductor gradient between adjacent structures is approved. The tolerances given are subject to electrical clearances.

3.2 INSULATOR INSTALLATION

A. Contractor shall provide double insulation, and installation shall be in accordance with the NCTCOG - Standard Specifications for Public Construction.

B. All insulators shall be clean before installation. Only clean rags, free from any abrasive material shall be used for cleaning insulators. Wire brushes shall not be used for cleaning any parts, metal or otherwise. In the completed line, all insulator assemblies and hardware shall be clean, bright and free from nicks, chips or other marks.

C. After installation of the OCS Support System, but prior to the Hi Pot Tests stated in Article 3.23 of this Specification, "OCS Testing and Commissioning", all insulators shall be megger tested. Insulators, which are found to be defective, shall be replaced.

D. Insulators with slight damage shall be repaired as recommended by the manufacturer. If the damage is appraised by the Authority as excessive, the insulator shall be replaced. Cracked insulators shall be replaced.

E. Porcelain insulators shall be used only in locations specified on the Contract Drawings. An equivalent synthetic insulator may be used as an alternate to a porcelain insulator subject to Authority approval.

F. Porcelain guy strain insulators and other types of porcelain insulators shall not be used for crossspans/headspans, or in any other locations (except for down guys) where they are exposed to vandals and their appearance might be objectionable.

G. Johnny Ball strain insulators shall not be used for cross spans, or in any other locations (except for down guys) where they are exposed to vandals and their appearance might be objectionable.

3.3 HARDWARE INSTALLATION

A. Hardware shall be installed in accordance with the manufacturer's Authority approved shop drawings. Bolts and nuts shall be properly tightened in accordance with the manufacturer's torquing recommendations using indicating torque wrenches. All bolts shall be of sufficient length for a minimum of a full thread to extend beyond the nut and locknuts. The total length of thread shall not protrude beyond the nut and locknut by more than 1-1/2 inches. Bolt ends shall not be cut off.

B. Locknuts shall be installed according to manufacturer's instructions.

C. Hardware shall be installed using tools and methods specified by the manufacturer and Authority approved.

D. Hardware shall be inspected for cleanliness and damage. Any item that does not fit, creates scraping of galvanizing during or after installation, or is found defective, will be rejected.

E. All turnbuckles shall be adjusted such that a minimum of 1 inch of thread remains in the body after final adjustment.

3.4 INSTALLATION OF ANCHOR BASE POLES

A. Poles shall be installed as shown on the Contract Drawings and as specified in these Specifications.

B. The type, location, setting height, offset of each pole shall be as specified in the Catenary Layout Plans.

C. Contractor shall determine the pole rake based on the proposed pole loadings and shall rake the pole as required as described in these Specifications.

3.5 INSTALLATION OF DOWN GUYS

A. Down guys of the sizes and types shown shall be installed as indicated on the Contract Drawings.

B. Down guys shall be installed before the catenary wires are strung. They shall be pulled taut, and secured in place with provisions for future adjustment as required to hold the structure in proper alignment after wires are pulled up.

C. Down guy attachments shall be installed as recommended by the manufacturer.
D. Each guy to an anchor shall have an 8 foot guy guard, installed as shown on the Contract Drawings.

3.6 INSTALLATION OF GALVANIZED STEEL AND STAINLESS STEEL WIRE AND WIRE ROPE

A. Galvanized steel and stainless steel wire and wire rope shall be used as shown on the Contract Drawings.

B. Galvanized steel and stainless steel wire and wire rope shall be cut and installed using tools and methods specified by the manufacturer.

C. Galvanized steel and stainless steel wire and wire rope shall extend no more than 4 inches from crimped terminations and shall have all free ends lashed to prevent fraying.

D. Splicing of the galvanized steel and stainless steel wire and wire rope will not be permitted. This includes all applications shown on the Contract Drawings.

3.7 INSTALLATION OF CANTILEVERS

A. Contractor shall determine the type of cantilever to be installed on each pole or support. The Contract Drawings for the cantilever assemblies are general in nature and the Contractor is responsible for the detail design based on the type of OCS and the loads applied. Double insulation shall be provided in accordance with NCTCOG - Standard Specifications for Public Construction.

B. Cantilevers shall be designed to clear the pantograph dynamic envelopes. Contractor shall request from the Authority the actual vehicle pantograph dimension prior to the cantilever final design. Steady arms shall extend no less than 3 inches and no more than 6 inches past the contact wire clamp. The heel settings for each cantilever and steady arm shall be determined by the Contractor and submitted to the Authority for approval.

C. The wire height and stagger values given on the Contract Drawings are related to the reference point and the superelevation, as shown on the Contract Drawings.

D. For stability during stringing, the cantilevers shall be temporarily restrained to prevent collapse due to swinging. The details of the restraint shall be submitted to the Authority for approval.

E. The along-track offset of the cantilever for various temperatures shall be as shown on the Contract Drawings, after the information has been confirmed by the Contractor. The along-track offset of the cantilever on completion shall be in accordance with its distance from the midpoint anchor for the prevailing temperature.

F. Cotter pins and nuts on each cantilever shall be located on the same side of the structure to assure uniformity along the line.

G. Assemblies fitted with pins, cotters, bolts and nuts shall be oriented where possible in such a manner as to lock these components together by gravity if the pins or nuts should become detached under service conditions.

H. Components employing a hinge or swivel shall be greased before assembly of the rubbing surfaces and cleaned of excess grease.

I. Defects in the galvanizing of the completed cantilevers assemblies shall be repaired by the application of a suitable zinc-rich, cold-galvanizing repair paint, ZRC Cold Galvanizing Compound or Authority approved equal, in accordance with these Specifications.

J. After installation of cantilevers and stringing of conductors, adjustment may be required to the stagger, heel setting, contact wire height and cantilever inclination to be within the specified design tolerances.

K. Conductor interfaces of all clamps for feeder terminations, equalizing jumpers and continuity jumpers shall be coated with conductive grease and cleaned of extra grease.

L. Conductive lubricating grease shall be applied to the retainer bars of cross contact bridges and cleaned of extra grease.

M. The cross-track alignment of the vertical centerlines between messenger, contact or bridle wires shall be within 1/2 inch per foot of vertical separation.

N. Authority approved conductive lubricating grease shall be applied to swivels, hinges, and other parts requiring lubrication.

O. End caps shall be installed on all cantilever and steady arms.

3.8 INSTALLATION OF CROSS-SPAN AND HEADSPAN ASSEMBLIES

A. Prior to installation of the headspan/cross-span assemblies, the Contractor shall record the following field details along the axis of the span(s) for review by the Authority:

1. Centerline to centerline measurement between Poles, track-to-track centerline dimensions, and adjacent track to pole centerline measurements.

2. Elevation of foundation finish levels and all tracks (rail) levels.
OVERHEAD CONTACT SYSTEM

3. Track superelevations and its directions taken facing towards increasing station locations.

B. Contractor shall review and note all field changes from the design, and submit these changes to the Authority for consideration.

C. The type of headspan/cross-span assemblies are given on the Contract Drawings as reference and are general in nature. Contractor is responsible for the detail design.

D. Double insulation shall be installed in accordance with the requirements of the NCTCOG - Standard Specifications for Public Construction.

E. Headspans/cross-spans shall be designed to clear the pantograph dynamic envelope. Contractor shall request from the Authority the actual vehicle pantograph dimension and verify the clearances of all assemblies and items prior to the headspan final design and construction directions. Steady arms shall extend no less than 3 inches and no more than 6 inches past the contact wire clamp.

F. Minor field adjustments of hangers, contact and messenger heights and headspan/cross-span wires shall be performed by the Contractor as directed by the Authority at no cost to the Authority.

G. Hangers shall be plumb within plus or minus 1/2 inch.

3.10 MESSENGER AND CONTACT WIRE STRINGING

A. All conductors shall be installed in accordance with good overhead line practice, and the manufacturers' recommendations, subject to Authority approval. Contractor shall submit, for Authority approval, the proposed methods for messenger and contact wire stringing installation. Due regard shall be made for conductor creep and in order to reduce creep prestressing of the conductors shall be used. The prestressing method of the conductors shall be submitted, for Authority approval, for the applicable conductor prior to installation. The initial stretch and the 10 year creep shall be removed at the time of installation.

B. Conductor tensions, cantilever settings, and counterweight settings are temperature related. During stringing, actual conductor temperatures as measured by contact thermometers shall be used in conjunction with the stringing charts to ascertain the various stringing parameters. The stringing charts on the Contract Drawings shall be checked by the Contractor for conformity to the actual wire data before messenger and contact wire stringing is started.

C. It shall be the Contractor's responsibility to ensure that the installation complies with approved OCS requirements as specified in Article 3.23 of this Specification. In addition the Contractor shall provide any temporary poles, foundations and down guys which are required to facilitate the system installation and construction staging at no additional expense to the Authority.

D. Splices in wire runs of new messenger and contact wires shall not be installed except as directed by the Authority. Splices shall be allowed where existing wire is to be extended, however they shall be kept to a minimum, and eliminated wherever possible. Before proceeding with installation, the Contractor shall submit a conceptual wiring plan showing proposed splice...
locations. All splice locations shall be Authority approved.

E. Splices for catenary conductors in auto-tensioned sections where installed shall comply with the following conditions, unless directed otherwise by the Authority:

1. Not more than 1 splice in 1 span (between any 2 supports).
2. Splices shall not be located within 25 feet of a support and shall be at least 1 foot from a hanger location and 20 feet from crossing points.
3. Splices shall not be permitted at grade crossings.
4. No more than 2 splices shall be allowed in any tension length.

F. Care shall be taken to avoid kinks in the wires. Destranding (birdcaging) of stranded conductor is unacceptable. Kinks in the contact wire will not be accepted.

G. The contact wire shall be free of twists from anchor clamp to anchor clamp. Splices in auto-tensioned sections shall be as specified and installed in accordance with the manufacturer's recommendations. Splices shall be located at least 25 feet from support points. Use and acceptability of splices shall be subject to Authority approval.

H. In-running contact wires crossed by another in-running contact wire shall be fitted with a cross contact bridge. The cross contact bridge shall be of sufficient length to ensure that the contact wires are allowed to move freely.

I. Potential equalizing (in-span), continuity and feeder jumpers shall be installed as shown on the Contract Drawings.

J. All termination fittings shall be oriented in accordance with the manufacturer's recommendations.

K. Both contact and messenger wires shall be grounded during and after the stringing process prior to energization.

3.11 INSTALLATION OF MIDPOINT ANCHORS

A. Midpoint anchor assemblies and contact wire restraint assemblies shall be installed at the locations indicated on the Contract Drawings and as recommended by the manufacturer.

B. Midpoint guy assemblies shall be installed in accordance with the Contract Drawings.

3.12 INSTALLATION OF SECTION INSULATORS

A. Section insulator types and locations shall be located as shown on the Contract Drawings.

B. Section insulators shall be installed as recommended by the manufacturer and as required to meet the design requirements specified in Article 2.12 of this Section.

C. The manufacturer's representative shall assist the Contractor in supervising the installation of the Section Insulators.

D. After installation, adjustment may be required to insure proper operation. This shall be performed as required and as directed by the Authority.

3.13 INSTALLATION OF SECTION BREAKS

A. Section breaks shall be installed at locations as indicated on the Contract Drawings.

B. Contractor shall submit, for Authority approval, the proposed procedure for construction of the section break, including type and installation of the 4-bolt contact wire clamp, insulated hangers and cut-in insulation.

C. Contractor shall install all hardware and fittings in accordance with the manufacturer's recommendations and procedures.

D. After installation and during live wire running tests, adjustment of the section break, including wire separations (vertical and horizontal) and the parallel running portion of the section break may be required to insure proper operation. This shall be performed as required and as Authority approved. All adjustments required shall be performed at no additional cost to the Authority.

3.14 INSTALLATION OF OCS DISCONNECT SWITCHES

A. Switches shall be field installed as shown on the Contract Drawings and specified herein and in Article 2.11 of this Section. Special attention shall be given to the orientation of the switch at each location. Field mounted switches shall be installed in accordance with the manufacturer's instructions. Anchor bolts and anchorage items shall be provided as required. External field wiring shall be performed as indicated. Clearance from the vehicle and pantograph shall be maintained at all times.

B. Contractor shall prepare a test plan for the motorized disconnect switch, which demonstrates each switch is correctly wired from the TPSS. Test shall include provisions for proper operation from the control panel in the substation with simulated Supervisory Control and Data Acquisition (SCADA) functions. Test plan shall include continuity, voltage measurement and
point-to-point verification. The testing shall also demonstrate the correct operation of the electrical interlocks.

C. Contractor shall ensure adequacy of walls for supporting and mounting the disconnect switches and accessories.

D. Prior to energization of the OCS, the Contractor shall verify correct operation of all disconnect switches installed under this Contract, and shall demonstrate to the satisfaction of the Authority the intended operation of the switch and the interlocks.

E. All wiring shall be provided as required. Conductor sizes, composition and insulation shall be as indicated on the Contract Drawings. All required additional hardware such as electrical conduits, clamps, junction boxes, bushings, connectors, grounding conductors, and all basic electrical materials needed for the installation of the equipment and accessories, including switch number as shown on the Contract Drawings, shall be provided and installed by the Contractor.

F. The installation shall conform to National Electrical Code (NEC) and National Electrical Safety Code (NESC).

G. Disconnect switches shall be arranged and installed as recommended by the manufacturer to meet the design requirements specified in Article 2.11 of this Section.

H. Disconnect switches shall be fitted, by the Contractor, with temporary locks, during installation, in order to prevent unauthorized operation of the switches.

3.15 INSTALLATION OF SURGE ARRESTERS

A. Surge arresters for the OCS shall be installed as shown on the Contract Drawings.

B. Each surge arrester shall be bonded to the grounding system by a No. 2/0 AWG copper wire with 2000 V-rated insulation, as shown on the Contract Drawings. The grounding conductor shall be installed in a conduit, which shall be attached to the pole. Contractor shall submit for Authority approval the proposed method for attaching to the pole and routing of the conduit from the surge arrester to the grounding system.

C. Bonding cable connections between the surge arresters and the OCS, and between the surge arresters and the grounding system, shall be installed, as shown on the Contract Drawings, with a minimum number of bends and the shortest possible length.

D. Bonding connections between the surge arresters and the grounding systems shall be of the exothermic weld type.

E. Refer to Subsection 2.2 of this Section, Grounding and Bonding System, for general requirements on grounding and bonding connections.

3.16 COUNTERWEIGHT ASSEMBLY INSTALLATION

A. Counterweight assemblies shall be installed at locations indicated on the Contract Drawings.

B. The type of counterweight assembly at each location shall be as indicated on the Contract Drawings.

C. A chart showing counterweight assembly height attachments referring to a reference level for various wire temperatures and tension lengths is included on the Contract Drawings. Contractor shall check, confirm and verify the information prior to the installation of the counterweight.

D. Counterweight assemblies shall be free moving between conductor temperatures of 20 degrees F and 120 degrees F. A mechanical stop shall be provided to restrain the counterweights from moving at temperatures above 120 degrees F and below 20 degrees F.

E. Special care shall be taken during installation of counterweight assemblies to obtain correct wire temperature and travel clearance for the counterweight and pulley assemblies. Preliminary tensioning of the OCS to remove 10 year creep shall be completed prior to finalization of the counterweight settings.

F. Weights for counterweight tensioning shall be standard cast iron, or steel/concrete composite units, as shown on the Contract Drawings, adjustment weights to be stacked as required to make up the required tension in each assembly. Weights shall be sized to ensure that they fit inside the web of the wide flange poles.

G. Authority approved lubricating grease shall be applied to pulley bearings, swivels, guideways, guide rods, and wire ropes as recommended by the manufacturer and as Authority directed and approved.

3.17 JUMPERS

A. Configurations of all types of jumpers shall be Authority approved.

B. Jumper wires shall have cut and tied ends projecting not more than 1/2 inch through open clamps. Stainless steel tie wraps shall be used for securing the cut ends of jumpers.

C. Feeding and full section jumpers in auto-tensioned catenary shall be of a length and configuration required to accommodate the anticipated differential movement of the conductors. Contractor shall determine and submit for Authority approval the calculations used to
establish the overall lengths of jumpers, based on actual field measurements.

D. In all cases, jumpers shall be installed and trained so as to avoid conflicts with the pantographs, adjacent cantilevers, and hangers.

E. Each cable end shall be cleaned with an accepted decontaminant immediately prior to making connections.

F. Connectors shall be as indicated and shall be installed in accordance with the manufacturer's recommendations.

G. Bolts in bolt-type connectors shall be lubricated with conductive grease as recommended by the manufacturer, and torqued to the bolt manufacturer's recommendations, using a calibrated torque wrench.

3.18 FEEDER RISERS

A. Where underground conduits are required, Galvanized Rigid Steel conduit risers, as shown on the Contract Drawings, shall be provided and installed as part of this Contract. Contractor shall provide and submit data for Authority review and approval, information which describes the material Contractor proposes to use and the methods used to support and attach the conduits to the OCS pole, to complete the feeder risers.

B. Contractor shall provide the feeder cable, conduit, conduit riser clamps, bolts, nuts, washers, conduit fittings, weather heads, and other hardware to complete the riser installation.

C. Riser conduit-end fittings shall provide for the mechanical support of the cable using a Kellums grip or Authority approved equal as well as a watertight cable seal.

3.19 INSTALLATION OF INSULATED CABLES

A. Insulated cables shall be installed by the Contractor in underground ducts, handholes and manholes, and in above ground feeder risers and conduit provided under this Contract, as shown on the Contract Drawings.

B. Care shall be exercised in pulling cables in conduit to avoid kinking, putting undue stress on the cable, compressing, distorting, or otherwise abrading cable insulation. A lubricating compound shall be used while pulling cables. Cable pulling tension applied during the pulling process shall not exceed the manufacturers' written recommendations. Pull tension calculations including maximum sidewall pressure, weight correction factor, coefficient of friction, conduit fill ratio, jam probability, and other relevant engineering factors shall be submitted to demonstrate this requirement. Rollers, jam, and quadrant blocks shall be used as required to facilitate cable installation.

C. Cable pull lengths shall be maximized so as to prevent splices.

D. Cables in the manholes shall be supported by galvanized steel hangers, racks and clamps, spaced a maximum of 3 feet apart. Negative cables shall be supported separately from the positive feeder cables. All cable supports shall be provided and installed by the Contractor.

E. Insulated cables shall be supported from headspans, support wires and cantilevers using stainless steel tie wraps with a maximum support spacing of 2 foot intervals as specified in these Specifications and as shown on the Contract Drawings.

F. Terminus: Terminations in manholes, pole and pad-mounted sectionalizing switches and to the feeder breaker buss(es) and negative return buss in the TPSS will be made by the Contractor. Terminations shall be made as specified in Article 3.20 of this Section, using the required termination kits specified in Article 2.5 of this Section.

G. Inspection and Tests: An insulation test shall be performed at 2.5 KVDC by the Contractor, and the results recorded and submitted to the Authority as specified.

3.20 INSTALLATION OF CABLE TERMINATIONS

A. General: Cable and conductor terminating devices shall be applied only to conductor sizes within the size ranges for which the devices are designed. Terminating devices shall be rated for the full ampacity of the cables.

B. Terminations No. 8 AWG and Larger:

1. Conductors shall be terminated by means of the specified pressure grip (solderless) lugs of the indented barrel type. Manual or hydraulic tools shall be utilized as specified for the size of wire by the lug manufacturer. The correct size jaws shall be used for the indenting tools so that a full stroke is required for proper indentation. To install the lug, the insulation shall be stripped from the conductor for the minimum length required to insert the conductor the full depth of the lug.

2. Unless otherwise specified, terminations of power conductors may be made directly in box-type lugs, without terminals, where such lugs are part of the electrical equipment or device as manufactured, provided that the lugs are of adequate capacity and rating, and are service proven for the specific application.
3. Where a special type of termination is recommended by an equipment supplier, data on the termination method shall be submitted to the Authority for approval.

4. Wherever possible, service proven terminations shall be used. Where new or untried devices are proposed, the Contractor shall submit samples and test data to the Authority, as required, for Authority approval to use, including on-site tests and demonstrations where required.

C. Terminating Tools: Terminals and connectors shall be installed with the tools recommended by the manufacturer.

D. Tagging Conductors: 2000-volt DC positive feeder cables, position indication, and 480V cable shall be tagged at each end, and in each handhole and manhole over the cable insulation. Tags shall be secured at both ends with nylon ties. Designations shall be by the circuit designation shown on the Contractor's Authority approved shop drawings and the Contract Drawings. Contractor shall provide a schedule of proposed wire tagging for review prior to printing of the sleeves.

3.21 INSTALLATION OF GROUNDING AND BONDING SYSTEMS

A. Grounding and bonding, including bonding between poles and pole foundations shall be installed in accordance with the Contract Drawings and as specified herein.

B. The Work shall be arranged in such a manner that each part of the grounding system, which is laid below finished grade, shall be completed and inspected before backfilling is undertaken. All precautions shall be taken to assure that no damage is done to the grounding and bonding conductors or connections during backfilling, compacting and concreting operations. Testing for ground resistance shall be performed in accordance with the requirements of this Specification before any finish surfacing is laid above the grounding and bonding conductors.

C. Grounding conductors shall be copper, of the size indicated on the Contract Drawings, unless otherwise shown or specified. Except where otherwise indicated by the Contract Drawings, grounding conductors shall be bare copper.

D. Subgrade grounding connections shall be of the exothermic heavy-duty type, unless otherwise noted on the Contract Drawings. Conductors and molds shall be prepared in accordance with the manufacturer's instructions before making these welds. With the Authority approval, brazing may be used where exothermic welds are not practical.

E. All exposed grounding connections between ground conductors and from ground conductors to equipment shall be made by bolted clamps. Pressure connectors may be used with the Authority's approval.

F. Ground tap connections to equipment shall be made at the points provided on the equipment for grounding and in accordance with the manufacturers' recommendations. Where ground pads are not provided, equipment or structures shall be drilled and connections made by means of bolts and nuts, or the equipment or structure shall be drilled and tapped and connected by means of a cap screw or post-type connector, as Authority approved. All paint, scale, rust, oxidation, or other foreign material shall be thoroughly removed from the points of contact on all metal surfaces before any ground connections are made. Galvanizing which is damaged or removed shall be repaired in accordance with the Authority approved procedure using cold applied galvanizing compound such as Galvalloy by Metalloy Products Co., Hardhat 2185 by Rust-Oleum or ZRC by ZRC Chemical Products or Authority approved equal.

G. Metallic conduit systems, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Wherever slip joints are used, suitable bonding shall be provided around the joint to insure a continuous ground circuit. Metallic boxes shall also be grounded to the bonding conductor, preferably by compression-type terminals bolted to boxes, unless the conduit connections to the box are threaded and the grounding conductor is brazed to the box. Screwed and brazed joints shall be carefully painted with bituminous paint.

H. Grounding systems required for connection to surge arresters mounted on the OCS poles shall consist of interconnecting ground rods, with a ground resistance of 5 ohms or less or as required by the surge arrester manufacturer. OCS pole ground resistance shall be as indicated in Article 3.23. Suggested ground rod configurations are shown in the Contract Drawings.

I. Local conditions shall dictate the configuration and location of the grounding system.

3.22 OCS TESTING AND COMMISSIONING

A. The Work specified in this Article includes final OCS testing and commissioning including providing Authority approved measurement and test equipment and all staff required to support Contractor and Authority tests.

B. Contractor shall provide the following items, which may be additions to the items in Article 2.15 in this Section, "Special Tools for OCS Installation," to be used as Authority approved measurement and test equipment:
1. Two insulated telescoping height measuring sticks, calibrated in feet and inches.

2. Two optical stagger gauges, calibrated in inches.

3. One mobile height and stagger gauge, constructed and provided as an integral unit on a track mounted cart or trolley, including demountable clearance "ears" simulating the shape and position of a raised pantograph current collector.

4. Contractor shall make available 1 high-rail platform truck along with a driver and platform operator to perform high-level inspections of the OCS. The platform shall be articulated, have OSHA conforming railings and shall be capable of being raised and lowered from the platform. This truck and operator(s) shall be made available for up to 120 hours of high-level inspections (day and/or night including weekends) by the Authority.

C. Quality Assurance: Contractor shall perform the testing and commissioning in accordance with Paragraph 1.4.D of this Section.

D. Submittals shall be in accordance with Paragraph 1.3.R of this Section.

E. All tests must be performed in accordance with the acceptance test procedures. No deviations shall be allowed unless Authority approved.

F. A test that fails shall be repeated and any corrective action taken to pass the retest shall be outlined in a new test report.

G. Contractor shall maintain configuration of OCS including tensioning, throughout the complete duration of Contractor and Authority testing. This includes adjustments to components of the system as required to maintain configuration and protect vehicle and vehicle component systems.

H. Applicable Standards:

1. Pertinent provisions of the following listed standards shall apply to the Work of this Section, except as they may be modified herein, and are hereby made part of this Specification to the extent required: NCTCOG - Standard Specification for Public Construction.

2. Federal, State and Local Authorities: All applicable codes and regulations.

I. Equipment:

1. General: Contractor shall provide the height and stagger gauges, and all other equipment required to make Acceptance Measurements. All measuring equipment will be as Authority approved.

2. Insulated Telescoping Height Sticks: Hastings Model 806-5, each with Catalog No. C-8104 carrying case, as manufactured by Hastings Fiber Glass Products, Inc., 770 Cook Rd., PO Box 218, Hastings, MI 49058, Tel. (616) 945-9541; or Authority approved equal, with 30 foot extended length, 50 inch collapsed length, weighing 6-1/2 pounds, marked in English graduations.

3. Optical Stagger Gauges: Type 1968 as manufactured by the Allgemeine Electricitats Gesellschaft (AEG), Frankfurt, Germany, or Authority approved equal, each comprising a measuring rod, an adjustable measuring bar, and a lens carriage called an "optic", modified to read in English graduations (inches and feet), and not in centimeters, and equipped for night measurement with built-in lighting and spare batteries.

4. Mobile Height and Stagger Gauge: Vehicle mounted, with demountable clearance "ears", and shall be custom fabricated. The unit shall be constructed to include a rigid tow bar for coupling to a track mounted "bucket" truck. The mobile height and stagger gauge shall comply with the Authority requirements for insulation between rails.

5. High Rail Inspection Vehicle: Contractor shall make available, for OCS Visual Inspection Requirements, a High Rail Inspection Vehicle. The inspection vehicle shall have a platform capable of accommodating a minimum of 8 people. The platform shall be able to adjust hydraulically (or electrically) to suit all contact wire heights and shall include all safety aspects including handrails and access ladders.

J. Test Procedures and Equipment:

1. The acceptance measurement and test equipment provided by the Contractor for his use shall be made available to the Authority for checking the location of the contact wire, and verifying that the registration assemblies conform to the clearance requirements of the pantograph clearance envelope. Each item of equipment will be used as follows:

   a. Insulated telescoping height measurement sticks will be used by the Authority to measure the heights of conductors and guys, track clearances to undersides of
b. Optical stagger gauges will be used by the Authority to verify the measurements given by the Contractor in the Acceptance Measurement Form.

c. The mobile height and stagger gauge will be used by the Authority only on electrically de-energized catenary, and for two purposes:

1) For visually checking the location (height and stagger) of the contact wire throughout the completed new electrified lines.

2) To confirm that the contact wire registration assemblies are installed in conformance with the requirements of the pantograph clearance gauge.

d. One insulated telescoping height measuring stick, and 1 optical stagger gauge, shall be readily available for use by the Authority at any time during the construction and acceptance measurement periods.

e. All measuring tapes, poles, sticks, and other equipment used to collate data when the OCS is energized must be non-conducting. Under no circumstances will use of metallic or conductive measuring tapes, chains and other devices be permitted.

2. Acceptance Measurements:

a. Upon completion of all construction, the Contractor shall measure the contact wire height, stagger, and other required dimensions and record the readings on an Acceptance Measurement Form, in the presence of the Authority.

b. Contractor shall prepare the Acceptance Measurements Table and it shall include the following information:

1) Track designation
2) Wire Run Number
3) Drawing number(s) where the structures of the Wire Run are shown
4) Name(s) of person(s) responsible for performing the acceptance measurements.
5) Sheet number of a Wire Run set.
6) Equipment or catenary style being measured
7) Temperature of the conductor in degrees F during the time of measurement
8) Weather condition during time of measurement, e.g., windy, raining
9) The date measurement was made
10) Structure number identification
11) Station location of the structure in feet as indicated on the Contract Drawings
12) Distance of the pole to the rail measured from the centerline of the nearest track to the face of the pole
13) Height of the foundation relative to the rail measured from the top of the low rail to the top (crown) of the foundation.
14) Cross-level difference of the 2 rails measured to the structure station (actual superelevation at the structure)
15) For use by the Authority
16) Distance measured at the structure from the contact wire to the vertical or superelevated centerline of the track (referred to as stagger)
17) For use by the Authority
18) The vertical distance between the contact wire and the track at the structure measured from the mean rail level (referred to as contact wire height at the support)
19) Distance between supporting structures measured along the track centerline

20) Same as subparagraph 3.22.I.2.b.14) above, except measured at midspan

21) For use by the Authority

22) Distance between the contact wire and the vertical or superelevated centerline of the track measured at midspan (referred to as midspan)

23) For use by the Authority

24) The average of the contact wire heights of the structures at each end of the span minus the contact wire height at midspan (referred to as sag)

25) For use by the Authority

26) The rate of change of contact wire height between the structures. This is equal to the difference of contact wire heights at each structure divided by the span (referred to as gradient)

27) Vertical distance measured at the structure between the contact wire and the messenger wire

28) Rise or fall of counterweight from median position

29) For counterweight - ambient temperature

30) Positions of counterweight stops

31) The vertical distance between the underside of the bridge and the vertical or superelevated centerline of the track

32) Electrical clearance from messenger or contact wire support to underside of bridge or tunnel roof with uplift force of 50 pounds on the contact wire at the point of measurement

33) At overlaps, section breaks and turnouts - height of in-running and out-of-running contact wire above rail-referenced level at each structure (Separate columns should be provided for in-running and out-of-running contact wire)

34) Comments or remarks as required

c. The Authority will use the Acceptance Measurements to determine compliance with the design and will inform the Contractor of required corrections.

d. Contractor shall execute corrections at no further cost to the Authority, except for adjustments required by the Authority that are changes beyond the requirements specified in the Contract Documents.

e. After execution of corrections, the Contractor shall re-measure and record affected data and submit the results to the Authority.

f. The Work of this Section will not be complete until corrections are completed and Authority approved.

3. Visual Inspection of Completed OCS:

a. At Contact Wire Level, the Contractor shall make the following checks, and remedy unsatisfactory conditions found during these checks:

1) Check fit and tightness of all components

2) Check split pins and locknuts are secure

3) Check contact wire for kinks, rolls, and damage

4) Check messenger wire for damage to strands

5) Check correct steady arm fittings

6) Check heel settings

7) Check that jumpers are of correct type, have adequate travel capability, are properly fitted, and are well formed to
reduce fatigue failure and interference with the vehicle pantograph

8) Check posture of pulley terminating plates

9) Check that hinge fittings have freedom to move under load

10) Check that a wire passing through a cantilever and not attached to it will clear any part of this cantilever by at least 3 inches throughout the range 4 to 120 degrees F

11) Check for clearance and separation between adjacent or crossing catenaries

12) Check installation for locations of possible interference with the passage of pantographs, including spots where pantographs could tangle with wires or suspension assemblies

b. From the Ground, the Contractor shall make the following checks:

1) Check that counterweights have freedom to travel and that the counterweight band does not bear on guide pipe.

2) Check that cantilevers have correct along-track offset.

3) Check that hangers are plumb and within design position.

4) Check that NCTCOG - Standard Specification for Public Construction and other applicable safety code requirements have been met.

5) Check pole rake

4. Contractor shall perform the following OCS Electrical Tests:

a. Circuit Continuity and Loop Resistance:

1) The Circuit Continuity and Loop Resistance test shall be performed before the Hi-Pot Test.

2) General: The purpose of this test is to obtain the DC loop resistance of each OCS section. This test checks both the OCS and the rail return system for electrical continuity and the absence of high resistance connections or inadvertent ground connections.

3) Procedures: The test entails short circuiting a discrete section of the OCS by connecting the OCS to its rails at one end, and applying a DC voltage at the other end. The length of section under test should be about 1 to 2 miles. The test shall be carried out in the following steps:

   a) Along-track feeders, which are electrically common to the OCS, shall be connected to the OCS.

   b) A DC source is required which will provide a current of nominally 300 amperes with an applied voltage of 24 volts, e.g., 2 car batteries connected in series.

   c) Measurements shall be made of the DC voltage at the points where the Test Circuit cables connect to the Positive Feeder and Negative Return cables so as not to include the resistances of the Test Circuit cabling. DC current shall be measured by placing an appropriate sized 50mv shunt in series with the Test Circuit. The circuit resistance shall be calculated from the measured values of voltage and current and shall be compared with the design values that are recorded on the test form. Apply test Voltage 3 times for
OVERHEAD CONTACT SYSTEM

approximately 5 seconds allowing 1 minute intervals between tests for component cooling. Average the 3 readings and record on Table C-1, DC Loop Resistance Test.

d) Any section having a discrepancy of more than 20 percent between the design value and the measured value shall be rechecked to ensure that all electrical connections are correctly made, or that there are no inadvertent ground connections to the OCS which are reducing the total length of the loop.

e) DC voltage shall be applied as shown in attached Figure C-1, DC Loop Resistance Test.

f) Record all items for each section on attached Table C-1, DC Loop Resistance Test. Compare calculated values with actual test results.

b. Hi-Pot Insulation Testing:

1) Hi-Pot testing shall not be performed until the Loop Resistance Testing is complete.

2) General: DC Hi-Pot tests shall be performed on the OCS. The Hi-Pot tests serve the following purposes:

a) Components such as insulators and feeders are checked for leakage.

b) The electrical withstand of minimum clearance areas, such as tunnels or overhead bridges, are verified under static conditions.

c) The electrical withstand of section insulators and disconnect switches are verified.

d) The test provides a means of periodically checking for any reduction in the insulation level of the OCS sections, by comparing voltage and leakage current with previously measured values.

e) A nominal DC Hi-Pot voltage of 2 x OCS rated voltage plus 1 kV shall be used for 5) DC loop resistance tests may be performed without disconnecting cables from the DC feeder positive busses and negative return buss by connecting test circuit directly to appropriate buss work after disconnecting all associated wiring and opening associated breakers and switches. The contractor shall submit for Authority approval a written procedure to accomplish the test configuration.
the test. Hi-Pot tests shall be carried out on the OCS sections as soon as possible after the continuity tests have been completed, in order to ensure that all of the section being tested is electrically continuous and is subjected to the test voltage. Maximum leakage current of 1 mA per mile can be expected for section lengths of 1 to 2 miles.

3) Procedure for Main Line Tracks: Along-track feeders which are electrically common to the OCS but disconnected from the substations. Adjacent OCS sections which are electrically isolated from the section under test shall be grounded by connecting the OCS to the rails. All surge arresters shall be disconnected from the section under test. A DC test voltage shall be applied to each OCS section in 500 VDC increments up to the nominal test voltage. The test voltage shall be held for 30 seconds at each increment. Circuit connections shall be as shown in attached Figure D-1, Hi-Pot Measurement. The leakage current at each value shall be measured and recorded as shown in attached Table D-1, DC Hi-Potential Tests, together with the weather conditions and temperature.

4) Precautions: The Hi-Pot measurements require application of high voltage to the OCS. Proper regard must be paid to safety. Test zones shall be clearly identified. All safety requirements established in the Safety program concerning the public, work personnel and equipment shall be strictly enforced. Personnel not directly associated with the tests should be clear of the tracks. Sections of OCS and associated feeders under test shall be isolated from the adjacent sections of the system, and all OCS sections adjacent to the section under test shall be grounded.

c. Ground Resistance Measurement at Surge Arresters:

1) General: The purpose of this test is to measure the ground resistance at each surge arrester location where the arrester is connected to a ground rod(s).

2) Procedures:

a) The ground resistance megger shall be connected as shown in attached Figure B-1, Ground Resistance Measurement. The lead from P1/C1 shall be as short as possible, and the electrodes and the ground rod should be in a straight line. It is not essential that the electrodes are parallel to the track, but this configuration will probably be the most convenient.

b) The electrodes shall be positioned at distances as shown in attached Table B-1, Ground Resistance, test position one, i.e., with \( x = 66 \text{ ft.} \) and \( y = 105 \text{ ft.} \) Current and potential electrodes shall be inserted into the earth to about 6 to 10 inches. For very dry soil, water shall be poured around the current electrodes. To ensure acceptable values of resistance, the ratio of distances \( x/y \) shall be approximately 62 percent. The resistance shall be
c) Keeping the x dimension the same as in step b, the current electrode shall be repositioned to y + 6 feet (test position two), and the resistance measured and recorded.

d) The resistance values obtained in steps b) and c) shall be compared and recorded on Table B-1, Ground Resistance. If the readings obtained are within 5 percent of each other, no further measurements are required, and the average value shall be used as the actual resistance. If the readings differ by more than 5 percent, x shall be increased by 10 feet and y made equal to \((x + 10)/0.62\) approximately (test position 3), and Steps b, c, and d shall be repeated as required.

e) This procedure shall be repeated for each surge arrester location for which a ground resistance measurement is required.

f) A measured ground resistance value of 5 ohms or less is desirable. Values ranging between 5 ohms and 20 ohms, or as recommended by the manufacturer, may be acceptable with the Authority's approval, while values greater than 20 ohms will require remedial action.

5. Contractor shall perform Clearance Envelope Tests for Pantograph and Vehicle:

a. General: The purpose of these tests is to verify the mechanical and electrical clearances of the LRV units on each section of the system. The tests shall be conducted after all installations are complete. Any section found to have insufficient clearance shall be adjusted to provide the required clearance.

b. Pantograph Clearance Envelope: Tests shall be performed initially with a rail mounted height and stagger gauge having the same profile as the vehicle pantograph. This gauge shall be used to verify the mechanical clearances between the pantograph and OCS components such as the heel settings of steady arms and contact wire clamps, and the electrical clearances between the OCS/pantograph combination and civil structures such as over bridges. Following these tests, final tests shall be performed with an actual LRV to verify the initial simulated results.

c. LRV Clearance Envelope: Tests shall be performed with an LRV towed or pushed through each track section. The following tests shall be performed:

  1) Dead Slow Tests at Walking Speed: The driver of the towing unit shall be prepared to stop at short notice during these tests.

  a) Trackside Structural Clearances to LRV Body and Pantograph: This includes poles, bridges, awnings, wayside signaling and electrical equipment housings.

  b) LRV body clearances shall be checked at the ends of each unit and at the midspan between trucks.

  2) Slow Speed Tests: Tests listed above under Subparagraph 5c1a shall be repeated at higher LRV speeds. Test speeds shall
be raised in successive increments recommended not to exceed 5 mph each. The maximum LRV dead wire run speeds shall be as recommended by the LRV manufacturer.

6. Live Wire Run Testing:

a. Contractor shall support Authorities System Integration Testing.

b. General: The purpose of these tests are to evaluate:

1) The current collection performance between the LRV and the OCS.

2) The adequacy of the power provided by the OCS for required vehicle performance.

c. Procedures:

1) Current collection performance tests shall be performed at LRV speeds in increasing increments of 20 mph each. LRV test speeds shall not exceed the specified track speed limits or as directed by the NCTCOG regulations for test vehicles.

2) During the current collection performance tests, particular attention shall be paid to:

a) Behavior of the pantograph on various contact wire profiles for signs of loss of contact.

b) Overlaps, section breaks, cross-contacts, turnouts, bridge approach spans, and section insulators for smooth running and takeover.

c) Takeover points at overlaps, section breaks, cross contacts, turnouts and section insulators for smooth transitions.

d) Dynamic clearances at bridge fittings, facias, crossing and parallel contacts, clearances to uplifted steady arms and supports.

e) Midspan offsets, stagger effects, and contact wire sweep.

3) Contractor shall provide video equipment for recording of the current collection performance tests. These tests will facilitate detailed analysis of the OCS after the tests have been performed. If an LRV is required to perform video taping, the Contractor shall coordinate LRV availability and scheduling with the Authority.

4) If adjustments are made to the OCS or to track alignment after the initial tests, the tests shall be repeated on the affected sections, and their results documented in the same manner as detailed in the preceding paragraphs.

7. Analyses of Results:

a. Analyses of test results shall be performed jointly by the Authority and the OCS designer.

b. Recommendations of system changes shall be jointly evaluated for feasibility by the above listed parties.

8. Acceptance Records:

a. Contractor shall produce records of all tests performed under these Specifications and in accordance with the following requirements:

1) NCTCOG - Regulations Engineer

2) OCS Designer

3) The Authority
3.23 FIELD TESTING

A. Field testing shall be thorough, continuing throughout the installation, fully documented, with the following as a minimum:

1. Electrical resistance tests shall be made during installation to verify continuity of the grounding system.

2. Measure, record and report the resistance to earth of each portion of the grounding system as soon as possible after installation so that corrective measures, if required, may be made with minimum disruption of construction. The required ground resistance for the OCS poles shall be 25 ohms or less and shall be 5 ohms or less for surge arresters or as required by the manufacturer. Where the resistance exceeds 25 ohms, ground rods, up to a maximum of 3, shall be provided. If the resistance then still exceeds 25 ohms, the Authority shall be advised.

3. Measure, record, and report the ground resistance at each pole.

4. Resistance-to-earth tests shall be witnessed by the Authority or designated agent and the written results of these tests shall be submitted to the Authority or designated agent for evaluation and instructions regarding any corrective action, which may be deemed required.

5. Ground resistance tests shall be made with a James G. Biddle Company Model 250220, Heavy-Duty, Megger Ground Resistance Tester, or Authority approved equal, using the 3-probe method described in IEEE Standard 81.

6. Section insulators shall be field tested as recommended by the manufacturer.

7. Field tests shall be witnessed by the Authority. Certified copies of the test results shall be submitted as required by Part 1 of this Specification Section.

3.24 SPARE PARTS

A. Contractor shall furnish the following Spare Parts to the Authority prior to final acceptance. All cable and wire material shall be in continuous lengths.

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cantilever Assemblies (Less Tube)</td>
<td>Ea.</td>
<td>6</td>
</tr>
<tr>
<td>Cantilever Tube</td>
<td>Lf.</td>
<td>200</td>
</tr>
<tr>
<td>Hanger Wire</td>
<td>Lf.</td>
<td>1000</td>
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</table>

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work described in this section shall be full compensation for providing and installing the Overhead Contact System complete in place as specified including finalizing design, shop drawings, submittals, testing, and inspection; and for all Work as described in the Contract Drawings and in this Section and other related Specification sections; and for all operations, materials, tools, labor, equipment and incidentals required to complete the specified Work.

4.2 PAYMENT

A. The Work described in this section will be paid as a lump sum.
Figure B-1
Ground Resistance Measurement

Note: Electrode depth shall be six to eight inches
Figure C-1
Loop Resistance Measurement

Messenger Wire

Section Break

Catenary Wire

Section Break

Catenary Poles and OCS Section Of Approximately 1 to 2 Miles

Positive Feeder

Running Rails

DC Voltmeter

DC Ammeter

DC Positive Test Source

DC Negative Test Source

Traction Power Substation

Note: Disconnect substation feeders for testing
Figure D-1
Hi-Pot Measurement

- Messenger Wire
- Catenary Wire
- Section Break
- Catenary Poles and OCS Section Of Approximately 1 to 2 Miles
- Earth Ground Applied For Testing
- Earth Ground Applied For Testing
- DC Hi-Pot Test Device
- Running Rails
- Earth Ground Applied For Testing
- Positive Buss
- Negative Buss
- Traction Power Substation

Note:
Traction Power Substation Feeders and Lightning Arrestors MUST be disconnected to perform test
### TABLE B-1

**GROUND RESISTANCE**

<table>
<thead>
<tr>
<th>ARRESTOR LOCATION</th>
<th>TEST POSITION</th>
<th>DISTANCE X (Ft)</th>
<th>DISTANCE Y (Ft)</th>
<th>MEASURED GROUND RESISTANCE (Ohms)</th>
<th>AVERAGE GROUND RESISTANCE FOR STR LOCATION (Ohms)</th>
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<tbody>
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<tr>
<td>Loop Impedance Test</td>
<td>Section</td>
<td>Section</td>
<td>OGs Track</td>
<td>Feeder</td>
<td>Feeder</td>
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<td>Item #</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Control Resistance Values</th>
</tr>
</thead>
</table>

- **NOTE**: For performing DC loop resistance tests, the power source should be disconnected. Each test shall be repeated at least 3 times, and the average shall be taken. The test shall be performed with the system in the normal operating condition.

- **CAUTION**: When performing this test, ensure that the system is not in a critical state. Discharge the system before performing the test.

- **Warning**: The test shall be performed in a well-ventilated area to prevent the buildup of hazardous gases.

- **Preparation**: Before performing the test, ensure that all safety measures are in place, and the test personnel are properly trained.

- **Procedure**: Follow the recommended test procedures, ensuring that all readings are taken accurately and recorded.

- **Reading**: Ensure that the readings are taken accurately and recorded.
## Sample Acceptance Measurements

### Form

<table>
<thead>
<tr>
<th>Station</th>
<th>Mid Span</th>
<th>Side Span</th>
<th>High Span</th>
<th>Low Span</th>
<th>Span</th>
<th>Right</th>
<th>Left</th>
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</table>

**Comments:**
<table>
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<tr>
<th>High Potential Test</th>
<th>Section</th>
<th>Section</th>
<th>Leakage @ 500VDC</th>
<th>Leakage @ 1000VDC</th>
<th>Leakage @ 1500VDC</th>
<th>Leakage @ 2000VDC</th>
<th>Leakage @ 2500VDC</th>
<th>Maximum Acceptable Leakage</th>
<th>Test Results</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>From Sta. #</td>
<td>To Sta. #</td>
<td>Testing Mileage</td>
<td>milliamps</td>
<td>milliamps</td>
<td>milliamps</td>
<td>milliamps</td>
<td>milliamps</td>
<td>milliamps</td>
<td>Pass / Fail</td>
<td></td>
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</tbody>
</table>

**Note:** Maximum allowable Hi-Pot leakage current is 1.0 milliamps per mile @ 2500VDC. Calculate acceptable limits proportional to Section length.

END OF SECTION 16371
SECTION 16425
LOW VOLTAGE SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing low voltage switchboard, 600 volts and less, and supporting devices as shown.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM B187/B187M - Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes
B. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)
C. National Electrical Manufacturers Association (NEMA):
   1. NEMA PB2 - Deadfront Distribution Switchboards
D. Underwriters Laboratories, Inc. (UL):
   1. UL 489 - UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
   2. UL 891 - UL Standard for Safety Dead-Front Switchboards

1.3 SUBMITTALS
A. Product Data.
B. Shop Drawings.
C. Testing: Perform the following tests at the manufacturer's plant or submit evidence to the Contracting Officer's satisfaction, that similar equipment has passed the tests.
   1. 60 Hz dielectric tests.
   2. Mechanical operations tests.
   4. Transformer case tests.
   5. Electrical operations tests.
   6. Control wiring checks.
   7. Rated current test.
   8. Momentary current test.
   10. Sequence test.

D. Field Testing: Submit a detailed plan of the proposed methods of and scheduling of the required field testing at least 30 calendar days before initiating the tests.
E. Test Reports: Submit certified test reports for tests at the manufacturer's plant and field tests.
F. Operation and Maintenance Manuals and Training: In accordance with Section 16001, "Electrical Systems - General".

1.4 QUALITY ASSURANCE
A. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of low voltage switchgear and switchboards of the types and sizes specified in this section.
   2. Incorporate equipment into this work which essentially duplicates equipment that has been in satisfactory use for a period of five years prior to the bid opening of this project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING
A. Location of Equipment: The Contract drawings are diagrammatical and not intended for use in determining the exact locations of the components of mechanical and electrical systems.
B. Assembly for Shipment:
   1. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
   2. Coordinate maximum dimensions of shipping sections with dimensions of access hatches, corridors, and doors to ensure shipping dimensions will allow movement of switchgear through structure without damage to equipment or structure, or undue difficulty.
   3. For shipping, disconnect interconnecting wiring. Coil one side of split with matching

DART - September 2004 16425 - 1
terminal block on either side. Identify wiring and terminal block points for reconnection.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide switchboards consisting of an assembly of free standing enclosed steel structures. Furnish each structure containing a group of molded case circuit breakers or instrument compartments in the front and a full height rear compartment for buses, incoming cable connections, and feeder-cable connections. Enclose the circuit breaker compartments completely with sheet steel barriers to segregate the breakers. Provide switchboards complying with applicable codes and standards. Furnish the switchboards with an Underwriters Laboratories label, permanently affixed.

B. Ratings:

1. Nominal Voltage: 208 or 480 volts.
2. Phase: 3.
3. Wire: 3 or 4.
4. Frequency: 60 Hertz.
5. Rated continuous current and short circuit rating as indicated on the drawings.

C. Furnish switchboards consisting of the required number of vertical sections bolted together to form one rigid switchboard, completely assembled, wired, and tested at the manufacturer's plant. If approved by the Contracting Officer, switchboards may be broken down into convenient shipping sections subsequent to the completion of the factory tests.

2.2 INSULATION STRUCTURE

A. Provide insulation structure which will not support combustion, produce toxic gases, or absorb moisture.

B. When insulation structure is subjected to electric arc, limit emission of conducting materials so as not to interfere with performance of circuit breakers.

2.3 BUS BARS

A. General Requirements: ASTM B187/B187M.

B. Continuous current rating of bus bars as indicated on the drawings.

C. Provide bus bars capable of withstanding mechanical stresses and heat due to maximum short-circuit current as stated on drawings.

D. Bus contact surfaces: Silver-plated at connection.

E. Neutral bus ampere rating: 50 percent of phase bus rating, unless indicated otherwise.

2.4 GROUND BUS

A. Copper bus, not less than 2 inches by 1/4 inch furnished secured to each vertical section structure and extending throughout the entire length of the switchboard section.

B. Make joints in ground bus with 4 bolts and overlap of 4 inches.

C. Switchboards to be used for service entrance equipment shall be provided with ground-to-neutral link in accordance with NFPA 70 (NEC) for grounding of neutral. For services in same AC switchboard room, single grounding electrode connection to tie-point of neutral from each power source is permitted.

2.5 CONTROL WIRING

A. Rate insulation at 600 volts, Type SIS as per NFPA 70 (NEC), copper, 14 AWG minimum. Flexible, Class C or higher, stranded wire used for wiring across hinged joints.

B. Use one continuous length of wire between terminals without splices or taps.

C. Terminal blocks: With screw-type terminals, circuit marking strips for indicating wire number, phenolic laminated dustcover and 10 percent minimum space terminal points.

D. For each individual wire, use same identification as is used on each terminal block marking strip.

E. Make connections at terminal of device, on terminal blocks or at control bus, using tinned copper clamp compression terminals with insulated sleeves.

F. Terminate interconnect wiring between compartments on terminal blocks before being wired to components.

G. Provide fuse blocks and fuses as required.

2.6 CIRCUIT BREAKERS

A. Provide molded case circuit breakers, thermal magnetic type, manually operated, and bolt-on.
B. Equip breakers 250 amperes frame and above with solid-state trip complete with built-in current transformers, solid-state trip unit and flux transfer shunt trip. Provide breakers with easily changed trip rating plugs with trip ratings as indicated on the drawings. Interlock rating plugs so they are not interchangeable between frames and interlocked such that breaker cannot be latched with rating plug removed. Provide breaker with built-in test points for testing long delay and instantaneous and ground fault (where shown) functions of the breaker by means of a test kit operated at 120 volts. Provide one test kit capable of testing breakers 250 ampere and above.

1. Provide solid-state instantaneous element continuously adjustable from approximately four to eight times the trip rating, with short time adjustment from instantaneous to ten cycle delay for coordination purposes.

2. Provide short delay override feature providing for instantaneous tripping on high magnitude faults.

C. Provide molded case circuit breakers with symmetrical RMS interrupting capacity as indicated.

D. Provide molded case circuit breakers with overcenter toggle-type mechanisms having quick-make, quick-break action. Calibrate breakers for operation in an ambient temperature of 40 deg. C. Provide each circuit breaker with trip indication by handle position. Provide 100 ampere frame size circuit breakers with a permanent trip unit containing individual thermal and magnetic trip elements in each pole. Provide a push-to-trip button on the cover for mechanically tripping the circuit breaker.

E. Provide current limiting circuit breakers rated at maximum standard symmetrical RMS interrupting capacity for each frame size at 480 volts. Current limiting circuit breakers must protect molded case breakers downstream as shown on the drawings. No deviations from this provision are acceptable. Submit manufacturers test data proving the protection from both peak currents and RMS energy of down stream devices.

2.7 GROUND-FAULT PROTECTION SYSTEM

A. Provide ground-fault protection as required per NFPA 70 (NEC), unless noted otherwise on the drawings.

2.8 ENCLOSURE

A. Dead-front, free-standing indoor steel enclosure designed for lineup with 480 or 208 volt switchboard, where applicable.
B. Furnish anchor bolts and anchorage items where required and field check to insure proper alignment and location. Provide templates, layout drawings, and instructions to insure correct placing of anchorage items in concrete. Check and verify dimensions of embedded items for correctness of location and detail before concrete is placed.

C. Install supporting members, fastening, framing, hangers, bracing brackets, straps, bolts, and angles as required to set and rigidly connect the work.

D. Provide temporary bracing, guys, and other devices as required to accomplish erection and to provide safety and stability until work is in final position and approved.

E. Align mismatched holes by reaming or replacing of clip connectors. Do not cut with torches.

F. Connect space heaters to temporary electrical service as soon as equipment arrives on the site.

3.2 FIELD TOUCH UP PAINTING

A. After installations are complete, clean thoroughly surfaces where shop paint coating is missing or abraded, bare steel, including bolts, nuts, washers, and welds, and paint each surface and item with the same paint as used for shop coating.

B. Field touch up shall be in accordance with Section 09920, “Interior Painting” for interior locations and Section 09970, “Coatings for Steel” for exterior locations.

3.3 TESTING START-UP

A. Provide testing in accordance with Section 16030, “Testing of Electrical Systems”.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”.

END OF SECTION 16425
SECTION 16450
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing, installing, and testing complete grounding and bonding systems.
B. Grounding and bonding systems for Communications Facilities and Systems are specified in Section 16876, “Grounding and Bonding - Communication System”.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
1. ASTM B187 - Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes
B. Institute of Electrical and Electronics Engineers (IEEE):
1. IEEE 142 – Recommended Practice for Grounding of Industrial and Commercial Power Systems
C. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
D. Telecommunications Industry Association (TIA):
1. TIA J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
E. Underwriters Laboratories, Inc. (UL):
1. UL 467 - UL Standard for Safety Grounding and Bonding Equipment

1.3 SUBMITTALS
A. Shop Drawings:
1. Locations of ground rods, connectors, cables, etc., and details of connections, terminations and access points.
B. Product Data:
1. Manufacturer's catalog data for proposed materials with installation recommendations.
2. Procedures and equipment for testing resistances and electrical continuity.
C. Certification: Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to the ground grid does not exceed specified values.

1.4 QUALITY ASSURANCE
A. Source Quality Control: Each Item UL-Listed, or approved equal.
B. Comply with TIA J-STD-607-A. Grounding system resistance is 25 ohms maximum unless otherwise noted.
C. Materials conforming to requirements of NEC and IEEE 142d. Furnish products listed and approved by UL listed or approved equal.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS
A. Grounding and Bonding Equipment: Conform to UL 467 or approved equal and additional requirements specified herein. Provide for compatibility for all components, equipment, and systems among all elements of the new systems and provide for compatibility for all components, equipment and systems with existing systems.
B. Ground Electrodes:
1. Ground rods: Copper clad steel or other material as shown on drawings. Minimum dimensions: 5/8 inch diameter by 10 feet long.
2. Ground rod installations where rock prevents the installation of standard ground rods: In areas where ground rods are shown to be installed and the presence of rock prohibits the installation of standard ground rods for an effective path to ground, install UL approved vertical or horizontal chemical ground rods.
C. Grounding conductor:
1. Grounding electrode conductors:
   a. Stainless steel or copper conductor, as shown on drawings, in accordance with the following: As specified in Section 16120, “Wires and Cables”, for single-conductor cable, 600 volts.
   b. Size unless otherwise shown:
      1) For use in ground grid and for connecting of ground grid to ground bus: No. 4/0 AWG or as shown on drawings.
      2) For connection of ground bus in the operation control center and communication rooms to main ground bus in ac switchboard rooms: No. 2/0 AWG.
GROUNDING AND BONDING

3) For other grounding electrode conductors: In accordance with NEC Table “Grounding Electrode Conductor for AC Systems”.

2. Equipment grounding conductor:
   a. Sized in accordance with NEC Article “Size of Equipment Grounding Conductors” unless otherwise shown on drawings.
   b. Equipment grounding insulated conductor: Single conductor stranded copper, with insulation, as specified in Section 16120, "Wires and Cables".
   c. Equipment grounding bare conductor integral with multiple-conductor cable: Section 16120, "Wires and Cables".

D. Bus bar: ASTM B187, size 2 inches wide by 1/4 inch thick, length as required.

E. Terminal lugs:
   1. For No. 4/0 AWG and smaller conductors: Copper compression terminal lugs.
   2. For No. 250 KCMIL and larger: Long barrel, copper, double-compression terminal lugs.

F. Ground connector:
   1. O-Z Gedney, Type KG or approved equal.
   2. Two-piece, designed for connecting grounding conductor to bus bar.
   3. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.
   4. Exothermic weld: Size and type per manufacturer’s recommendations.

G. Jumpers: Insulated copper braided or leaf-type flexible jumper, size as required.

H. Bus bar insulators: Fibrous glass reinforced polyester insulator with 1/2 inch diameter threaded holes at both ends for bus bar installation, size per manufacturer’s recommendations.

I. Coal Tar Epoxy: Polyamide cured coal tar epoxy, Dupont Corlar 823 CTE, Koppers Company No. 300M, PPG Industries 97-640 or 97-641 or approved equal, applied to a dry film thickness of 8 mils per coat.

J. Epoxy Resin Encapsulation: Two-component epoxy resin type with plastic snap mold, as manufactured by Duriron Company, 3M Company or approved equal.

K. Exothermic Welds and Coatings: Metal alloy consisting of copper oxide and aluminum provided in individual plastic tubes equal to Cadweld products. Weld molds shall be made of solid graphite.

PART 3 - EXECUTION

3.1 GROUNDING

A. Ground Connections:
   1. Weld buried ground connections exothermically, in accordance with manufacturer’s recommendations. Clean and coat with coal tar epoxy applied with a 32 mils dry film thickness using multiple coats. Allow drying between coats and before backfilling. Encapsulate with epoxy resin, buried ground connections of grounding electrode conductors running to ground buses as shown.
   2. Use terminal lug to connect grounding conductor to equipment enclosure. Secure connector or terminal lug to the conductor so as to engage strands equally by using tools and pressure recommended by the manufacturer.
   3. Exothermically weld connections for ground rods in manholes and hand holes, as shown.
   4. Splices in grounding conductors are not permitted.
   5. Where ground rods are required, they shall be installed in accordance with manufacturer’s recommendations. See Section 16001, “Electrical Systems - General”, Article 1.12 - Operation and Maintenance (O & M) Manuals.

B. Ground Grid:
   1. Install ground grid consisting of bare stranded copper conductors as shown on Drawings and ground rods buried in earth, in pattern and at locations shown. Install ground rods vertical if possible. If this is impossible, rods may at an angle or (as a last resort) buried horizontally 24 inches (minimum) below grade.
   2. Bury top of ground rod 30 inches minimum below grade or as shown.
   3. Provide 24 inch minimum separation between ground rods and concrete structures.
   4. Interconnect ground rods using bare stranded copper conductors.
   5. For connecting ground grid to ground bus in each traction power substation provide 4 No. 4/0 AWG copper conductors.
   6. For connecting ground grid to ground bus in electrical room, tie-station, ac switchboard room or cooling tower fan shaft, and drainage pumping station, provide 4 No. 4/0 AWG copper conductors.
7. For additional grounding of power transformers provide 1 insulated copper conductor from nearest ground grid for each transformer ground pad. Provide 1 insulated copper conductor for service transformer between the transformer ground pad and nearest ground grid.

8. Unless otherwise shown, leave a pigtail of ground conductor of sufficient length, above finished floor for connection to ground bus, ground plates, or service entrance equipment.

C. Ground Bus:

1. Install ground bus bar, as required or as shown on drawings. The ground bus for the power substation a.c. switchboards and chiller plant equipment shall be 2 inches wide by 1/4 inch thick and length to cover the area of equipment as required.

2. Install ground bus bar, as per Item 1 in train control center and communications rooms and where shown.

3. Mount ground bus bar on insulators 2 feet above finished floor, unless otherwise shown, using cap screws and expandable threaded anchor.

4. Provide insulator support at each end of ground bus and at intervals not exceeding 3 feet.

5. In power substations, ac switchboard rooms, chiller plants, fan shafts, and drainage pumping stations, connect the ground bus to No. 4/0 AWG insulated copper conductors running from associated ground grid.

6. In train control center, communication, electrical, and mechanical rooms, kiosk (if used), and other locations shown, connect ground bus to main ground bus in associated ac switchboard room, using No. 2/0 AWG insulated copper conductor. Connections shall be mechanical and/or exothermic, manufacturer to be approved by the Authority.

7. Install No. 4/0 AWG insulated copper conductor, with one end connected to the ground bus in the ac switchboard room, at the following locations:

   a. In each tunnel for main line track, support grounding conductor on channel inserts in tunnel wall.

   b. Install grounding conductor in cable trough area and conduit reserved for ac power.

D. Equipment Grounding Conductor: Provide equipment grounding copper conductor for following services and as shown:

   1. Feeders.

2. Three-phase branch circuits.

3. Emergency lighting branch circuits.

4. Parking lot lighting branch circuits.

5. Circuits feeding load centers.


E. Grounding of Service Equipment:

1. Ground in accordance with NEC.

2. Ground enclosure and ground bus in switchgear, switchboard, motor control center and panel boards to ground bus provided in substation or room, using insulated ground conductor.

3. Install copper bonding jumper between neutral and ground bus as shown.

F. Grounding of Separately Derived AC System:

1. Ground in accordance with NEC.

2. Ground secondary neutral and enclosure of transformers to nearest ground bus or insulated grounding electrode conductor.

3. For transformer located outside of buildings, install additional grounding connector between transformer secondary neutral/enclosure and ground bus or grid using insulated copper conductor.

G. System Neutral Grounding: Provide 3-phase alternating current secondary distribution systems wye point connected with neutral grounding at the source.

1. Install system neutral and ground bus and equipment ground conductor or both as indicated.

2. Solidly ground neutral deriving equipment.

3. Connect secondary wye neutral points to ground:

   a. At Equipment: Connect neutral points to primary source equipment ground and secondary ground bus where required.

   b. At power transformers and load centers: Provide copper conductors, sized, as indicated, but in no case smaller than that required by NEC.

   c. At Dry Type Transformers: Use equipment ground conductor for connection of equipment and neutral to ground system.
H. Equipment Grounding:

1. Alternating current panelboard, disconnect switches, switchgear, switchboards, and motor control centers:
   a. Connect continuous equipment ground bus by copper ground wire to building or facility ground bus.
   b. Provide ground wire equal in size to largest conductor in line feeding equipment, but not less than No. 6 AWG, nor larger than No. 4/0 AWG.
   c. Install ground wire in rigid steel conduit bonded at both ends.

2. Wiring, channels, metallic conduit, rigid galvanized steel, flexible conduits, metallic boxes, panel boards, and transformer enclosures. Ground the ground bus with copper ground conductors sized as specified.

3. Motors, Lighting Fixtures, and Equipment: Ground in accordance with NEC.

I. Grounding for Personnel Safety:

1. In substations, tie stations, electrical and mechanical rooms, chiller plants, fan shaft, and pumping station, bond exposed metallic structure, motor frame, AC equipment enclosure, ductwork, and metallic piping to local ground bus, using minimum of No. 6 AWG insulated grounding conductor.

2. Bond escalators and elevators motor frames, AC equipment enclosures and metallic structures to equipment grounding conductor in AC power feeder. Where feasible, supplement such grounding by a connection to ground bus using No. 1/0 AWG insulated grounding conductor.

3. Bond metallic ladders, walkways, handrails, and stairs at locations as shown, to local ground bus, using insulated copper conductor, No. 6 AWG minimum, except where these metallic objects are located within 6 feet of the edge of the platform (adjacent to track ways). These metallic objects shall not be grounded and shall be protected from touch shock potential by other trades.

4. Bond and ground exposed metallic structures in open areas to separate grounding electrodes in accordance with the following requirements:
   a. Light standards: Bond and ground each light standard to a ground grid or to 1 or more separate ground rods. Provide maximum resistance to ground of 25 ohms, for each light standard.

b. Cable troughs alongside track: Bond and ground metal cable troughs to 1 inch diameter by 10 foot long ground rod, buried with top 2 feet below grade, at approximate 50 foot intervals and at each end with a minimum 2 foot separation from reinforced or buried metallic structures whenever possible, using No. 4 AWG insulated copper conductor. At expansion and contraction joints, install No. 4 AWG jumper for electrical continuity.

c. Railings, metal guard rails and fences alongside track: Bond and ground fence to 5/8 inch diameter by 10 foot long ground rod, buried with top 2 feet below grade, at approximate 500 foot intervals and at each end, with 2 foot separation from fence post footing and other reinforced structures, using No. 4 AWG copper insulated grounding conductor. For electrical continuity install No. 4 AWG insulated jumper.

d. Railing, metallic cable trough, catenary poles, and metallic deck structure on aerial structure:
   1) Hand railing as shown. Provide electrical continuity with No. 6 AWG insulated copper jumper.
   2) At each end abutment and mid span piers where shown, install No. 4/0 AWG insulated copper conductor between the bonded deck structure and the ground grid via the weatherproof junction box or manhole as shown.
   3) Provide electrical continuity and ground rods for catenary pole foundations as shown.

e. Wayside metal equipment (equipment mounted along the guide way adjacent to tracks) including, but not limited to, cabinets, poles, pull boxes, and junction boxes: Bond and ground each item to 1 or more ground rods to provide 25 ohms or less resistance to ground.

5. In underground locations, bond and ground hand railing at each end and at approximate 50 foot intervals to nearest ground bus or ground conductor, using No. 6 AWG insulated copper conductor. For electrical continuity, where necessary, install No. 6 AWG insulated copper jumper.

6. Weld grounding and bonding connections exothermically to metallic structures, catenary poles, cable troughs, hand railings, and fences.
7. Deck structures (provided with standard internal rebar): At each end abutment and mid span, install No. 4/0 AWG insulated copper conductor between the bonded deck structure and the ground grid via a weatherproof junction box or a manhole as shown on the drawings.

8. Deck Structures (provided with epoxy coated internal rebar, as shown on drawings): Do not provide grounding conductors and/or ground rods/electrodes.

3.2 FIELD QUALITY CONTROL

A. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.

B. Ground resistance not to exceed the following:

1. Maximum resistance to ground indicated in Table 16450-1, Maximum Resistance to Ground.

C. To meet resistance requirements, install additional ground rods or use soldier piles as ground rods where available. Isolate piles used for grounding from those bonded for stray current and cathodic protection (See Section 13100, "Corrosion Control").

D. Test metallic conduit and raceways, equipment enclosures, metallic cable troughs, fences, handrailings, metallic structures, and light standards for continuity to grounding system.

E. Test resistance of connections and conductors between ground bus in train control center rooms/communications rooms and ground bus in associated AC switchboard rooms, traction power substations, and dc tie stations for electrical continuity.

F. Conduct tests in presence of the Contracting Officer.

G. Prepare and submit certifications as specified.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”
### TABLE 16450 - 1
MAXIMUM RESISTANCE TO GROUND

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MAX. OHMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Grid/Bus in AC Switchboard, Services Buildings and Communication</td>
<td>2</td>
</tr>
<tr>
<td>Chiller Plants, Traction Power Substations and DC Tie Stations</td>
<td>2</td>
</tr>
<tr>
<td>Grounding in Fan Shafts and Grounding in Drainage Pumping Stations</td>
<td>3</td>
</tr>
<tr>
<td>Catenary Poles/ Foundations in Open Areas</td>
<td>25</td>
</tr>
<tr>
<td>Joint Use Catenary Poles</td>
<td>25</td>
</tr>
<tr>
<td>Grounding in Electrical and Mechanical Rooms</td>
<td>25</td>
</tr>
<tr>
<td>Light Standards, Cabinets, Poles, Manholes, Hand holes, Pull Boxes,</td>
<td>25</td>
</tr>
<tr>
<td>Junction Boxes, Cable Troughs, Metallic Raceways, Hand Railings, Metal Guard Rails and Fences</td>
<td>25</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies furnishing and installing of interior dry type transformers, and oil filled pad mount transformers and supporting devices.

1.2 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):
   1. ANSI C57.94 - Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
   2. ASTM D3145 - Standard Test Method for Thermal Endurance of Electrical Insulating Varnishes by the Helical Coil Method

C. Institute of Electrical & Electronics Engineers (IEEE):
   1. IEEE C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
   2. ANSI/IEEE C2 - National Electrical Safety Code (NESC)

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)

E. National Electrical Manufacturers Association (NEMA):
   1. NEMA TR1 - Transformers Regulators and Reactors

1.3 SUBMITTALS

A. Certification: Prior to purchase, submit for approval certified manufacturer's test data for each type and rating of transformer from each manufacturer, of the following tests conducted within the past two years:
   1. Applicable IEEE C57.12.00 routine and optional tests

   2. Noise level tests.

   3. Performance and Test Data. Submit guaranteed performance data consisting of losses, no load and full load, percent impedance, percent regulation of 1.0 and 0.8 power factor, and the average sound level in dB; and test data. Correct data to the appropriate NEMA reference temperatures.

B. Product Data and Shop Drawings: Include drawings or catalog cuts showing dimensions, weight, wiring diagrams, or catalog cuts showing primary and secondary connections, taps, ratings and characteristics, anchor bolt plan or mounting brackets or platforms furnished separate from the transformer, and grounding requirements.

C. Submit evidence of UL listing or label.

D. Operations and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".

E. Manufacturer's Data: At least two weeks before start of any shop coating work, submit to the Contracting Officer for approval three each of the following:
   1. Complete Data Sheets with surface preparation and the coating materials to be used, identified by the manufacturer, brand name, and product number.

1.4 QUALITY ASSURANCE

A. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of dry transformers and pad mounted transformers of the type specified in this section.

   2. Equipment: Provide that the transformers incorporated into this work essentially duplicate transformers that have been in satisfactory use for a period of five years prior to the bid opening of this project.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Identify and tag electrical terminations and connections prior to shipping. Do not remove identification tags prior to installation.
PART 2 - PRODUCTS

2.1 GENERAL

A. General:

1. Provide nameplate on each transformer in accordance with Section 16040, "Identification of Electrical Equipment".

2. Build transformers incorporating thermally stabilized UL Class H insulation to permit continuous operation at 240 deg. F in an ambient of 105 deg. F without loss of life expectancy in accordance with NEMA TR1.

3. Insulating materials to be in accordance with NEMA Standard for a 430 deg. F UL component recognized insulation system.

4. Construct the transformer cores with high grade, non-aging steel laminations having high magnetic permeability, and low hysteresis and eddy current losses. Keep magnetic flux densities well below the saturation point. Clamp the core laminations together with heavy, structural steel angles.

5. Noise level: Not to exceed NEMA TR1 sound levels.

6. Transformer taps (unless otherwise shown on drawings) 25 kVA and smaller: minimum four standard 2-1/2 percent taps, two above and two below rated voltages. Larger than 25 kVA: minimum standard 2-1/2 percent taps, two above and four below rated voltages.

7. Furnish suitable wall brackets for each transformer that is to be wall mounted.

8. Provide a UL label on each transformer.

9. Provide lifting eyes or brackets.

10. Transformer materials: Conform to ASTM D635.

B. Buses: Provide transformers with adequately supported copper buses, having the following additional requirements:

1. Bus bar silver-plated at bolted connection point.

2. Joints welded or bolted for mechanical and electrical short circuit stresses.

C. Grounding Pad: Equip enclosure with grounding pad, drilled, and tapped for connection to station grounding system. Refer to Section 16450, "Grounding and Bonding", for complete grounding requirements.

D. Finish: Degrease metallic surfaces and thoroughly clean. Prime with zinc primer and finish with light gray enamel; minimum dry film thickness two mils.

2.2 INDOOR TRANSFORMERS

A. NEMA type, indoor, dry, double-wound, with insulated copper conductor, suitable for operation on 60 Hertz.

B. Rating:

1. kVA rating: As indicated on the Drawings.

2. Voltage rating:

   a. Three-phase transformers: 480 volts delta primary to 208Y/120 volts secondary neutral brought out.


C. Impregnate transformer coils and cast under vacuum into molds with epoxy resin. Cast each phase separately.

D. Protect the core against corrosion by a resin coat. Hot dip galvanize iron parts of transformer except the core.

E. Core and coil:

1. Completely isolate from the enclosure by means of vibration absorbing mounts with no metal-to-metal contact between the core and coil and the enclosure.

2. The vibration isolating system: Design to continually secure the core and coil unit to the enclosure. Sound isolating systems requiring the removal of tie-down facilities are not acceptable.

F. Ventilating openings: Louvered type; do not use expanded metal coverings.

G. Transformer enclosures: Construct of 14-gauge sheet steel, with lifting eyes. Holes in the enclosures requiring the use of spreader bars are not acceptable.

H. In addition to standard accessories, include winding temperature indicator with alarm and trip contacts.
2.3 **PAD-MOUNT OUTDOOR TRANSFORMERS**

A. Compartmental type, oil cooled, tamperproof, and weatherproof without exposed screws or bolts, suitable for mounting on a concrete pad.

B. Sealed tank construction with a welded cover. The tank to remain sealed with an oil temperature range of 120 deg. F to 225 deg. F.

C. Temperature rise not to exceed 150 deg. F at full load in an ambient temperature of 102 deg. F and conform to NEMA TR1.

D. The high and low compartments: Locate side by side separated by a steel barrier with high voltage door fastenings not accessible until the low voltage door has been opened. Provide the doors with a single padlock. Provide tank grounding provisions in each compartment. Provide lifting eyes and jacking pads.

E. High voltage compartment: Consist of a two position, load-break gang operated oil switch, current limiting fuses and three 15 kV or 25 kV distribution class lightning arresters as required.

F. Low voltage compartment: Consist of a main molded case secondary circuit breaker.

G. Accessories: In addition to standard accessories, include dial type thermometer, liquid level gauge, pressure relief valve, and mounting provisions for low voltage current and potential transformers.

3.2 **TESTING START-UP**

A. Provide testing in accordance with Section 16030, “Testing of Electrical Systems”.

3.3 **TOUCH UP**

A. Touch up nicks and scratches incurred in shipping and installation. Damage to paint shall be neatly refinished after installation and before commissioning.

3.4 **NAMEPLATES**

A. Provide nameplate on each transformer in accordance with reference standards, Section 16040, “Identification of Electrical Equipment”.

4.1 **GENERAL**

A. In accordance with Section 16001, “Electrical Systems - General”
SECTION 16470
POWER AND LIGHTING PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing, installing, and making electrical connections in the electrical panelboards as shown.

1.2 REFERENCE STANDARDS
A. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)
B. Underwriters Laboratories, Inc. (UL):
   1. UL 50 - UL Standard for Safety Enclosures for Electrical Equipment
   2. UL 67 - UL Standard for Safety for Panelboards

1.3 SUBMITTALS
A. Product Data: Panelboards.
B. Shop drawings: For Panelboards; 1 inch scale for elevations and details to scale to reflect graphically the construction elements. Submit scaled plans and elevations of electrical rooms, closets and enclosures with lighting and power panelboards located.
C. Certification: Certify that completed components comply with standards referenced.
D. Operation and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".
E. Manufacturer's Data: At least two weeks before start of any shop coating work submit to the Contracting Officer for approval two each of the following:
   1. Complete Data Sheets with surface preparation and the coating materials to be used, identified by the manufacturer, brand name, and product number.

1.4 QUALITY ASSURANCE
A. Source Quality Control:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of power and lighting panelboards of the type specified herein.

PART 2 - PRODUCTS

2.1 PANELBOARDS
A. General:
   1. UL-listed and UL-labeled (unless shipped as a factory-mounted component of a UL labeled enclosed type panelboard) not over 48 inches high.
   2. Main bus, neutral bus, separate ground bus, and a main circuit breaker where indicated on drawings.
   3. Buses of copper and terminals rated solderless type, suitable for either copper or aluminum conductors sized at maximum rated terminal capacity.
   4. Provide panelboards with a metal directory frame. Directory to be legible and indicate panelboard designation, source from which feed originates, and equipment controlled from each circuit breaker.
   5. Construct panelboards cabinets of UL 50 code gage sheet steel, bearing the manufacturer's nameplate or stamp and the Underwriters' Laboratories inspection label. Cabinets shall be NEMA 1 for indoor locations and NEMA 3X for outdoor locations, unless noted otherwise.
   6. Provide panelboard cabinets with means for securing, supporting, and adjusting the panelboards and trim.
   7. Factory-clean panelboard cabinets and coat with one coat of zinc primer, and paint with one coat of gray baked-on enamel except DC panelboard cabinet color to be OSHA red.
   8. Procure panelboard cabinets without knockouts.
   9. Equip panelboard cabinets with sheet steel trim and hinged door with catch and lock.
   10. Provide panelboards with space, terminals, and bus capacity, for future addition of circuit breakers as indicated on the drawings.
   11. Provide panelboard gutter space as required by the NEC.
12. Where gutter spaces are occupied by feeder cables, increase gutter spaces as required.

13. Markings per UL 67.

14. Permanent numerical identification at each breaker space.

B. Distribution Panelboards: 480/277 volts or 208/120 volts, three-phase, four wire with molded case circuit breakers in the quantities, sizes, rating, and number of poles indicated.

C. Power and Lighting Panelboards:
1. 208/120 volts, three-phase, four wire, or 480/277 volts, three-phase, four wire with molded case circuit breakers in the quantities, sizes, rating, and number of poles as indicated.
2. 240/120 volts, single-phase, three wire with single pole or two pole molded case circuit breakers in the quantities, sizes, and ratings as indicated.

D. DC Panelboards: Rated for 125 volts DC, two wire with two pole molded case circuit breakers in the quantities and sizes indicated.

E. Circuit Breakers:
1. Provide molded case branch circuit breakers, and where called for on drawings, a main circuit breaker of the ampere rating and number of poles as called for.
2. Unless otherwise shown, provide circuit breakers having short circuit current interrupting capabilities in excess of available fault current at the panelboard, but no less than:
   a. 22,000 amperes symmetrical for 120/208 volts or 120/240 volt service.
   b. 22,000 amperes symmetrical for 277/480 volts service.

F. Circuit Breaker Enclosure: Where a single circuit breaker is required (not in a panelboard) provide an individual enclosure of the type called for on drawings. If type is not stated on drawings, provide one of the following types, according to locations:
1. In tunnels and other underground locations not in enclosed rooms: NEMA type 4X (non-metallic) or NEMA type 4 (stainless steel).
2. Outdoors: NEMA type 4X (non-metallic) or NEMA type 4 (stainless steel).
3. Other locations (including electrical and mechanical rooms in substations or subway stations): NEMA type 1.

G. Load Centers: For applications where the main circuit breaker (or other main overload protection) is rated 100 amperes or less, a load center may be used instead of a panelboard as described above. The load center shall meet or exceed requirements shown on the drawings. In load centers, plug-in branch circuit breakers are acceptable.

H. Manufacturer: Square D, General Electric, Siemens or approved equal.

I. Nameplate: Provide nameplate on each transformer in accordance with reference standards, Section 16040, “Identification of Electrical Equipment”.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Surface mount panelboards unless otherwise indicated.

B. Mount panelboard cabinets rigidly in place with top of cabinet 6'-6" maximum above finished floor unless otherwise indicated. Bottom of cabinets shall be 6 inch minimum above floor.

C. Install panelboards in enclosures in accordance with manufacturer's instructions, if practicable, before mounting enclosure.
D. Adjust cabinets and panelboards straight and plumb and fasten securely in place.

E. Verify that circuit breakers have correct rating for the applicable circuit application as indicated.

F. Perform wiring in accordance with UL 67, NFPA 70 (NEC) and manufacturer's instructions.

G. Make conduit connections in accordance with Section 16111, "Conduits".

H. Provide grounding as specified in UL 67, NFPA 70 (NEC), and Section 16450, "Grounding and Bonding". Connect neutral wire directly to neutral bus, and ground wire to ground bus, in the same panel as circuit interrupting device.

I. Route, harness, and support conductors in gutters, wiring spaces, and compartments with bending radii not less than recommended by conductor manufacturer.

J. Install bonding jumpers from conduits entering cabinets to ground bus.

K. Identify each circuit in cabinet, record identity of each circuit and type circuit identity on directory card and place card in frame on door panel. Information on the directory card shall be neatly typed.

L. Attach identification tabs bearing the number of the circuit to wires in panelboard gutters.

M. Apply field touch-up paint as provided by the manufacturer.

N. In wet locations mount surface mounted panel boards and circuit breaker enclosures on standoffs, so they are a minimum of 1/2 inch from the wall. Use non-corrosive material for standoffs. If continuous strips or channels are used for standoffs, mount them vertically, to minimize areas for collection of water. Provide drip pan where required by Authority Having Jurisdiction (AHJ).

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16470
PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing switches and receptacles, as shown.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

B. National Electrical Manufacturers Association (NEMA):
1. NEMA WD1 - General Color Requirements for Wiring Devices
2. NEMA WD6 - Wiring Devices - Dimensional Specifications

C. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

D. Underwriters Laboratories, Inc. (UL):
1. UL 98 - UL Standard for Safety Enclosed and Dead-Front Switches

1.3 SUBMITTALS
A. Product Data: Provide manufacturer's standard catalog data for all items described in this section indicating conformance and compliance with standards and codes indicated.

PART 2 - PRODUCTS

2.1 LIGHTING SWITCHES
A. Unless otherwise specified, provide specification grade switches which meet or exceed all requirements of NEMA WD1 and WD6, and are UL listed. Voltage and amperage ratings of all switches must equal or exceed voltage and amperage of the circuit to be switched.

B. Provide single pole interior lighting switches of specification grade, 20 amperes, 120-277 volts, quiet type, with solid silver cadmium oxide contacts, clamp type terminals, and wide toggle handle with neoprene bumper pads.

C. Provide three way interior lighting switches of specification grade, 20 amperes, 120-277 volts, quiet type, with solid silver cadmium oxide contacts, clamp type terminals, and wide toggle handle with neoprene bumper pads.

D. Provide switch and pilot light of specification grade, 20 amperes, 120-277 volts with solid silver cadmium oxide contacts, clamp type terminals, and rugged lexan handle that is lighted red when the switch is in the ON position (unless noted otherwise on the drawings).

E. Provide single pole exterior lighting switches similar to the interior switches except equipped with a hinged cast aluminum gray cover plate and fiber shield for weatherproofing.

F. Provide white switches for normal lighting circuits.

G. Provide red switches for emergency circuits served from generator or Central Emergency Lighting Power Supply (CELPS).

2.2 HEAVY DUTY SAFETY SWITCHES IN INDIVIDUAL ENCLOSURES
A. Provide safety switches of heavy duty type and UL listed, rated at 240 volts or 600 volts, as required.

B. Provide switches with switch blades which are fully visible in the "OFF" and "ON" positions when the switch door is open. Plate all current carrying parts to resist corrosion and promote cool operation. Construct switches with removable arc suppressors where necessary to permit easy access to line side lugs. Provide front removable type lugs, UL listed for 194 degrees F copper wires.

C. Provide quick-make, quick-break switches such that, during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing or opening action of the contacts has started. Provide operating handle as an integral part of the box, not the cover. Make provisions for padlocking the switch in the "OFF" and "ON" positions. Provide switches with a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the "ON" position, and to prevent closing of the switch mechanism with the door open. The handle position shall indicate whether the switch is "ON" or "OFF".

D. Where called for on the drawings, furnish switches in NEMA 4X, NEMA 12, or code gauge UL 98 stainless steel NEMA 4 enclosures without knockouts. Provide positive means of sealing the cover. Provide quick release latches. Provide covers with pin type hinges and gaskets. Unless noted otherwise, provide enclosures as follows:
1. In tunnels and other underground locations not in enclosed rooms: NEMA Type 4X or stainless steel NEMA Type 4.

2. Outdoors: NEMA Type 4X or stainless steel NEMA Type 4.

3. Other Locations (including electrical and mechanical rooms in substations or subway stations): NEMA Type 1.

E. Furnish switches horsepower rated for AC and/or DC as indicated by standard drawings. For fusible switches rated 100 through 600 amperes at 240 volts and 30 through 600 amperes at 600 volts, provide a UL listed method of field conversion from standard Class H fuse spacing to Class J fuse spacing. These switches also must accept Class R fuses and have provision for field installation of a UL listed rejection feature to reject all fuses except Class R. Provide the UL listed short circuit rating of the switches at 200,000 RMS symmetrical amperes when Class R or Class J fuses are used with the appropriate rejection scheme. Provide the UL listed short circuit rating of the switch, when equipped with Class H fuses, of 10,000 RMS symmetrical amperes.

F. The enclosure shall be finished completely in the shop in accordance with Section 05130, "Structural Steel -Buildings" and Section 09970, "Coatings for Steel". Paint and Coatings System No. 1, except complete coatings of paint will not be applied in the field. Field painting shall be limited to touch up of nicks and scratches incurred in shipping and installation. All damage to paint shall be neatly refinished after installation and before commissioning.

2.3 RECEPTACLES

A. Unless otherwise specified, provide receptacles which meet or exceed all requirements of NEMA WD6 and are UL listed. Provide heavy duty receptacles, specification grade.

B. Provide single convenience receptacles of 20 amperes, 125 volts AC, 2-pole, 3-wire grounded, consisting of a heavy-duty reinforced molding, grounding screw, side and back wired, straight blade type.

C. Provide duplex convenience receptacles similar to the single type.

D. Provide single outlet, weather-proof convenience receptacles, 20 amperes, 125 volts AC, 2-pole, 3-wire grounded, consisting of a heavy-duty reinforced molding, grounding screw, side wired and turn-to-lock type with matching plug complete with cast box, hinged cast aluminum gray cover plate and fiber shield for weatherproofing.

E. Provide single outlet, heavy duty turn-to-lock receptacles rated at 30 amperes 208/120 volts with 2-poles, one neutral pole and ground pole back wired consisting of a black phenolic base complete with matching plug.

F. Provide welding receptacles 60 ampere, 480 volts, 4-pole grounded type complete with malleable iron box with cadmium finish, pressure terminals, phenolic insulating blocks, watertight gasket, grounding detent springs, and neoprene gasket with matching plug cable grip assembly. Provide receptacles meeting OSHA requirements.

G. Provide special purpose outlet in traction power substations 20 amperes, 240 volts, 3-pole grounded type with malleable iron box with cadmium finish, pressure terminals phenolic insulating blocks, watertight gasket, grounding detent springs, and neoprene gasket with matching plug cable grip assembly.

H. Provide clock outlets at 15 amperes, 120 volts AC, heavy duty, hanger type consisting of a brown phenolic body and stainless steel plate.

I. Equip receptacles for use in restrooms, washrooms, tunnels, and outdoor locations with solid-state ground-fault circuit interrupter actuating at 5mA. Provide receptacles with integral interrupters - not interrupters at the circuit breaker. Connect receptacles with interrupters so that the interrupter will not affect any other receptacles.

J. Provide white receptacles for normal general receptacles.

K. Provide red receptacles for emergency circuits served from generator or CELPS.

2.4 COVER PLATES

A. Unless otherwise specified, provide cover plates conforming to NEMA WD1 and WD6.

B. Furnish a cast feraloy plate to suit the device, gasketed for exterior mounting on surface mounted interior and exterior Type FS or FD boxes for switches and receptacles.

C. Furnish cover plates of stainless steel minimum 0.032 inch thick, brush finish on flush mounted switch and receptacle boxes.

D. In public areas provide cover plates fabricated of stainless steel ASTM A167 Type 302, No. 4 satin finish.

E. For special purpose outlets commercially produced using special material, configuration, and size, use plate of brushed stainless steel and of a design for the particular application.
F. Provide engraved red filled, recessed lettering stainless steel “EMERGENCY” cover plates for emergency circuits served from generator or CELPS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install receptacles rigidly to outlet boxes at the location shown on the Drawings.

B. For exterior locations, mount receptacles in watertight cast type outlet boxes with threaded hubs or bosses and equipped with gasketed cover and captive cap of the screw or twist type.

C. Adjust devices to the vertical and flush with front of boxes.

D. Install cover plates on switches and receptacles.

E. Install switches, receptacles, and cover plates complete plumb, square, and tight in accordance with NEC and Local Electrical Codes.

F. Where switch enclosures are surface mounted in wet locations, provide standoffs so they are a minimum of 1/2 inch from the wall. Use non-corrosive standoff material. If continuous strips or channels are used for standoffs, mount them vertically.

G. Provide circuit identification at each receptacle and switch in accordance with reference standard, Section 16040, “Identification of Electrical Equipment”.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16490
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, transporting, repairing, and installation of lighting fixtures, mounting poles, and control devices.

1.2 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO LTS - Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):

1. ASTM A123 - Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A276 – Standard Specification for Stainless Steel Bars and Shapes
3. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
4. ASTM A507 - Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled
5. ASTM A575 – Standard Specification for Steel Bars, Carbon, Merchant Quality M-Grades
8. ASTM B137 - Standard Test Method for Measurement of Coating Mass per Unit Area on Anodically Coated Aluminum
10. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
11. ASTM D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

C. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

D. The Society for Protective Coatings ( Formerly known as Steel Structures Painting Council) (SSPC):

1. SSPC-SP 10 - Near-White Blast Cleaning

E. Underwriters Laboratories, Inc. (UL): UL Standards shall apply unless Authority authorizes an approved equal.

1. UL 496 - UL Standard for Safety Edison-Base Lampholders
2. UL 508 - UL Standard for Safety Industrial Control Equipment
3. UL 542 - UL Standard for Safety Lampholders, Starters, and Starter Holders for Fluorescent Lamps
4. UL 773 - UL Standard for Safety Plug-In Locking Type Photocontrol for Use with Area Lighting
5. UL 935 - UL Standard for Safety Fluorescent-Lamp Ballasts
6. UL 1029 - UL Standard for Safety High-Intensity-Discharge Lamp Ballasts
7. UL 1598 - UL Standard for Safety Luminaires

1.3 SUBMITTALS

A. Product Data: Include photometric curves from a nationally known independent photometric laboratory for each fixture type. The manufacturer's data is not an acceptable substitute. Fixture substitutions must meet or exceed photometric performance of the fixture specified. All components shall be compatible to all other components within system or equipment. Unless determined to be beneficial to the Authority, all components, equipment and systems shall be fully compatible with DART's electronic and built environments.
B. Shop Drawings: Submit scaled plans and elevations of electrical enclosures with locations of lighting control equipment (time clocks, lighting contactors, terminal strips, hand-off-automatic switches, etc.) in relation to electrical panelboards and other electrical gear.

C. Wiring diagrams and bill of materials.

D. Samples: 1 of each type of fixture, as requested or directed by the Contracting Officer.

E. Documentation:
   1. Verification that each fixture is in compliance with applicable codes, regulations, reference standards, and specifications for the location at which it is to be used. Indicate requirements that each fixture meets.
   2. Calculations: Submit calculations by a Professional Engineer, registered in the State of Texas, certifying that assemblies of foundation, anchor bolts, pole, arms, and luminaire will withstand specified wind pressure, wind speed, stress, deflection, vibration, and fatigue.

F. Templates: Submit a template for the anchor bolt pattern of the mounting poles.

G. Mounting details and installation instructions.

H. Field Testing:
   1. Submit a detailed plan of the proposed methods of and scheduling of the required field testing at least 30 calendar days before initiating the tests.
   2. Submit certified test reports.

I. Manufacturer’s Data: At least 2 weeks before start of any shop coating work, submit to the Contracting Officer for approval 2 each of the complete data sheets with surface preparation and the coating materials to be used, identified by the manufacturer, brand name, and product number.

1.4 QUALITY ASSURANCE

A. Comply with applicable AISI, ANSI and NAAMM standards.

B. Each lighting fixture: UL-labeled or listed.

C. Experience:
   1. Installer: Select a firm regularly engaged for 5 years or more in the installation of the products described herein.

2. Manufacturer: Select subcontracting firms regularly engaged for 5 years or more in the manufacture of the products described herein.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Transport and place lighting fixtures and mounting poles into cartons or crates to provide protection during transit and storage to the Worksite.

B. Inspect lighting fixtures and mounting poles upon delivery for damage. Repair minor damage provided the finish items are equal in all respects to new work; otherwise, remove and replace damaged items as indicated. If damaged, polycarbonate panels shall not be repaired but shall be replaced.

C. Store lighting fixtures and mounting poles at the site under cover. Place units on at least a 4-inch high sills on floors in a manner that will prevent damage and rusting. Avoid the use of non-vented plastic or canvas shelters which could create a humidity chamber.

D. Hardware shall be provided and stored in original unopened packages, clearly labeled with manufacturer’s name, brand, specification identification data, and identification as shown on approved shop drawings or submittals.

E. Hardware for lighting fixtures, mounting poles, and control devices shall not be stored at any location unprotected from contact with soil and from exposure to the elements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide products of one of the manufacturer’s on the Lighting Fixture Schedule unless otherwise noted, and as follows:

   1. For lighting fixtures where only one manufacturer is listed, the Contractor shall provide either the product listed or an approved equal product.

   2. For lighting fixtures where more than one manufacturer is listed, the Contractor shall select one for each fixture type and shall use that fixture on the entire project.

2.2 PRODUCTS AND MATERIALS

A. General Requirements for Lighting Fixtures:

   1. Interchangeability: Components of same type, size, rating, functional characteristics and make are to be interchangeable.
2. Ground mounted HID light fixtures shall have cold weather ballasts (negative 4 to negative 22 degrees F minimum starting temperature).

3. Specialty light fixtures shall be as scheduled and shown on drawings.

4. In accordance with UL 1598.

5. All light fixtures shall have the capability of automated monitoring.

6. Both Metal-Halide and LED fixtures shall be Energy Star or Lighting Consortium rated and approved.

7. Materials:
   a. Steel:
      1) Sheet: ASTM A507, 22-gauge minimum
      2) Bar: ASTM A575.
   b. Steel pipe: ASTM A53, Type S.
   c. Stainless steel:
      1) Sheet: Comply with ASTM Standards for 22-gauge minimum.
      2) Bar: ASTM A276, Type 316.
      3) Finish: AISI Alloy 304, NAAMM Finish No. 4, unless otherwise shown.
   d. Aluminum: Alloy as recommended by manufacturer, unless otherwise shown or specified.
      1) Sheet and plate: ASTM B209.
      2) Extrusion: ASTM B221, 0.109 inch minimum thickness, unless otherwise shown.
      3) Cast:
         a) Die cast: ASTM B85, 0.1875 inch minimum thickness, unless otherwise shown.
         b) Sand cast: ASTM B26/B26M, 0.1875 inch minimum thickness, unless otherwise shown.
   e. Plastic:
      1) Resin: As shown.

8. Lamps:
   a. In accordance with applicable ANSI Standards.
   b. Fluorescent:
      1) Wattage and size: As shown or specified.
      2) Color: Cool white, unless noted otherwise.
      3) Type:
         a) Preheat start: Lamps rated 20 watts or less.
         b) Rapid start: Lamps rated above 20 watts.
      4) Rated life minimum:
         a) Super high output (SHO), very high output (VHO) and high output (HO), lamps: 12,000 hours.
         b) F6T5/CW: 6,000 hours.
         c) Preheat start lamps other than F6T5: 9,000 hours.
         d) Rapid start lamps: 18,000 hours.
         e) Other types: 12,000 hours.
   c. Metal-halide:
      1) Wattage: As shown.
      2) Size: As shown.
3) Color: Clear unless otherwise noted.

4) Lamp operating position: As shown.

5) Base: Mogul.

6) Rated life:
   a) 175 watts: 10,000 hours.
   b) 250 watts: 10,000 hours.
   c) 400 watts: 20,000 hours.
   d) 1,000 watts: 12,000 hours.

d. LED:
   1) Wattage: As shown.
   2) Size: As shown.
   3) Color: Clear unless otherwise noted.
   4) Lamp operating position: As shown.
   5) Base: As shown.
   6) Rated life:
      a) 50,000 hours (minimum) for all lamps

4) Metal Halide:
   a) Rated 660 watts, 600 volts: Medium screw base.
   b) Rated 1,500 watts, 600 volts: Mogul screw base.

b. Fluorescent:
   1) In accordance with UL 542.
   2) Rated 660 watts 600 volts.
   3) Integral starter holder for preheat type lamps, with starter.
   4) White thermosetting phenolic compound base and body, silver plated phosphorous bronze contacts, self-aligning neoprene gasket face.

c. Provide mechanical self-retaining neoprene gasket for dust and moisture proof seal between lamp and lampholder.

9. Lampholders for Metal Halide:
   a. Incandescent and metal-halide:
      1) In accordance with UL 496.
      2) Black or white thermosetting phenolic compound, glazed porcelain, or neoprene base and body as shown. Neoprene unit molded in one piece, weatherproof, oil-resistant, with vibration-absorbing socket construction.
      3) Incandescent: Rated 660 watts 250 volts for medium screw base.

   b. Fluorescent lamps:
      1) UL 935, Class P thermally-protected and high power factor type.
      2) Operable on 120 volts or 277 volts, 60 Hertz as shown or necessary, type and rating suitable for associated lamp.
3) Maximum utilization of 2-lamp ballasts in public are lighting fixtures.

c. LED Lamps:

1) LED lamp wattage shall provide adequate lighting to meet or exceed agency requirements for light spread and illumination.

2) All components shall be compatible with all other components within a system or equipment. LED fixtures shall have the capability of automated monitoring.

3) LED luminaires shall be Type SB3; Kim-AR3P70-80L4K for single luminaires or Type 2SB3; Kim-AR3P70-80L4K for dual luminaires, or Authority approval equal.

4) LED fixtures shall be Energy Star or Lighting Consortium rated and approved. LED fixtures could qualify for the Oncor Incentive Program funding.

11. Fixture body and housing: Shape size and material as shown.

12. Reflector: Shape, size, and material as shown. Aluminum or stainless steel polished to mirror finish unless otherwise shown. Minimum thickness 22-gauge unless otherwise shown.

13. Fixture wire: Per NEC, suitable for maximum temperature of fixture operating in 115 degrees F ambient.

14. Gasket:

a. Keyed gasket: One-piece extruded solid neoprene having Shore A durometer hardness of 30 plus or minus 5 when tested in accordance with ASTM D2240.

b. Self-retainig gasket:

1) One-piece, extruded EPDM molded gasket.

2) Resistant to aging, heat, ultra-violet light, water, oil, weathering, and setting as determined by ASTM D1056, NEMA 12.

3) Cemented to component with resilient neoprene sealing compound compatible with finish. Adhesive not applied to diffuser.

c. Silicone gasket equal to neoprene, at Contractor’s option.

d. Provide gaskets for fixtures located in tunnels having UL labeling for wet locations and able to withstand water hose spray cleaning with 100-psi water pressure.

15. Hardware:

a. Latches, catches, release mechanism, hinges, screws, bolts, studs, nuts, rivets, washers, and springs. Heavy-duty stainless steel or bronze, as shown.

b. Latches and catches: Captive type.

c. Operating hardware: Self-retaining type.

16. Construction:

a. Fixture body, reflectors, wiring channels, end caps, and castings formed to prevent buckling or distortion.

b. Minimum of 2 wire clips provided in wiring channel to support wiring.

c. Seams and joints continuously welded and ground smooth.

d. When aluminum is in contact with dissimilar metal, separate contact surfaces with gasket, non-absorptive tape, or coating to prevent corrosion.

17. Finish: Electrostatic powder coating: Prepare surfaces by sandblast cleaning complying with SSPC-SP 10 near white blast cleaning, applying coating promptly after cleaning. Ground material to be coated. Apply coating as electrostatically-charged dry powder using electrostatic spray gun to produce DFT of 6 mils within plus or minus 2 mils. Cure by heat treatment.

18. Mark each fixture and its components in accordance with applicable reference standard.

19. Fasteners: Size and type shown or as approved by Contracting Officer.

a. Provide Type 304 or 316 stainless-steel fasteners.
B. General Requirements for Mounting Poles:

1. Mounting poles: Steel, straight, round, and as shown. Complete assembly of anchor bolts, pole, arms, and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH, in accordance with AASHTO LTS. Pole assembly to be designed in accordance with AASHTO requirements for permissible stresses, deflection, vibration, and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60. Poles assembly is to be designed to support an additional 18-pound attachment at a height of 10 feet above grade. Maximum dimension of attachment 16.5 inches (L) by 15.6 inches (W) by 9.44 inches (H).

2. Grout: Section 03305, “Portland Cement Concrete”, non-shrink. Where recommended by manufacturer, prime surfaces to be grouted.

C. General Requirements for Control Devices: Contractor shall provide the following:

1. Lighting Contactors:
   a. UL 508, electrically held (unless noted otherwise), equipped with silver alloy contacts, designed to control incandescent, tungsten, halogen, fluorescent, high-intensity discharge lamp load.
   b. Number of poles: As shown.
   c. Continuous current rating: As shown.
   d. Line and load voltage: 480 or 208 volts 3-phase ac, or 277 or 120 volts single-phase ac, 60 Hertz as shown.
   e. Control coil rated 120 volts ac, 60 Hertz.
   f. Control:
      1) Heavy-duty 3-position, selector switch with positions labeled HAND/OFF/AUTO for lights controlled by photoelectric cell and/or time clock.
      2) ON-OFF switch for indoor lights.
   g. Enclosure: NEMA 1; fabricated from steel, cleaned, degreased, primed with zinc primer and finished with light gray enamel; minimum dry film thickness, 2 mils.

2. Photoelectric Control:
   a. UL 773, designed to respond to natural daylight with 15-second inherent delay to prevent functioning due to sudden bright light such as vehicle lights or lightning and to operate in ambient temperature from 0 degrees F to 125 degrees F.
   b. Adjust to turn lights ON within plus or minus 2 or 1 foot-candles, unless otherwise specified. ON to OFF ratio: 1 to 3.
   c. Rating: 1800 VA at 120 volts or 277 volts, 60 Hertz, as shown.
   d. Contacts: SPDT; one NC, one NO.
   e. Cells: Hermetically sealed.
   f. Enclosure: Weatherproof and tamperproof aluminum enclosure equipped with locking receptacles when mounted on fixture or designed for mounting on outlet box as shown and as necessary.

3. Limit Switches:
   a. NEMA ICS, industrial-control.
   b. Suitable for mounting in folding gate cabinet. Switch contacts closed when cabinet door is fully closed and latched. Switch contacts opened when respective cabinet door is not fully closed.
   c. Voltage rating: 120 volts ac.
   d. Current rating: 10 amperes continuous.
   f. Actuator: Lever-operated and adjustable, with spring return.
   g. Mounting: Plug-in type with receptacle tapped for conduit size as shown.
   h. Contacts: Single-pole double-throw; one NO, one NC; snap action.

4. Time Switch:
   a. Intermatic Series T170CR, specifically, Model No. T173CR.
b. 24 hour, 7 day dial time switch with skipper, UL-listed, heavy-duty type suitable for controlling type of lighting fixtures shown. Provide for continued operation (auto-carryover) during power failure if called for on drawings.

c. Type: As shown, with contacts capable of switching continuous load of 40 amperes per pole at 120 or 277 volts as required. Switch function to be double pole-single throw.

d. Providing up to 6 automatic ON/OFF operations each day.

e. Removable ON/OFF trippers designed for minimum ON period of 1 hour and minimum 2 hour period between one OFF operation and next ON operation.

f. Provision for manual ON and OFF operation of switch by hand without disturbing weekly preset schedule.

g. Provision for omitting operation of switch on selected days.

h. Provide only if called for on drawings or in other specifications: Spring-driven reserve power suitable for operation of switch for 16 hours minimum in the event of a power failure; upon restoration of power, switch transfers to synchronous motor drive, or similar carryover mechanism, and automatically resets.

i. Terminals designed to accommodate up to No. 8 AWG conductor cable.

j. Clock motor operation at 120 volts, 60 Hertz as shown and within temperature range of minus 40 degrees F to 130 degrees F.

k. Enclosure:

   1) NEMA 1, steel, surface-mounted, unless otherwise noted.

   2) Hinged flush front door with catches and spring loaded door pull.

   3) Finish: Metallic surfaces cleaned, degreased, primed and finished with 1 coat of enamel.

   5. Guards: Where called for on drawings provide metal guards (cast or fabricated of heavy wire) to protect fixtures from physical damage. Guard shall be supplied by the supplier of the fixture.

2.3 LIGHTING FIXTURES

A. Lighting fixture types shall be as scheduled in the drawings.

B. Platform Pole Base Cover: Kim

C. Lighting, PRA, round, 11-7/8 inch diameter, 2 piece cast aluminum full cover of 319 alloy, secured by tamperproof, stainless steel screws, custom cast to accommodate standard 5 inch outside diameter round, non-tapering steel pole or Authority approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lighting fixtures of types indicated at locations as follows:

   1. Mount fixtures rigidly in place. Use expansion anchors and machine screws for concrete surfaces and toggle bolts for hollow concrete masonry surfaces. Use appropriate fasteners for attachment to other surfaces. Support lighting fixtures independent of suspended acoustical panel ceiling systems.

   2. Use stainless steel fasteners. Where a metal contacts concrete or a dissimilar metal, separate contact surfaces with gasket, non-absorptive tape, or bituminous coating to prevent corrosion.

   3. Mount fixtures plumb, level, and in straight lines. Install stems of suspended fixtures plumb. Group-mounted continuous rows of fluorescent fixtures to appear as one unit.

   4. Install 12-inch minimum length of liquid-tight flexible conduit for connection between fixture and outlet box unless otherwise shown. Use fixture wire from outlet box in branch circuit to lighting fixture and connect fixtures to branch circuit in accordance with Section 16120, "Wires and Cables".

   5. Install chase nipple where fluorescent fixtures are installed in continuous groups.

   6. Clean lamps, diffusers, globes, reflectors, and exposed-to-view surfaces of fixtures after aiming and adjusting has been approved.
B. Installation of Pole-Mounted Fixtures:

1. Form concrete base as shown, in accordance with Division 3, "CONCRETE". Use templates provided by the pole manufacturer for setting anchor bolts.

2. Install mounting pole of type shown. Use double nuts to erect poles plumb. Pack void between concrete base and pole base plate with non-shrink grout, as specified in Section 03305, "Portland Cement Concrete", and install as specified in Section 05130, "Structural Steel - Buildings".

3. Install conductors, leaving 3-foot minimum lengths of conductors for fixture connections; tape or otherwise secure in place pending final connection.

4. Install lighting fixtures in accordance with approved shop drawings.

5. Connect wiring using pressure connectors.

C. Install photoelectric controls and time switches as shown or in accordance with manufacturer's instructions.

D. Ground lighting fixtures, mounting poles, time switches, photoelectric controls, and lighting contactor enclosures in accordance with NEC and Section 16450, "Grounding and Bonding".

E. Touch up nicks and scratches incurred in shipping and installation. Damage to paint shall be neatly refinished after installation.

3.2 FIELD QUALITY CONTROL

A. Ensure that earth foundation for mounting poles is prepared and compacted in accordance with Section 02220, "Grading, Excavating, and Backfilling".

B. Testing:

1. Furnish necessary personnel and equipment and perform tests and adjustments in the presence of the Contracting Officer. Schedule adjustment of exterior installations to occur during hours of darkness.

2. Test lighting circuits for continuity and proper operation.

3. Test fixtures, mounting poles, and equipment enclosures for continuity of grounding system.

4. Aim and adjust fixtures to provide distribution pattern approximately as shown and as approved.

5. Test time switches, control devices, and contactors for connection in accordance with wiring diagram.

6. Check tightness of cable connections of time switches, lighting contactors, photoelectric controls, and limit switches.

7. Test operations of circuits, control devices, and contactors.

8. Test foot-candle levels with a precision light meter to assure that design requirements are met in all areas. Pole lights will be measured at 4 equidistant points of 90 degree intervals around the pole. Actual foot-candle levels shall meet or exceed those shown on the Designer’s photometric analysis.

3.3 INSPECTION

A. Materials furnished in this Contract shall be presented for inspection at the place of manufacture. Contractor shall provide the Contracting Officer all necessary facilities to examine the work during its progress as well as the finished product to verify that the materials comply with the Specifications.

3.4 PERFORMANCE REQUIREMENTS

A. Contractor shall be responsible for the compatibility of the lighting fixtures and mounting poles during installation with the plans and Specifications.

B. If LED fixtures are utilized, the project could be eligible for the ONCOR Incentive Program and funds.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16500
SECTION 16502
ANCHOR BOLTS AND FOUNDATIONS FOR LIGHTING POLES

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies providing and installing the anchor bolt with washers and nuts for lighting mounting poles.

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
   2. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
   3. ASTM F436 - Standard Specification for Hardened Steel Washers
   4. ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

1.3 SUBMITTALS
A. Copies of templates of anchor bolt patterns.
B. Samples: One set of anchor bolts with nuts and washers.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS
A. General Requirements for Mounting Poles: Anchor bolts: Bolts, nuts, and washers:
   1. Anchor Bolts: ASTM F1554, Grade 55, unless noted otherwise on drawings. ASTM A563, Grade A for nuts. ASTM F436, Type 1 for washers.
   2. Galvanized per ASTM A153/A153M
   3. Bolts hooked, unless otherwise shown or recommended by manufacturer of pole or structure being anchored.
   4. Two nuts and one washer for each anchor bolt for plumbing pole or leveling structure.
B. Template: In accordance with mounting pole manufacturer and the plan.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Installation of Pole-Mounted Anchor Bolts and Foundation:
   1. Form concrete base as shown, in accordance with Division 3, "CONCRETE". Use templates provided by the pole manufacturer for setting anchor bolts.
   2. Install anchor bolt plumb and in accordance with the plans.
   3. Install conduit and grounding devices in accordance with Division 16, "ELECTRICAL" and the plans.

3.2 FIELD QUALITY CONTROL
A. Ensure that earth foundation for mounting poles is prepared and compacted in accordance with Section 02220, "Grading, Excavating, and Backfilling".
B. Ensure that concrete for mounting pole foundation is prepared and placed in accordance with Section 03300, "Cast-In-Place Concrete", Section 03200, "Concrete Reinforcing", and Section 03100, "Concrete Formwork".

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. In accordance with Section 16001, "Electrical Systems - General"

END OF SECTION 16502
PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide battery operated units consisting of batteries, battery charger, and switching mounted in a case and with lamps mounted in or on the case, and/or remote heads and concealed light units as shown on the drawings. Provide unit for operation on 277 volts and/or 120 volts supply and for supplying emergency light automatically and instantly upon failure or interruption of normal electric power.

B. Provide a battery powered alternating current 277/480 volts central emergency lighting power supply (CELPS) including battery, battery charger, inverter, and static bypass switch for both linear and non-linear lighting.

1.2 REFERENCED STANDARDS

A. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
   3. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

B. Underwriters Laboratories, Inc. (UL)
   1. UL 1778 - UL Standard for Safety Uninterruptible Power Systems
   2. UL 924 - UL Standard for Safety Emergency Lighting and Power Equipment
   3. UL 924A - UL Standard for Safety Emergency Lighting and Power Equipment (15-minute duration)

1.3 SUBMITTALS

A. Product Data and Shop Drawings:
   1. Include photometric curves of emergency lighting fixtures.
   2. Outline dimensions, mounting details, and installation instructions for each equipment furnished.
   3. Equipment arrangement drawings including battery rack.

B. Technical data:
   1. Storage Battery:
      a. Ampere-hour rating of battery at a 90 minute discharge rate.
      b. Maximum available short circuit current.
      c. Charge rate from fully discharged state to fully charged state within 24 hours.
   2. Inverter:
      a. Efficiency at rated load.
      b. kVA rating at 0.8 power factor and unity power factor.

C. Certification: Provide certificates which certify values for the following:
   1. Design tests.
   2. Output voltage and frequency of AC emergency power system are within specified limits.
   3. Output voltage of inverter has sine wave with maximum of 10 percent total harmonic distortion under load condition.
   4. The operational performance of the automatic transfer switch.
   5. Each emergency lighting unit is in compliance with applicable codes, regulations, and standards for the location at which it is to be used.

D. Operational and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".

E. Field Testing:
   1. Supervisory Control And Data Acquisition (SCADA): Refer to Section 16030, "Testing of Electrical Systems".
   2. Submit a detailed plan of the proposed methods and scheduling of the required field testing at least 30 calendar days before initiating the tests.
   3. Submit certified test reports.
1.4 QUALITY ASSURANCE

A. UL-labeled or listed each emergency lighting unit.

B. Comply with applicable AISI, ANSI and NEMA standards.

C. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of the products described herein.
   2. Furnish products in this section which essentially duplicate products by the same manufacturer, that have been in satisfactory use for a period of 5 years prior to the Bid Opening of this Project.

D. Factory Testing: Prior to shipment, manufacturer shall fully and completely test system to assure compliance with specifications. These tests shall include operational discharge and recharge tests on internal battery to guarantee rated performance.

PART 2 - PRODUCTS

2.1 TYPES OF LIGHTING

A. Emergency Lighting Units: TYPE I
   1. Provide 12 volts sealed maintenance free lead-calcium type battery.
   2. Provide each battery encased and permanently sealed in a heat and impact resistant case to operate unattended without requiring water for a period of not less than 5 years.
   3. Furnish the battery charger consisting of a 2-rate and constant voltage type, completely solid state with no moving parts.
   4. Operation of battery charger is as follows:
      a. Charger shall operate on input voltage of 120 or 277 volts, as stated on drawings.
      b. Apply the supply voltage through the internal circuitry until such time as the charging current drops to a predetermined value, at which time the charger will switch “off” and a bleeder load be placed upon the battery.
      c. As the battery voltage falls, the battery charger automatically switches ON at a predetermined voltage which is set lower than the float voltage specified by the manufacturer.
   5. The battery charger automatically and continually samples the battery throughout its life. This sampling rate will vary with type of battery, being as often as once every 15 seconds to once every half-hour.
   6. During charging, the indicator light will be on until such time as the battery charger switches from high to OFF.
   7. Upon switching to OFF, the indicator light will extinguish and then gradually increase in intensity until the battery charger is switched to the high rate for the next sample.
   8. While the unit is charging the indicator light will burn steadily.
   9. During the final phases of charging, the light will blink at a comparatively high rate several times per minute. As the charge is completed, the blinking rate will slow down as well as the length of time the battery charger is ON at each sample. This indicating lamp will indicate by burning brightly should the battery charger open up for any reason.
   10. Provide units capable of operating in emergency mode for a minimum of 1.5 hours at not less than 87.5 percent of normal battery voltage.
   11. Provide completely solid-state switching, which energizes the sealed beam lamps, when an interruption of the 120 volts or 277 volts power occurs or a power failure occurs.
   12. Provide lamps of 12 volts, with wattage, diameter, and beam spread as described on drawings. Provide that lampheads, mounted on case, or remote heads, are adjustable both vertically and horizontally.

B. Self-Contained Emergency Lighting Units: TYPE II
   1. Completely self-contained, fully automatic, fluorescent, halogen, quartz, or incandescent lamps, suitable for recess, semi-recess, or surface mounting.
   2. Designed to provide automatic emergency lighting for a minimum of 90 minutes upon failure of normal power.

   d. The supply voltage will then be applied to the battery and the current drawn from the charger by the battery measured.

   e. If this current exceeds a predetermined value, the charger will lock on at the higher rate until the current drops to the specified flow at which time the charger will automatically switch OFF.
3. Units that will operate at 120 volts or 277 volts.

4. Unit equipped with automatic solid-state charger and sealed lead-calcium, maintenance free, 12-volt battery.

2.2 CENTRAL EMERGENCY LIGHTING POWER SUPPLY (CELPS)

A. Provide a solid-state standby power supply for emergency operation of fluorescent, high intensity discharge (HID), halogen lighting at 277 volts, 60 Hertz. Distribution of standby power to lighting to be 277/480 volts, 3-phase, 4-wire. Unit kVA rating as shown.

B. The CELPS lighting power supply shall provide uninterruptible power during modes of operation. There shall be no interruption of power to the critical load when the CELPS transfers to and from battery operation. The unit cabinet shall be forced air cooled by internally mounted fans.

C. The CELPS unit shall meet the following:

1. Input voltage range: Plus 15 percent to minus 20 percent of nominal input voltage.
2. Input Frequency: 60 Hertz plus 5 percent
3. Input current: Sinusoidal, 95 percent power factor under line/load conditions
4. Output voltage regulation: Plus 3 percent No Load to Full Load, High Line to Low Line
5. Output frequency: 60 Hertz plus 0.5 Hertz when on inverter
6. Output waveform: Sine wave
7. Output harmonic distortion: Less than 5 percent single harmonic
8. Output crest factor: 2 to 1
9. Output overload: 125 percent of rated for 10 minutes; 150 percent per 10 seconds
10. Output protection: Fault current limited
11. Modes of Operation:
   a. NORMAL: During normal operation, utility (or generator) power is converted to DC, drawing sinusoidal input AC current at unity power factor under load conditions. This converter supplies DC power to the inverter and battery charger sections. The inverter supplies the load through the static bypass switch (SBS) without using the energy stored in the battery section.
   b. EMERGENCY: Upon loss of input power or when power exceeds the specified input limits, the control logic shall allow the inverter to draw energy from the batteries without interruption to the load and disconnect the input line. The transfer to the batteries shall be uninterrupted “no break” power transfer. The inverter shall supply power from the batteries, through the static bypass switch to the critical load. The output shall be sinusoidal and without specified limits. If power is not restored before the batteries have been exhausted, the CELPS shall completely shutdown protecting the batteries from possible damage.
   c. FAILURE: In the event of a CELPS component failure in either the rectifier converter or the inverter, the unit’s static bypass switch will transfer the load, without interruption to the utility power and will alarm providing visual and closed contacts for remote annunciation. Upon loss of utility AC power, a summary alarm for the CELPS shall report to the Train Control Center (TCC) through a set of dry contacts connected to the terminal blocks of the demarcation panel.
   d. RECHARGE: Upon restoration of input utility power and before the batteries are completely exhausted, the CELPS shall automatically return to normal operation. This transfer to normal operation shall be uninterrupted. The battery charger shall automatically recharge the batteries to full capacity while the CELPS is maintaining the full critical load.

D. Where 3-phase distribution is indicated, provide single 3-phase supply with a 3-phase static switch and a control to keep the 3-phase outputs synchronized and approximately 120 degrees apart, so they can share 1 neutral conductor without overloading.

E. The complete CELPS system includes batteries, battery charger, inverter, and controls necessary or indicated.

1. Battery:
   a. Provide sealed lead acid or lead-calcium, maintenance-free batteries with absorbed electrolyte, requiring no special attention for shipping or storage, in high-impact plastic cases.
b. The batteries shall have an expected life of 10 years. The batteries shall be fully wired and contained within either the CELPS cabinet or a separate battery cabinet. Battery run time (based on 120 percent full load) shall be no less than the specified time of 90 minutes, or 15 minutes where an emergency standby generator provides 90-minute requirement. The battery float voltage shall be 2.25 volts per cell unless specified otherwise. Battery shall be protected with fuses, DC disconnect or circuit breaker. Optional extended battery run times shall be available from the manufacturer.

2. Battery Charger: Provide a battery charger of solid state construction with ferroresonant transformer and full wave bridge rectifier, with 3 rates of charge: "fast charge" to replenish the battery after use, "equalizing charge" to complete the charge evenly in cells, and "trickle charge" for continuous maintenance of charge. Furnish solid state timer to provide an equalizing charge at intervals of approximately 90 days. Input to charger shall be 277/480 volts, 60 Hertz. Charger shall recharge batteries in 10 times discharge time maximum.

3. Inverter:
   a. Provide a solid-state inverter which provides 277/480 volts, 3-phase, 4 wire power, at 60 Hertz, having tolerances of 5 percent for voltage and 3 percent for frequency. Output: sinusoidal with maximum of 10 percent total harmonic distortion, suitable for a lighting load of fluorescent, HID and halogen lamps. Automatic controls and protection include: low battery voltage disconnect, short circuit protection, brownout protection, current limiting, and overload protection of 130 percent.
   b. Inverter shall convert power supplied, from the utility or generator, when within specified limits or from the batteries, when within the battery manufacturer's specified limits, to alternating current (AC) power. It shall be a pulse width modulated (PWM) type design without the need of a transformer. The unit shall have a single power PCB for maximum reliability.

4. Provide static transfer switch to accomplish the load transfer operation described above.

5. The unit shall contain a static bypass switch (SBS) as a standard feature. The normal operating mode of the SBS is to connect the inverter to the critical load with the utility in a standby mode; in case of any converter/rectifier or inverter failure, the SBS will transfer to the utility without interruption to the critical load. The use of a transformer, to convert the utility, is permitted when the input utility voltage does not match the CELPS output voltage requirements.

6. Provide enclosures for the entire system to meet NEMA 1 requirements. Enclosures: free-standing or wall-mounted having maximum dimensions of 42 inches wide, 80 inches high, and 24 inches deep with hinged doors on front of cabinets. Provide nameplates in accordance with Reference Standard, Section 16040, “Identification of Electrical Equipment”.

7. CELPS:
   a. The CELPS shall be hardwired input and output. Optional output distribution circuit breaker panels shall be available from the manufacturer when required.
   b. The CELPS system status panel shall have a 160-character liquid crystal display (LCD). The LCD display shall indicate CELPS operating information such as input voltage, input current, output voltage, output KW, etc. The monitoring system shall include the following:
      1) Menu driven display with text format
      2) Real time clock (time and date)
      3) Alarm history with time and date stamp
      4) Battery back-up memory
   c. The following metering parameters shall be displayed:
      1) Input AC voltage line-to-line and line-to neutral for each phase
      2) Input AC current for each phase
      3) Input frequency
      4) Battery voltage
5) Battery charge/discharge current
6) Output AC voltage line-to-line and line-to-neutral for each phase
7) Output AC current for each phase
8) Output frequency
9) Percent of rated load being supplied by the CELPS
10) Battery time left during battery operations
d. The following alarm messages shall be available:
   1) Input power out of tolerance
   2) Input phase rotation incorrect
   3) Incorrect input frequency
   4) Charger in reduced current mode
   5) Battery charger problem
   6) Battery failed test
   7) Low battery warning
   8) Low battery shutdown
   9) DC bus overvoltage
   10) Bypass frequency out of range
   11) Load transferred to bypass
   12) Excessive retransfers attempted
   13) Static switch failure
   14) UPS output not synchronized to input power
   15) Input power single phased
   16) Input voltage single phased
   17) Input voltage sensor failed
   18) Inverter leg overloaded
   19) Output under voltage
   20) Output overvoltage
   21) Output overcurrent
   22) System output overloaded
   23) Load transferred to bypass due to overload
   24) Overload shutdown
   25) Control error
   26) Critical power supply failure
   27) Load transferred due to internal protection
   28) Fan failure
   29) Over temperature shutdown pending
   30) Over temperature shutdown

e. The following status messages shall be displayed:
   1) Normal operation
   2) Load on maintenance bypass
   3) Load on UPS
   4) Load on static bypass
   5) System shutdown
   6) UPS on battery
   7) Normal input power present
   8) CELPS on battery operation
   9) Low battery condition
   10) CELPS in bypass mode

f. Three communications ports shall be available. One port shall be provided for dry contact closures for the following parameters:

   1) Normal input power present
   2) CELPS on battery operation
   3) Low battery condition
   4) CELPS in bypass mode

    g. The second and third ports shall be based upon RS-232 and RS-485 protocol. Operating parameters, including input and output data and unit status, shall be available for remote monitoring via the RS-232 and S-485 ports.

    h. SCADA Alarm Contacts: Provide 1 set of fail-safe, closed loop logic,
Form C normally open and normally closed dry contacts in the CELPS. The normally open contact to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1) CELPS system failure alarm.

**PART 3 - EXECUTION**

**3.1 INSTALLATION OF EMERGENCY LIGHTING UNITS**

A. Install emergency lighting units of types shown at locations shown as follows:

1. Mount units rigidly in place. Use expansion anchors and machine screws for concrete surfaces and toggle bolts for hollow concrete masonry surfaces. Use appropriate fasteners for attachment to other surfaces. Support units independent of suspended acoustical panel ceiling systems.

2. Where aluminum contacts concrete or dissimilar metal, separate contact surfaces with gasket, nonabsorbptive tape or coal tar epoxy coating to prevent corrosion. Use only stainless steel fasteners.

3. Install wiring in accordance with NEC and Section 16120, "Wires and Cables".

4. Clean lamps, heads, reflectors, and exposed-to-view surfaces of units after aiming and adjusting has been approved.

**3.2 INSTALLATION OF AC POWER SUPPLY**

A. Install and secure equipment in cabinets.

B. Connect components and make connections to other equipment as indicated.

C. Provide for a factory service representative to inspect and test the complete system, including field tests described below.

**3.3 TESTING**

A. Refer to Section 16030, "Testing of Electrical Systems" for testing requirements.

**PART 4 - MEASUREMENT AND PAYMENT**

**4.1 GENERAL**

A. In accordance with Section 16001, "Electrical Systems - General"

END OF SECTION 16605
SECTION 16620
STANDBY POWER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the basic minimum technical requirements for furnishing and installing of natural gas engine generator set and associated auxiliary equipment providing standby power to the essential loads.

B. The work includes complete fabrication, inspection, testing, and delivery of electrical and mechanical equipment and systems, structures, materials, and appurtenances covered by the specification. Provide on-site installation, testing, and start-up.

C. Work includes, but not limited to:

1. Natural gas engine generator set rated 277/480 volts, 3-phase, 4-wire, 0.8 power factor, 60 Hertz, (capacity as stated on drawings), completely assembled and wired with:
   a. Natural gas engine generator, exciter-voltage regulator, automatic starting equipment, intake air filters, lube oil coolers, water pumps, exhaust muffler(s) and related instruments and accessories necessary for operation.
   b. An engine-generator control panel for instruments and accessories.
   c. Integral skid support.
   d. Neutral grounding connection for generator.

2. An automatic load transfer switch installed and wired in the 480 volts motor control center to provide automatic starting and stopping of the engine and switching the load.

3. Main circuit breaker at generator capable of carrying the full load of the unit plus 25 percent safety margin.

4. A complete set of special tools or equipment for installation and maintenance of the equipment. This includes equipment not readily available in stores.

5. Battery and battery charger complete with rack.

6. Electrical and mechanical connections external to the natural gas engine generator set, control panel and motor control center.

7. Install the generator outdoors and the automatic transfer switching equipment indoors. Location elevation is approximately 500 feet above sea level, outside air temperatures range 0 deg. F to 115 deg. F.

1.2 REFERENCE STANDARDS

A. Institute of Electrical & Electronics Engineers (IEEE):
   1. IEEE 112 - Standard Test Procedure for Polyphase Induction Motors and Generators

B. Military Standards (MIL):
   1. MIL-STD-705C - Generator Sets, Engine Driven Methods of Tests and Instructions

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA MG1 - Motors and Generators

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 110 - Standard for Emergency and Standby Power Systems

E. Underwriters Laboratories, Inc. (UL):
   1. UL 1008 - UL Standard for Safety Transfer Switch Equipment

1.3 SUBMITTALS

A. Product Data and Shop Drawings:
   1. Final layout drawings with dimensions.
   2. Control, wiring, and connection drawings.

B. Manufacturer's Data: At least two weeks before start of any shop coating work, submit to the Contracting Officer for approval three each of the following:
   1. Complete Data Sheets with surface preparation and the coating materials to be used, identified by the manufacturer, brand name, and product number.
C. **Test Reports:** Submit 6 copies of each test report, signed by a responsible representative of the Contractor to the Contracting Officer as a proof of compliance with the inspection and test requirements of this Specification.

D. **Certified Performance Certificates:** Provide the Contracting Officer with 6 copies of certificates which certify values for the following:

1. Design tests.
2. Stability, full power, voltage, and frequency regulation of the standby system.
4. The operational performance of the automatic transfer switch.

E. **On-Site Test Procedures:** Prepare and submit on-site test procedures as per requirements of Paragraph 1.2 in this section for service and approval.

F. **Operation and Maintenance Manuals, and Training:** In accordance with Section 16001, "Electrical Systems - General".

G. **SCADA Alarm System Testing:** Refer to Section 16030, "Testing of Electrical Systems".

**1.4 QUALITY ASSURANCE**

A. **Experience:**

1. Manufacturer: Select a firm regularly engaged in the manufacture of standby power systems of the type specified in this section.
2. Incorporate equipment into the system which duplicates equipment that has been in satisfactory use for a period of five years prior to Bid Opening of this Project.

B. **Source Quality Control:**

1. Factory tests:
   a. Inspect the engine generator set, automatic transfer switch, and their auxiliaries for the requirements of this specification particularly in regard to workmanship, materials, dimensions, finish and markings, and to assess its conformance with other requirements stated or reasonably implied and not covered by specific tests.

b. Carry out production and conformance tests in accordance with the relevant standards and, in addition, perform the following tests:

   1) Continuity test.
   2) Operation and mechanical adjustment tests.
   3) Maximum motor starting capacity (maximum kVA) and maximum power level (maximum kW).
   4) High potential test on field and armature.
   5) Torsiograph analysis per MIL-STD-705C, Method 504.2.
   6) Fuel consumption (no load, 1/2, 3/4 and full load).
   7) Engine: Generator cooling air flow.
   8) Transient and voltage dip response and steady state governing.
   9) Single step load pickup per NFPA 110, Paragraph 5-13.2.6.
   11) 3-phase short circuit test for mechanical and electrical strength.
   12) Compliance with Underwriter’s Laboratory Standard for Safety, Automatic Transfer Switches, UL 1008.
   13) Vibration tests:
       a) Engine alone.
       b) Engine and generator coupled for various loading.
   14) Temperature rise per NEMA MG1 definition.
   15) Insulation resistance.
16) Carry out a full load test on the set for a period of 4 hours and followed immediately by 2 hours at 10 percent overload.

17) Overspeed trip.

C. At the conclusion of test procedures, inspect the equipment for wear, cracks, distortion, or deficiency prior to shipment.

PART 2 - PRODUCTS

2.1 STANDBY POWER SYSTEM

A. Provide a standby power system meeting requirements of NFPA 110 including design, fabrication, specifications, prototype tests, one-step full-load pickup, and installation acceptance and the following:

B. Suitable for outdoor installation and having the capacity to operate the generator and accessories at full load on a standby basis.

C. Free from harmful torsional vibrations within the normal operating speed range in accordance with Manufacturer's Standard design.

D. Capable of operating at 110 percent load for two hours of any 24 consecutive hour period with outside air temperature range as specified in Paragraph 1.1 of this section.

E. Provide ample insulation and mufflers to minimize noise.

F. Provide means to allow mechanics access to the engine for major overhauls.

2.2 NATURAL GAS ENGINE

A. 4 or 2 cycle, water cooled as required, of the manufacturer's standard design with proven service reliability, for natural gas.

B. Direct coupled to the generator and the complete set mounted on a steel skid type base frame with suitable anti-vibration mountings and anchor bolts.

C. The brake horsepower rating of each engine: Not less than that required to produce continuous rated generator output at 1800 RPM and under specified service conditions.

D. Equip the engine with a high performance electronic governor to maintain frequency within limits, as specified below, by controlling engine and generator speed.

1. Stability: Plus or minus 0.5 percent maximum variation at any constant load from no load to full load.

2. Regulation: Four percent maximum frequency deviation between no load steady-state and full load steady-state, unless otherwise specified.

E. Engine accessories include, but not limited to the following:

1. Necessary speed, pressure, and temperature sensors and devices for indicating alarm and safety trip functions.

2. Flexible hose connections necessary to isolate the engine from piping and equipment not mounted on the engine.

3. Thermostatically controlled heaters to lube oil and jacket water at warm start temperature if required.

4. Local indicating devices including:
   a. Fuel pressure gauge.
   b. Lube oil pressure gauge.
   c. Jacket water temperature indicator.
   d. Engine tachometer.
   e. Engine hour-meter.

5. Local engine alarms (only) including low lube oil level.


7. Exhaust silencer and duct.

8. Air inlet cleaner (dry type) and air manifold.


10. Lifting eyes for handling of engine.

F. Engine cooling water system includes as a minimum the following:

1. An engine-mounted radiator with blower type fan with guards.

2. Jacket water pump, engine driven.
3. An engine-mounted, thermostatically controlled electric immersion heater. Heater: Single phase, 60 Hertz at 120 volts.

G. Engine Lubricating System:
1. Complete lubrication system which supplies oil to the driven equipment and auxiliaries.
2. Provide full details of the lube oil system.
3. Furnish the specifications of the lubrication oil to be used and the maintenance procedure compatible with the lubrication oil used and schedule of oil changes required.

H. Engine Fuel System: Furnish with the engine a complete fuel line system including but not limited to the following:
1. Fuel lines, as specified in Section 15060, “Piping and Accessories”.
2. Necessary controls.

I. Exhaust System: Engine exhaust pipe shall be schedule 40 black steel, welded from each engine exhaust manifold and extended to a suitable weatherproof terminal located as shown.

2.3 ENGINE STARTING SYSTEM

A. Equip engine with an electric starting system of sufficient capacity to crank the engine at a speed which will allow for full start of the engine. Arrange the starting pinion to disengage automatically when the engine starts.

B. A 24 volts battery of the lead-calcium, maintenance free type for the starting with a current output not less than 150 percent of the engine cranking requirements based on a minimum of 6 cranking cycles, each of 10 seconds duration.

C. Mount battery in an acid resistant battery rack.

2.4 GENERATOR

A. Synchronous-salient pole type designed and constructed in accordance with NEMA Standard MG.1.

B. Design the generator and excitation system to provide for operation at the overload capability of the engine, at rated power factor, frequency and voltage, with a temperature rise not exceeding 195 deg. F at 105 deg. F ambient for NEMA Class F insulation.

C. Solidly ground the star point of the generator windings.

D. Securely brace and protect generator power leads from mechanical damage where they pass through the stator frame. Provide means to prevent hot air from the generator entering the terminal box. Provide protective non-magnetic bushings where the generator leads pass through sheet metal plates.

E. The exciter-voltage regulator system: Solid state, brushless complete with components necessary to provide remote and manual voltage control, automatic voltage regulation, parallel compensation, exciter shutdown, automatic field flashing, and positive surge protection for any solid state components utilized in the system.

F. Provide a terminal box of sufficient size and space for AC Power leads (line & neutral). Provide terminal boxes with appropriate terminal blocks for disconnection and testing of electrical connections.

G. Provide 120 volts, 60 Hertz, single-phase heaters of a capacity to prevent condensation when the generator is not operating. Provide means to energize the heaters when the generator is not running. Automatically de-energize the circuit when the generator is running.

H. Provide surge capacitors and arrangement so their terminals are located between feeder cable terminations and phase windings.

2.5 BATTERY CHARGER

A. Provide a battery charger to operate from 120 volts, 60 Hertz, supply to automatically recharge the battery and be of the current-limiting constant-voltage type. The solid-state charger consists of a voltmeter, ammeter, and an alarm light which floats at a voltage per cell and equalizes at a voltage per cell as recommended by the battery manufacturer. It includes overload protection, AC failure alarm feature with a set of alarm contacts for remote indication, silicon diode full wave rectifiers, voltage surge suppressors, DC ammeter, and fused AC input. Voltage regulation conforms to battery manufacturer’s recommendations.

B. Provide ampere output with automatic cut-out during engine starting.

C. The charger contains the capabilities to maintain and charge the battery in full compliance with the battery manufacturer’s recommendations and warranty restrictions.
2.6 INSTRUMENT AND CONTROL PANEL

A. Furnish engine-generator control panel, lighted, and mounted with vibration isolators.

B. The control panel includes the following items, mounted and wired, in addition to those normally supplied.

1. A complete start-stop control which starts the engine on closing contact, and stops the engine on opening contact.

2. A manual selector switch providing 3 control positions, RUN-STOP-REMOTE. The RUN position permits the engine to be started locally at the set and run unloaded; the STOP position prevents local starting or automatic starting of the engine; the REMOTE position readies the system for automatic start or stop on demand of the automatic transfer switch or on programmed exerciser. Provide for remote indication and control.

3. An adjustable solid state temperature compensated cranking control circuit that provides a minimum of 10 seconds cranking period followed by a minimum of 7 seconds rest time. A sensing device automatically disconnects the starting circuit when the engine has started. If the engine has not started in approximately 60 seconds or 3 cranking tries, lockout the engine starting control, and indicate with the overcranking signal. No further starting attempts take place until the overcranking device has been manually reset.

4. The engine shuts down and gives visual remote indication with alarm lights for the following faults:
   a. Low lube oil pressure.
   b. High engine temperature.
   c. Overspeed.
   d. Engine overcrank.
   e. Generator faults.

5. Provide visual and audible alarms for the following battery and charger faults:
   a. Loss of 120 volts, 60 Hertz supply.
   b. Low DC volts.

6. Provide control and indication systems on separate circuits and fuse each circuit.

7. Engine lock-out relay and alarm relays and circuits.

8. Control for heaters in the generator.


10. Lube oil temperature gauge.

11. Ammeter with ammeter switch.

12. Voltmeter with voltmeter switch.

13. Tachometer.

14. Voltage level adjustment.

15. Panel illumination lights and switch.

C. SCADA Alarm Contacts: Provide one set of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the generator control panel. The normally open contact to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Generator failure for any of the alarm conditions.

2.7 BRUSHLESS EXCITER - STATIC VOLTAGE REGULATOR

A. Furnish with a fast response static voltage regulator combination mounted on the generator.

B. Automatic voltage regulator shall be within plus or minus 1 percent for a load variation from no load to full load, power factor variation from 0.8 lagging to unity and generator field heating from ambient to rated operating temperature rise.

C. Manual operation to be independent of the automatic voltage regulator control circuitry.

D. The output voltage level: Adjustable within plus or minus 5 percent of the rated voltage.

E. The solid-state regulator module: Shock-mounted and epoxy encapsulated for protection against vibration.

F. Provide ventilation and cooling to maintain proper operating temperature inside the equipment.

G. A series boost to sustain generator excitation during any combination of fault conditions and sustaining a minimum of 300 percent rated current for a minimum period of 15 seconds.
H. Ensure the silicon rectifiers are not subjected to peak inverse voltages in excess of 80 percent of their rating under any operating conditions. Provide surge protection as required.

2.8 MAIN CIRCUIT BREAKER
A. Provide main circuit breaker enclosed in a NEMA 1A enclosure mounted on the skid close to generator. Equip circuit breaker with thermal and magnetic trip elements and, if required, with current limiters. Rate circuit breaker for carrying the full load of the unit plus minimum 25 percent safety margin.

2.9 SKID SUPPORT
A. Support the engine and generator, and control panel on a heavy duty rigid skid.
B. Provide a heavy duty skid of rigid fabricated steel construction for engine operation and to withstand twisting. Provide means for lifting and hauling at each end of the skid. Provide vibration isolators between the engine-generator set and skid.

2.10 GROUNDING
A. Electrically ground engine, generator, control panel, and other metallic components mounted on the structural base to the skid.
B. Provide the structural base skid with two copper compression type grounding lugs (for up to #4/0 AWG copper bare cable) located at diagonally opposite corners for connection to the grounding system.

2.11 AUTOMATIC TRANSFER SWITCH
A. Capacity:
1. Supply an automatic transfer switch with a continuous electrical rating of sufficient amperage capacity to meet the requirements of both the maximum standby power system output and normal power service, 480 volts AC, and compatible with the standby power system. Furnish the complete automatic transfer switch from the manufacturer of the standby system to insure system compatibility between the generator and the automatic transfer switch.
2. The automatic transfer switch rating shall be not less than the value shown on the drawings.

B. Operation:
1. Supply the automatic transfer switch with precision calibrated voltage sensors to monitor the normal power source and signal the standby power system on a partial loss of power on any phase where feedback voltages exist. The voltage sensors:
   - Adjustable to signal startup when line voltage drops 5 percent to 20 percent below pickup voltage setting and to signal shutdown when line voltage returns to 75 percent to 100 percent of normal voltage and factory adjusted to start at 70 percent of normal voltage and shutdown at 100 percent.
2. A time delay relay, adjustable from 0.5 to 10 seconds, to avoid nuisance start-ups on momentary voltage dips or power outages. Factory set at 5 seconds.
3. When the standby system has reached a proper related voltage and frequency, provide a transfer time delay, adjustable from 0.5 to 10 seconds, to allow the standby system to stabilize. Factory set at 2 seconds.
4. The automatic transfer switch voltage sensors sense the return of normal power and a time delay, adjustable 0 to 15 minutes to delay the retransfer of the load to normal to avoid short term normal power restoration. Factory set at 10 minutes.
5. After the load has been retransferred to normal source, a time delay, adjustable 0.5 to five minutes, permits the standby system to run unloaded to cool down before shutdown. Transfer is to be automatic, either in actual power interruption or automatic exercise. Factory adjustment set at 5 minutes.
6. Provide the operation current for transfer and retransfer from the source to which the load is to be transferred. Ensure that an automatic bypass retransfers the load from the standby system to the normal source if the standby system output interrupts after the normal source voltage has been restored.
7. Provide a test switch to simulate an interruption of power from the normal source.
8. Furnish an automatic exerciser to operate the system at pre-selected intervals for pre-selected time periods: intervals to include once per week, and operating time to be 15 minutes or any multiple of 15 minutes.
selector switch permits selection of "without load" or "with load" operation. "Without load" the electric set runs unloaded and "with load" the automatic transfer switch transfers the load to the standby system after proper time delays, the same as it would for an actual source interruption.

9. Provide a device to electrically disconnect the control section from the transfer switch for maintenance service during normal operation.

10. Provide the automatic transfer switch with a means of safe manual operation.

11. SCADA Alarm Contacts: Provide one set of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the automatic transfer switch. The normally open contact to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:
   a. Loss of normal AC utility power.

C. Rating and Performance:

1. Rate the automatic transfer switch for continuous full load duty, for all classes of load, both inductive and non-inductive, at 480 volts, enclosed in a non-ventilated NEMA 1 enclosure. Design, build, and test to close on an inrush current up to and including 20 times the continuous rating of the switch without welding or excessive wear of the switch contacts. The automatic transfer switch: capable of enduring 6000 cycles of operation, at rated current, at a rate of 6 cycles per minute, without failure. A cycle shall consist of 1 complete opening and closing of both sets of main contacts on an inrush current of 10 times the continuous rating of the switch.

2. Construct the automatic transfer switch to withstand the effects of a fault current available at 480 volts and a testing rating of withstanding a short circuit current for a minimum of 6 cycles (0.1 second) without main contact damage, from a test circuit having an open circuit voltage at 600 volts RMS, 60 Hertz with a power factor per the connected load and in conformance of UL 1008, "Standard for Safety Automatic Transfer Switches".

2.12 CONTROL AND PROTECTION

A. Furnish control and protective equipment as required for the complete operable system.

B. Produce a suitable control scheme to integrate with the 480 volts, 3-phase, 4-wire motor control center.

2.13 NAMEPLATES

A. Furnish nameplates for each instrument and device. Identify devices such as relays, fuses, and terminal blocks.

B. Provide a nameplate for each piece of equipment with appropriate data such as equipment number, rating, serial number, and manufacturer. Fix nameplates in a conspicuous position.

C. Provide nameplates in accordance with Reference Standard, Section 16040, “Identification of Electrical Equipment”.

2.14 PAINTING

A. Thoroughly clean and degrease before priming metal surfaces. Cover prime coat with 2 air-dried coats of finish paint to provide an average dry thickness of 4 mils.
B. Apply the surface finish free of runs, drops, ridges, waves, and laps, and paint in such a manner as to provide an even film covering corners and crevices. Provide exterior finish of manufacturer's standard color and white interior finish coating thickness of minimum 2 mils.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Secure the engine generator set to the concrete pad with anchors. Install and wire the automatic transfer switch completely in the 480 volts motor control center or as indicated on drawings. Hand clean exterior surfaces and apply touch up paint as required after electrical and mechanical connections are made.

3.2 ON-SITE TESTS

A. Refer to Section 16030, “Testing of Electrical Systems” for testing requirements.

3.3 COMMISSIONING

A. After installation, perform acceptance load-test on the Engine Generator set with maximum essential load connected for a minimum period of 2 hours in the presence of the Contracting Officer.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16620
SECTION 16670
LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION
   A. This section specifies furnishing and installing lightning protection systems and supporting devices, as shown.

1.2 REFERENCE STANDARDS
   A. Lightning Protection Institute (LPI):
      1. LPI 175 - Lightning Protection Institute Standard of Practice
   B. National Fire Protection Association (NFPA):
      1. NFPA 70 - National Electrical Code (NEC)
      2. NFPA 780 - Standard for the Installation of Lightning Protection Systems
   C. Underwriters Laboratories, Inc. (UL):
      1. UL 96 - UL Standard for Safety Lightning Protection Components
      2. UL 96A - UL Standard for Safety Installation Requirements for Lightning Protection Systems

1.3 SYSTEM DESCRIPTION
   A. Design, furnish, install, and test work associated with providing a lightning protection system. Use the lightning protection system described herein and shown on the Contract Drawings as a guide. Modify the system specified as required to obtain the Master Label.

1.4 SUBMITTALS
   A. Shop Drawings: Show locations of air terminals, conductors, ground rods, and systems connections. Show devices with dimensions on shop drawings.
   B. Product Data: Include manufacturer's literature.
   C. Provide certification that the system and system components are UL listed.
   D. Operation and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".

1.5 QUALITY ASSURANCE
   A. Experience:
      1. Manufacturer: Select a firm regularly engaged in the manufacture of lightning protection systems of the type specified herein and listed by Underwriters Laboratories.
      2. Installer: Have the work performed by an installer certified by the Lightning Protection Institute as a Master Installer.

1.6 JOB CONDITIONS
   A. When required to install items supplied by others:
      1. Complete field assembly and internal connections.
      2. Provide all supporting members, fastenings and fittings, to adapt the system to the architectural and structural conditions.
      3. Mount in place and make connections required to the building systems.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR LIGHTNING PROTECTION MATERIALS
   A. Comply in weight, size, and composition with the applicable requirements of the UL96, UL 96A, NFPA 780, NFPA 70, and LPI 175, relating to the type of building on which the lightning protection system is installed. Provide air terminals, cables, ground rods, and connectors used in the lightning system with an Underwriters' Laboratories, Inc. label.

2.2 AIR TERMINALS
   A. Provide air terminals of solid copper, tapered to a point, except when mounted on aluminum surfaces use aluminum air terminals. Sizes of the air terminals shall be 12 inches long by 3/8 inch diameter unless shown otherwise on the drawings.
   B. In locations exposed to smoke and gas emissions, provide air terminals with lead coating, 1/16 inch minimum.

2.3 CONDUCTORS
   A. Provide conductors consisting of commercially pure copper cable, except when installed on aluminum surfaces use aluminum cable with
transition to copper downleads. Sizes of conductors are as shown on the Drawings, or if not shown, comply with NFPA 780.

2.4 **THROUGH ROOF AND THROUGH WALL FITTING**

A. For penetrations of roofs and walls, provide fittings with solid brass or stainless steel rods with provision for attaching conductors at each end, and provision for watertight sealing.

2.5 **GROUND RODS**

A. Provide copper clad steel ground rods not less than 3/4 inch in diameter and 10 feet long.

2.6 **CONNECTORS**

A. Above grade connectors: Bolted type, specifically designed for lightning protection systems. Use bronze connectors with copper conductors, and aluminum connectors for aluminum conductors. Use bimetal clamps (bronze and aluminum) for transition from aluminum cable to copper cable. Connections below grade: As specified in Section 16450, "Grounding and Bonding". Connectors below grade and concealed connectors shall be exothermic type.

**PART 3 - EXECUTION**

3.1 **INSTALLATION ERECTION**

A. Install the lightning protection system as shown on the Drawings. Firmly attach the air terminals to the roof with anchor bolts or with other suitable means. Secure roof conductors by means of clip fasteners and concrete anchors as required. On built-up roofing an approved adhesive conductor holder may be used. Space fasteners or conductor holders not more than 3 feet apart.

B. Do not run cables continuously through roofs or walls; use thru roof and thru wall fittings.

C. Properly flash where fittings or air terminals pass through roof or walls, to conform with the roofing and wall requirements. Fasten materials to eliminate any possibility of displacement and need for subsequent maintenance.

D. Bond all grounded sizeable metallic objects located within 6 feet of the system or metal connected to the system with approved fittings and conductor. Use bimetal connectors between dissimilar metals. Include bonding of all required metal work on roof in this work.

E. Install grounding cable connections to prevent compromise between corrosion control insulators and systems.

F. Perform installation work under the supervision of an installer listed with Underwriters Laboratories.

3.2 **TESTING START-UP**

A. Test lightning protection system for continuity to the grid, or to the ground rod, and also in accordance with all applicable codes and standards.

3.3 **MASTER LABEL**

A. Prepare an application for a MASTER LABEL plate conforming to UL 96A and mail it to the Underwriters' Laboratories, Inc. The MASTER LABEL plate will be received by the Authority directly from Underwriters' Laboratories. The lightning protection system will not be accepted until the "MASTER LABEL" plate has been received by the Authority.

B. If a "Master Label Certificate" is provided instead of the "MASTER LABEL" plate, the certificate shall be laminated and installed at the appropriate location.

**PART 4 - MEASUREMENT AND PAYMENT**

4.1 **GENERAL**

A. In accordance with Section 16001, "Electrical Systems - General"
SECTION 16721
FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies the minimum technical requirements for design, fabrication, testing, and installation of fire alarm and detection system.

1.2 REFERENCED STANDARDS
A. American Society for Quality (ASQ):
1. ASQ Z1.11 - Quality Assurance Standards

B. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
2. NFPA 72 - National Fire Alarm Code
3. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
4. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

C. Underwriters Laboratories, Inc. (UL):
2. UL 193 - UL Standard for Safety Alarm Valves for Fire-Protection Service
3. UL 217 - UL Standard for Safety Single and Multiple Station Smoke Alarms
5. UL 464 - UL Standard for Safety Audible Signal Appliances
6. UL 539 - UL Standard for Safety Single and Multiple Station Heat Detectors
7. UL 864 - UL Standard for Safety Control Units for Fire-Protective Signaling Systems
8. UL 1480 - UL Standard for Safety Speakers for Fire Protective Signaling Systems
10. UL Fire Protection Equipment Directory
11. UL Electrical Appliance and Utilization Equipment Directory.

1.3 SUBMITTALS
A. Product Data and Shop Drawings to show as a minimum:
1. Final layout drawings with outline dimensions.
2. Control, wiring, and connection diagrams.
3. Bill of materials
4. Details of mounting methods for detectors and initiators.
5. Standby battery and circuit voltage drop calculations.
6. Fire alarm equipment data sheets.

B. Provide detail drawings prepared and signed by a Texas Licensed Fire Safety Professional Engineer for the design and installation of the fire alarm system.

C. Certification of source quality control:
1. Provide certification that each piece of equipment meets the requirements of ASQ Z1.11 quality assurance program and also satisfies safety related quality requirements imposed by regulating agencies.
2. Perform design, production, and operational tests, and submit certified test reports for each type of equipment.
3. Verify that each piece of equipment is in compliance with applicable codes, regulations, standards, and UL listings.
4. Submit a certificate of approval from the local fire department.
5. Submit shop drawings, including all notes and comments, approved by local fire department or local jurisdictional Authority.

D. Field Testing:
1. Supervisory Control and Data Acquisition (SCADA) Alarm: Refer to Section 16030, “Testing of Electrical Systems”.
2. Submit a detailed plan of the proposed method and scheduling of the required field testing at least 21 calendar days before initiating the tests.
3. Submit certified test reports of operational performance of fire alarm and detection system.

E. Operation and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".

1.4 QUALITY ASSURANCE

A. Experience:

1. Furnish products of a manufacturer regularly engaged in the manufacture of fire alarm and detection systems.

2. Incorporate equipment into the system which duplicates equipment that has been in satisfactory use for a period of 5 years prior to the Notice To Proceed.

PART 2 - PRODUCTS

2.1 FIRE ALARM CONTROL PANEL

A. Provide a fire alarm control panel with IP communications for reporting and monitoring to a remote IP compatible Digital Alarm Communication Receiver (DACR). Coordinate equipment and communications compatibility with DART IP DACR for transmission of alarm and trouble and supervisory signals to SCADA Monitoring System and Central Station. Refer to Section 16854, “Fire Alarm Subsystem – Communications System” for additional system information.

B. The system shall be two wire” with “end-of-line” device at the end of each circuit. Provide Class B, Style 4 Signaling Line Circuits (SLC) and Class B, Style Y Notification Appliance Circuit (NAC). Provide standard keying of all equipment. Construct the control panel with solid state electronic modules consisting of light emitting diode (LED) type high contrast visual indicators and the following minimum features as required:

1. Initiation device circuits.

2. Alarm indicating circuits.

3. Supervised annunciator circuits.

4. Earth ground supervision circuits.

5. Form C alarm contacts (2.0 amps at 24 VDC each).

6. Form C trouble contacts (2.0 amps at 24 VDC each).

7. Form C supervisory contacts (2.0 amps at 24 VDC each).

8. Set of dry contacts per zone, as required, (SPDT 2.0 amps at 24 VDC each).

9. SCADA Alarms: Provide sets of dry contacts (for Fire Alarm, Supervisory and System Trouble) for input to the SCADA system, at the Station Demarcation Terminal Cabinet. Three sets of dry contacts (for Fire Alarm, Supervisory and System Trouble) to be provided as an input to the Fire Alarm Control Panel.

10. Automatic battery charger and sealed maintenance free storage battery with all required devices providing 24 VDC, for 48 hours operation on loss of normal 120 volts, AC supply.


12. Form C output contact for remote station or local energy connection.

13. Provision for remote testing of the complete system.

14. Provision for remote transmission of alarms and indications from each subway station or a facility using data transmission system and also remote automatic activation of alarm devices. Use normally closed contacts at demarcation panel for normal operation and open for alarm conditions so panel failure results in an alarm condition.

C. Construct the panel to display the following visual indications:

1. Zone in which fire alarm condition is detected.

2. Zone in which there is a malfunction of a detector circuit.


4. AC power failure

5. Battery charger failure, battery voltage, and battery current.

D. Power Supply:

1. Provide integral power supply for panel and fire alarm peripherals. Provide control panel and peripheral needs with filtered power.

2. Design power supplies to meet UL and NFPA requirements for power-limited operation on external signaling lines, including initiating circuits and indicating circuits. Provide UL listing for power-limited circuit applications and use positive temperature coefficient devices for current limiting.
3. Provide input power rated at 120 volts, 60 hertz. Provide internal supervised batteries and automatic charger. Provide both positive and negative ground fault supervision, battery/charger fail condition, AC power fail indicators. Provide supervision of modular expansion power supplies as may be required.

2.2 FIRE MANAGEMENT PANEL

A. Provide a fire management panel as shown on the Contract drawings. Construct the panel to graphically display each area of the station or facility with zone annunciation devices.

B. Fabricate the fire management panel with the following features:
   1. LED type visual indicators.
   2. Display trouble and alarm for each initiated device.
   3. Lamps behind graphic display.
   4. Graphic display behind a clear plexiglass pane.
   5. Key operated test switches.
   6. Suitable for 48 hours operation after loss of normal 120 volts, AC Supply.
   7. Zones shall be color coded.

C. Provide space as shown on drawings for fire hot-line phone and public address microphone equipment, as provided by others.

2.3 MANUAL FIRE ALARM STATIONS

A. Construct the manual stations to be double action type. Provide the stations with high impact polycarbon or metallic, red enclosure with raised white lettering and a smooth high gloss finish. Make provisions for two separate and distinct actions to activate an alarm. Provide a common key to reset the station.

2.4 COMBINATION RATE OF RISE AND FIXED TEMPERATURE DETECTORS

A. Provide plug-in, twist-lock type combination rate of rise and fixed temperature detectors to operate when the rate of rise of the temperature exceeds 15 degrees F per minute, or the temperature of the surrounding air exceeds 190 degrees F. Provide the unit a high intensity LED alarm to remain lit after activation until manually reset.

B. Construct the detector with two independently operated thermal elements. Make the rate-of-rise element as self-restoring and the fixed temperature element as non-restorable.

2.5 SMOKE DETECTORS

A. Provide solid-state, photoelectric type smoke detectors in accordance with UL 268. Provide a locking screw to discourage unauthorized removal of the head from the base. Ensure that the removal of the detector head causes the interruption of the supervisory circuit of the alarm loop and also activates a trouble signal.

B. Provide detectors with insect screens and completely closed backs to restrict entry of dust and air turbulence. Ensure that the electronics of the unit are completely shielded to protect against false alarms from electro-magnetic and radio-frequency interferences.

C. Provide a red LED in each unit with a flashing status to indicate power on and a steady glow to indicate alarm. Provide a functional test switch in each unit.

2.6 DUCT SMOKE DETECTORS

A. Provide duct-mounted photoelectric smoke detectors downstream of air filters on air supply system with capacity greater than 2,000 cfm per NFPA 90A. Provide detectors capable of operating in velocities of 300 to 4,000 feet per minute without adverse affects on detector sensitivity and with direct interface to the system without interface zone modules.

B. Provide a noryl molded plastic enclosure with integral conduit knockouts and housing with gasket seals to ensure proper seating to the ductwork. Provide sampling tubes that extend a minimum of 75 percent across the width of the duct. Provide porosity filters to reduce sensor/camber contamination and provide integral single pole double throw auxiliary control contacts for air-handling unit shutdown. Coordinate with mechanical subcontractor for interface and verify shutdown is achieved upon an alarm signal from the duct smoke detector. Connect duct detectors to fire alarm panel to initiate a supervisory signal.

2.7 AUDIO/VISUAL ALARMS

A. Provide horn/light combination units suitable for low voltage operation from the fire alarm panel. Provide the horn output rating not less than 87 dBA, per UL 464, and not less than 15dB above ambient noise level. Provide a red Xenon strobe light for visual signal. Ensure that the horn and light operate only when a fire alarm signal is annunciated. Provide weatherproof enclosures installed outdoors or below grade. Provide white enclosure with red lettering.
FIRE ALARM AND DETECTION SYSTEMS

2.8 KNOX BOXES
A. Connect to Knox box tamper switch; refer to Section 10525, "Fire Department Key". Connect switch to fire alarm panel to initiate a supervisory signal.

2.9 FIRE SPRINKLER SWITCHES
A. Connect to fire sprinkler water flow switches to initiate an alarm signal and valve tamper switches to initiate a supervisory signal. Refer to Section 15300, "Fire Protection Systems", as necessary.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install the fire alarm and detection system in accordance with the drawings, Specifications, all applicable codes, manufacturer's recommendations, and with the following requirements:

1. Install wiring in accordance with NEC and NFPA 72.
2. Use galvanized rigid steel conduit and fittings.
3. Paint junction and pull boxes red and label FIRE ALARM, identify circuit present using black marker.
4. Connect the fire alarm and detection system to 120 volts, AC, single phase, power supply.
5. Use color coded wires throughout.
6. Connect alarms and indications to interface terminal blocks, where shown on Drawings. Use normally closed contacts at non-alarm conditions.
7. Coordinate the installation with other pertinent systems.
8. Install copy of as-built plans at Fire Alarm Control Panel.

B. Field Testing:
1. Refer to Section 16030, "Testing of Electrical Systems".
3. Furnish equipment to perform tests.
4. Test the completed system in accordance with NFPA 72.
5. Test each device and equipment individually for its operational performance.
6. Test that in the event of loss of normal 120 volts, AC power supply, storage batteries are capable of supplying power to the complete system for 48 hours in stand by mode. After 48 hours in stand by mode, system must capable of indicating an alarm condition (audio/visual devices activated) for minimum of 5 minutes.
7. Test each output and input circuit to and from the remote terminal unit (RTU).
8. Provide test of the interface between the Fire Alarm Control Panel and remote IP DACR.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. In accordance with Section 16001, “Electrical Systems - General”.

END OF SECTION 16721
SECTION 16722
INTRUSION ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the minimum technical requirements for design, fabrication, testing, and installation of intrusion alarm and detection system.

1.2 REFERENCE STANDARDS

A. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

B. Underwriters Laboratories, Inc. (UL):
   1. UL 464 - UL Standard for Safety Audible Signal Appliances

1.3 SUBMITTALS

A. Shop Drawings to show as a minimum:
   1. Final layout drawings with outline dimensions.
   2. Control, wiring, and connection diagrams.
   4. Details of mounting methods for detectors and initiators.
   5. Details of all sensor devices and access control systems.

B. Certification of Source Quality Control:
   1. Provide certification that each piece of equipment meets the requirements of ASQ Z1.11 quality assurance program and also satisfies safety related quality requirements imposed by regulating agencies.
   2. Perform design, production, and operational tests, and submit certified test reports for each type of equipment.
   3. Verify that each piece of equipment is in compliance with applicable codes, regulations, standards and UL listings.

C. Field Testing:
   1. SCADA Alarm: Refer to Section 16030, "Testing of Electrical Systems".

PART 2 - PRODUCTS

2.1 INTRUSION ALARM CONTROL PANEL

A. Provide an intrusion alarm control panel as shown on Contract Drawings. Construct the panel with solid state modules, suitable for multi-zone keypad programmable control with digital communicator, or for card type with magnetic strip or bar code. Design the panel with the following minimum features and quantity as required:
   1. Circuit supervision, detection, and indication.
   2. Output expansion circuits.
   3. Zone expansion circuits.
   4. Siren driver.
   5. Battery voltage and charging current indication.
   6. Automatic battery charger and sealed maintenance free storage battery with all required devices providing 24 volts DC with capacity to carry the system on standby for 48 hours with the normal 120 volts AC power off.

2. Submit a detailed plan of the proposed methods and scheduling of the required field testing at least 21 calendar days before initiating the tests.

3. Submit certified test reports of operational performance of intrusion alarm and detection system.

D. Operation and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".

1.4 QUALITY ASSURANCE

A. Experience:
   1. Furnish products of a manufacturer regularly engaged in the manufacture of intrusion alarm and detection systems.
   2. Incorporate equipment into the system which duplicates equipment that has been in satisfactory use for a period of five years prior to the Notice to Proceed.
7. Vandal resistant enclosure with tamper switches as required for Grade A, Grade B UL listings.

8. Additional remote keypads.

9. Light emitting diode (LED) annunciators.

10. Provision for remote testing of the complete detection system.

11. Other ancillary controls as required for operation of the system

B. Construct the panel to indicate the following alarms and indications:

1. Alarm from each intrusion detection zone.
2. Zone in which there is a malfunction of a detector circuit and devices.
3. AC power failure.
4. Battery charger failure or low battery voltage.

C. Provisions for remote transmission of alarms and indications from each subway station or a facility using Data Transmission system and also remote automatic activation of alarm devices.

D. SCADA Alarm Contacts: Provide five sets of fail-safe, closed loop logic, Form C normally open and normally closed dry contacts in the intrusion Alarm control panel. The normally open contacts to be connected to the Station Demarcation Terminal Cabinet for the following alarm functions:

1. Consolidated Services Building Intrusion Alarm, TVM No. 1, 2, 3 and 4 Intrusion Alarms.

2.5 DETECTOR DE-ACTIVATION SWITCHES

A. Provide keypad detector de-activation switches.

1. Integrated with intrusion alarm control unit or separate wall-mounted unit.
2. Labeled 0 - 9, * and #
3. Resistant to entry of dirt and moisture.
4. Keypad shall provide tactile feedback of operate; membrane keypads are not acceptable.
5. Powered by intrusion alarm control panel.
6. Have LED indications of status:
   a. Ready.
   b. Armed.
   c. Alert.

2.6 END OF LINE DEVICES

A. Provide end of line devices as required for each detector circuit for a fully supervised system. Provide devices of the type and characteristics which are in strict accordance with the manufacturer's recommendations and design.

2.7 AUDIBLE ALARMS

A. Provide inside and outside audible alarms of the horn type operating on 18-30 VDC. Provide those for outside installation in weatherproof enclosures. Provide horns which measured at ten feet, have an output rating of no less than 87dBA, per UL 464. Provide a different sound than the fire warning alarms sound. Provide Authority approved sound characteristics of the device.

B. Provide unit with tamper switches mounted and wired. Construct the unit with heavy material to resist attack. Provide supervision for unit against cover removal.

2.8 ULTRASONIC MOTION DETECTORS

A. Provide ultrasonic motion detectors which sense intruder presence by transmitting ultrasonic energy into a protected zone. Provide the ultrasonic energy at a frequency higher than 20 kHz. Provide the system for selective filtering to minimize breaking glass. Provide sensors which protect a 10 feet radius of glass area. Provide each sensor with a latching LED to indicate the appropriate detector in alarm.
nuisance alarms due to external sources of ultrasonic energy. Provide a system that adapts to changing levels of air turbulence and consists of a control unit and transceivers as required. Facilitate testing of the unit with a test/alarm LED.

2.9 INFRARED MOTION DETECTORS

A. Provide infrared motion detectors which detect intruder presence by monitoring the level of infrared energy emitted by the objects within a protected zone. Provide detector which is sensitive to infrared energy emitted at wavelengths corresponding to the human body and objects at ambient temperatures.

B. Provide sensors that have tamper switch to supervise cover removal. Facilitate unit testing with a walk test/alarm LED. Operating range from 0 deg. F to 120 deg. F. Provide sensors with a required wide angle of protection or by flipping the optic lens provides a required barrier pattern. Include as required an optional long range lens.

2.10 MICROWAVE MOTION DETECTORS

A. Provide microwave motion detectors which sense intruder presence by transmitting electromagnetic energy into a protected zone. If more than one device is used in an area, provide different frequencies of operation. Provide a system for selective filtering to minimize nuisance alarms.

B. Provide an LED for test/alarm verification of the microwave sensor. Provide suitable sensor for the required wide angle and trap pattern protection. Provide detector that is programmable to default to alarm.

2.11 PHOTOELECTRIC DETECTORS

A. Provide photoelectric detectors that sense intruder presence by establishing a series of infrared or ultraviolet beams and detecting beam disruptions. Provide the beam transmitters that are designed to emit no perceptible light. The beam may be reflected by mirrors before being received and amplified. Provide uniquely modulated transmitted beam to prohibit an intruder from shining another light source into the receiver to escape detection.

B. Provide the operational range between transmitter and receiver up to 500 feet and allow 180 degree horizontal and 40 degree vertical aiming capability for the movable optic. Facilitate testing of the unit with a test/alarm LED. Provide for testing of alignment and tolerance of dust and dirt on covers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the intrusion alarm and detection system in accordance with the drawings, Specifications, all applicable codes, the manufacturer's recommendations as approved by the Contracting Officer, and with the following requirements:

1. Install wiring in accordance with NFPA 70 (NEC).

2. Use galvanized rigid steel conduit and fittings.

3. Connect the intrusion alarm and detection system to 120 volts, AC, single phase, 60Hz power supply.

4. Use color coded wires throughout the system.

5. Connect alarms and indications to interface terminal blocks.

6. Install audio/visual alarm units a minimum 8 feet above finished floor. If ceiling is too low to permit 8 foot mounting height, mount the unit as high as possible.

7. Coordinate the installation with other pertinent systems.

3.2 FIELD QUALITY CONTROL

A. Field Inspection: Prior to field testing, check equipment installation in accordance with manufacturer's recommendations and including verification of the following:

1. Connection of circuits in accordance with wiring diagrams.

2. Tightness of wire, cable, conduit, and terminal blocks.

3. Check the installations of sensors and detectors as per manufacturer's strict recommendations and specified requirements.

B. Field testing:

1. Refer to Section 16030, "Testing of Electrical Systems".

2. Provide service of manufacturer's engineering representative and supporting
field crew to conduct tests in the presence of the Contracting Officer.

3. Furnish equipment to perform test.

4. Test the completed intrusion alarm and detection system including line supervision tests; testing of all sensors, switches, annunciators, consoles, and power supplies.

5. Test each device and equipment individually for its operational performance.

6. Test that in the event of loss of normal 120 volts AC power supply, storage batteries are capable of supplying power to the complete system for 48 hours.

7. Test each output and input circuit to and from the remote terminal unit (RTU).

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16722
SECTION 16750
STATION COMMUNICATIONS DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies station communications devices and required accessories, intended for patron use, located on station platforms and concourse levels, station elevators, pedestrian underpasses, pedestrian overpasses, and other publicly accessible locations as shown on the Contract Drawings.

B. The Contractor shall furnish, install, wire, terminate, and test station communications devices, consisting of Passenger Emergency Call (PEC) Telephone Units and Elevator Emergency Telephones as described in this specification, from station pedestal and elevator locations to a common station demarcation panel as shown on Contract Drawings.

C. New communications devices furnished and installed under this contract shall be compatible with standard analog PABX extensions delivered from either existing or new DART owned and operated voice network switches over the Communications Transmission System.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME):
   1. ASME A17.1 - Safety Code for Elevators and Escalators

B. Military Specification (MIL):
   1. MIL-DTL-915/1F - Cable, Power Electrical, 600 Volts, for Outboard Use Only (Not for Inboard Use), Type CVSF

C. National Fire Protection Association (NFPA):
   1. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

1.3 SUBMITTALS

A. Material Specification Data Sheets and Product Samples: The Contractor shall submit within 120 days after NTP complete specification data sheets and product samples (as requested by DART) for approval, for the following equipment and material:
   1. Communications devices, including PEC and elevator emergency telephone
   2. Equipment Enclosures
   3. Protected Terminal Block Assemblies and Protector Modules
   4. Telephone Cable
   5. Power Cable (for Blue Light)

B. Mechanical Drawings: The Contractor shall submit drawings for approval, at least 30 days prior to fabrication or factory inspection. Drawings shall include the following:
   1. Location Marker Detail
   2. Enclosure Identification Details (including painting and lettering)
   3. Operating Instructions or Details
   4. Mounting and installation details for PEC and Elevator Telephones

C. Electrical Drawings and Calculations: The Contractor shall submit the following Single Line Drawings and calculations within 120 days after NTP:
   1. Blue-light light power and control circuit end-to-end wiring details
   2. Telephone cable end-to-end wiring and termination details to include each device and the station demarcation panel
   3. Protector terminal and equipment grounds to station ground grid end-to-end wiring details
   4. Power cable voltage loss and telephone cable loop voltage loss calculations to confirm proper device operation at designed cable lengths

D. Product Documentation: The Contractor shall submit, within 30 days of installation, the following documentation for communications devices and other equipment furnished and installed under this contract.
   1. Operations and Maintenance Manuals
   2. Installation and Troubleshooting Guides
   3. Product part numbers, cut-sheets, and installation manuals for hardware, software, and accessory equipment associated with the remote maintenance package (as described in Section 2.1.B.14 of this specification) designated for use with communications devices furnished and installed under this contract

E. Default or As-built Configuration and Provisioning Information: The Contractor shall submit, within 30 days of installation, detailed information for each installed communications device to allow system integration by follow on contractors and consultants. Information should include:
   1. Programming passwords
   2. Programmable feature settings
3. Board level switch/strap settings

4. Other configuration or provisioning which deviates from manufacturers default state

F. Test Procedures: The Contractor shall submit, at least 30 days prior to any testing, complete procedures for each cable test and functional testing requirement listed in Sections 3.2.A and 3.2.B of this specification section.

G. Training Procedure and Plan: The Contractor shall submit, at least 120 days prior to final acceptance, a complete training plan and procedure provided by the manufacturer representative to satisfy the requirement listed in Section 2.6 of this specification section.

H. Field Testing:
   1. Station Demarcation Terminal Cabinet Testing: Refer to Section 16030, “Testing of Electrical Systems”.

1.4 QUALITY ASSURANCE

A. Communications devices shall be registered under FCC Regulations, Part 8, 15, and 68, and shall comply with UL1459.

B. Communications devices shall be UL listed.

C. Communications devices shall be ADA compliant and shall be designed and installed in accordance with the most current ADA Standards for Accessible Design (28 CFR Part 36).

D. Communications devices shall meet local codes and/or regulations for emergency operation as established by the authority having jurisdiction.

PART 2 - PRODUCTS

2.1 PASSENGER EMERGENCY CALL (PEC) UNIT

A. PEC units shall be installed on platforms, concourses, pedestrian underpasses or overpasses, walkways, fare vending areas, or other public areas in the vicinity of Light Rail stations in locations and quantities shown on the Contract Drawings to provide a means of emergency communications from a station patron to the train control center.

B. Passenger Emergency Call Instrument:
   1. The unit shall be an outdoor-rated (NEMA 3R or better), weatherproof, hands-free, ADA compliant emergency telephone instrument.
   2. Call Operation and Functions:
      a. Telephone shall operate on a standard telephone line or an analog PABX or key system extension.

b. The telephone shall operate from a single cable pair in an auto-dial DTMF mode. The unit shall be capable of programming, storing, and dialing a minimum of two successively dialed telephone numbers, each at least 10 digits in length.

c. The telephone shall be capable of auto-answering and operating in a monitor mode, where authorized personnel may silently connect a call from any station connected to the PABX network to any field telephone and monitor activity immediately around the telephone.

d. The telephone shall have a DTMF call disconnect function, enabling the control center operator to disconnect the call by pressing and sending a single touch tone key or a series of no more than three touch tone keys.

3. Telephone shall have only a single, 3/4 inch minimum sized button to initiate a call. The unit shall not have a 12-digit dial pad nor shall the telephone have a corded handset.

4. Sound pressure level (SPL) within three feet in front of instrument should be a minimum of 3 dB above peak ambient station sound levels and conform to the NFPA 72 requirement of minimum intelligibility of 0.70 on the Common Intelligibility Scale (CIS) scale, corresponding to a Speech Transmission Index (STI) of 0.50. Concealed microphone sensitivity and speaker volume adjustment controls shall be provided for DART maintenance personnel to adjust the instrument to acceptable levels.

5. The telephone shall have an auxiliary output that enables peripheral equipment, such as a blue light strobe, to be activated when the emergency call button is pressed. The auxiliary output shall be a solid-state relay that isolates the control voltage from the output contact.

6. Device Impedance: Off-hook impedance presented to the line shall be 600 ohms or less. On-hook line impedance shall be the ringer impedance.

7. Power Supply. Telephone line powered, requiring no battery back up or external power source.

8. Loop Current (at 48V supply). Minimum range of 24-80 mA.


10. Ringer Equivalency (REN). 1.0A or less.

12. Environmental. Minus 20 deg C to plus 60 deg C and humidity of 0 to 95 percent non-condensing.

13. Local and Remote Programming. The telephone shall be capable of local programming, through the use of a concealed, integrated, internal keypad or through the use of an externally attached programmer. The telephone shall be capable of remote programming by calling into the phone over its connected telephone line using any standard touch tone telephone set connected on the same network.

a. Programming shall be held in non-volatile memory and shall be saved in the event of disconnection from telephone line.

b. A password of at least four digits shall be required to enter the programming mode when dialing through the system to program in remote mode.

14. Remote maintenance. The telephone shall be capable of operation with an externally Windows based PC monitoring and reporting package that utilizes the existing telephone line for connection. Maintenance calls shall not interfere with or pre-empt emergency call operations. The telephone and the PC based monitoring package shall:

a. Automatically report operational status to PC (keep alive and/or health status) for new telephones on network

b. Automatically report and database any telephone fault condition

c. Provide call usage reports (with time, date, call length, and other information)

d. Provide telephone identification upon incoming call from any field telephone

e. Generate reports of maintenance data and call statistics

C. Unit Enclosure, Identification, and Indication:

1. The telephone instrument may be installed as a self-contained unit or as a unit within a stanchion, pedestal, or other enclosure so long as the environmental rating for the instrument specified in this section is maintained.

2. A readily identifiable location marker plate indicating station name, address, and telephone location (ie. north or south pedestal) shall be installed on or adjacent to the faceplate of each telephone.

3. A blue light fixture or beacon with vandal-resistant lens and a lamp and strobe, or combination of flashlamp, strobe, incandescent, fluorescent, or other light, shall be installed with each emergency telephone. Beacon shall be powered by an uninterruptible 120V AC power source from the station electrical panel.

a. Conduits containing power lines shall be separate from those containing telephone signal wire. Power cable shall be sized adequately for cable distances and voltage drops and shall conform to the requirements of Section 16120: Wires and Cables.

b. Lamp shall remain constantly on during on-hook situations and shall provide a high-intensity strobe when telephone goes off-hook.

c. Lamp shall be rated, at a minimum, for 60 Watt output.

d. Flash rate of strobe shall be a minimum of 1 Hz and a maximum of 3 Hz.

e. Lamp fixture shall be rated NEMA 3R or better.

4. The word “Emergency” shall be incorporated on the faceplate and/or enclosure of the telephone.

a. Letters shall be raised no less than 3/32 inch, accompanied by Grade 2 Braille lettering, and otherwise comply fully with requirements of the ADA.

b. Operating instructions shall be incorporated with or adjacent to the telephone.

5. The telephone instrument shall provide on demand information to authorized personnel at the Train Control Center that identifies the Station location, address, and telephone location (ie. north platform) and that assistance is required.

6. An easily identifiable and labeled visual indication shall be provided on the telephone faceplate, which is activated by authorized personnel at the Train Control Center, to acknowledge that two-way communications link has been established.

a. The visual indication shall be extinguished when the two-way communications link is terminated.
b. The label for this indication shall not imply that any emergency response has been automatically dispatched or is otherwise underway. Such a prohibited example is, “Help is on the way”. Examples of permissible phrases include, “Call Received When Lit”, “Call Connected”, or “Received”.

c. If a lamp is used as the visual indication, it shall be an LED device.

2.2 ELEVATOR EMERGENCY TELEPHONE

A. An elevator emergency telephone shall be integrated into each elevator cab installed in stations or any other public area servicing LRT patrons to provide a means of emergency communications from a station patron, located inside the elevator, to the train control center.

B. Elevator Emergency Telephone Instrument

1. The telephone instrument shall be a hands-free, ADA compliant emergency telephone.

2. Call Operation and Functions

   a. Telephone shall operate on a standard telephone line or an analog PABX or key system extension.

   b. The telephone shall operate from a single cable pair in an auto-dial DTMF mode. The unit shall be capable of programming, storing, and dialing a minimum of two separate successively dialed telephone numbers, each at least 10 digits in length.

   d. The telephone shall be capable of auto-answering and operating in a monitor mode, where authorized personnel may silently connect a call to any field telephone and monitor activity immediately around the telephone.

   e. The telephone shall have a DTMF call disconnect function, enabling the control center operator to disconnect the call by pressing and sending a single touch tone key or a series of no more than three touch tone keys.

3. The telephone shall have only a single, 3/4 inch minimum sized button to initiate a call. The unit shall not have a 12-digit dial pad nor shall it use a corded handset in the car.

4. Sound levels at areas within the elevator cab shall be uniform and conform to the NFPA 72 requirement of minimum intelligibility of 0.70 on the Common Intelligibility Scale (CIS) scale, corresponding to a Speech Transmission Index (STI) of 0.50. Sound pressure level (SPL) within three feet in front of instrument should be a minimum of 3 dB above peak ambient station sound levels. Concealed microphone sensitivity and speaker volume adjustment controls shall be provided for DART maintenance personnel to adjust the instrument to acceptable levels.

5. Device Impedance: Off-hook impedance presented to the line shall be 600 ohms or less. On-hook line impedance shall be the ringer impedance.

6. Power Supply. Telephone line powered, requiring no battery back-up or external power source.

7. Loop Current (at 48V supply). Minimum range of 24-80 mA.

8. Signaling. Loop start (FXO/FXS compatible).

9. Ringer Equivalency (REN). 1.0A or less.


11. Environmental. Minus 20 deg C to plus 60 deg C and humidity of 0 to 95 percent non-condensing.

12. Local and Remote Programming. The telephone shall be capable of local programming, through the use of a concealed, integrated, internal keypad or through the use of an attached programmer. The telephone shall be capable of remote programming by calling into the phone over its connected telephone line using any standard telephone set connected on the same network.

   a. Programming shall be held in non-volatile memory and shall be saved in the event of disconnection from telephone line.

   b. A password of at least four digits shall be required to enter the programming mode when dialing through the system to program in remote mode.

   c. Connection for external programmer (if required) shall be concealed to patrons during normal operation.
13. Remote maintenance. The telephone shall be capable of operation with an externally Windows based PC monitoring and reporting package, compatible with the maintenance system specified for the PEC unit, that utilizes the existing telephone line for connection. Maintenance calls shall not interfere with or preempt emergency call operations. The telephone and the PC based monitoring package shall:
   a. Automatically report operational status to PC (keep alive and/or health status) for new telephones on network
   b. Automatically report and database any telephone fault condition
   c. Provide call usage reports (with time, date, call length, and other information)
   d. Provide telephone identification upon incoming call from any field telephone
   e. Generate reports of maintenance data and call statistics

C. Telephone Mounting, Identification, and Indication:
   1. Telephone assembly shall be flush mounted into a recessed area in the elevator control panel, with brushed stainless faceplate finish or a finish to match the elevator panel. Alternatively, the unit may be mounted without faceplate behind an existing control panel that is integral to the elevator cab assembly, so long as the speaker and microphone cutouts match, the elevator control panel labeling satisfies ADA standards, and specified features and functions of the telephone are made available. Mounting height shall be in accordance with ADA Standards for Accessible Design, 28 CFR Part 36, Section 4.10.14.
   2. A readily identifiable location marker plate indicating station name, address, and telephone location (ie. south elevator) shall be installed on or adjacent to the faceplate of each telephone.
   3. The word “Help” shall be permanently incorporated and visible on the faceplate of the telephone or elevator control panel adjacent to the call button.
      a. Letters shall be raised no less than 3/32 inch, accompanied by Grade 2 Braille lettering, and otherwise comply fully with requirements of the ADA.
      b. Operating instructions shall be incorporated with or adjacent to the telephone and shall conform to ASME A17.1a-2002 Section 2.27.7.3.

2.4 The telephone instrument shall provide on demand information to authorized personnel at the Train Control Center that identifies the Station location, address, and elevator identification (ie. north or south elevator) and that assistance is required.
   a. The visual indication shall be extinguished when the two-way communications link is terminated.
   b. The label for this indication shall not imply that any emergency response has been automatically dispatched or is otherwise underway. Such a prohibited example is, “Help is on the way”. Examples of permissible phrases include, “Call Received When Lit”, “Call Connected”, or “Received”.
   c. If a lamp is used as the visual indication, it shall be an LED device.

2.3 STATION PROTECTORS AND ENCLOSURES
   A. Protected terminal block assemblies, as manufactured by Marconi Communications, Circa Enterprises, Krone, or an approved equal, shall be installed at each Passenger Emergency Call unit with positions sufficient to terminate cable pairs plus at least 100 percent spare terminations at each telephone location. Station protectors shall be three element gas or solid-state type, designed to provide heavy duty transient and power fault protection for this telephone line application and shall have the following operating characteristics:
      1. Balanced operation
      2. DC Breakdown at > 350V @ 2KV/sec
      3. DC Holdover Voltage of < 150V, < 200ms
      4. Surge Life of > 750 surges @ 10A, 10x1000μsec
   B. Individual terminals shall be sized to accept OSP and inside wire conductors.
   C. An enclosure shall be installed beneath or adjacent to each telephone enclosure to house the protected terminal blocks. The enclosure shall be a NEMA 3R or better gasket protected enclosure with screw-on cover or approved equal. Cover screws shall be tamper-resistant and non-corrosive. The enclosure shall be sized to house the telephone station protectors and wiring. Cable cut outs shall be sized to accept inbound and outbound cables.
D. Station protectors and enclosures are not required at elevator emergency telephone locations.

2.4 TELEPHONE CABLE

A. OSP telephone cable between the station demarcation panel and communications devices shall be no less than 6 pair, filled, and shall conform to RUS Specification 7 CFR 1755.890 (PE-89).

B. The conductors shall be solid annealed bare copper conforming to the latest requirements of ASTM B3. The conductors shall be no smaller than No. 22 AWG.

1. Conductors shall be individually insulated with a colored, solid insulating grade, high density-polyethylene or polyolefin of ICEA S-56-434.

2. The insulating material color shall be coded per U.S. telephone industry standards with color concentrates chosen for permanency and electrical balance of individual circuits. The colors of insulated conductors shall be supplied in accordance with ICEA S56-434, Section II-7 and shall comply with the requirements of EIA TIA-359.

3. The insulated conductors shall be twisted into pairs. The length of pair twists shall be designed to meet ICEA S45-434 latest edition.

4. The average twist length of any pair in the finished cable shall not exceed 6 inches.

5. The insulated pairs shall be twisted and assembled into a cable core into specified color combinations to provide pair identification as well as low susceptibility to noise pick-up and with varying lay lengths to minimize cross-talk.

C. The filling compound, a petroleum jelly base multi-component, shall be applied to the cable core in such a way as to provide as near to 100 percent fill of the available air space within the core as is commercially practicable. The filling compound shall be applied in a manner to fill voids and conductor interstices under the core to restrict the migration of moisture. The filling compound shall be compatible with the insulation and other cable components.

D. The filled core shall be completely covered with a layer of non-hygrosopic, non-wicking polymeric tape applied with overlap over the cable core to ensure high dielectric strength from cable core to shield.

E. 0.008-inch thick corrugated aluminum tape shall be applied over the core. The tape shall be coated with a 0.002-inch thick copolymer compound and shall be applied longitudinally with overlap.

F. The outer jacket shall be of virgin, black high molecular weight polyethylene copolymer except low-smoke jacketed cables that shall be as specified below. The overall jacket shall be sequentially marked at 2-foot intervals with cable type, year of mfg., footage, pair count, conductor size and manufacturer. The jacket shall be free from holes, splits, blisters or other imperfections and shall be smooth and concentric.

G. Conductor insulation shall conform to RUS Specification 7 CFR 1755.97 Bulletin 345-63 "RUS Standard for Acceptance Test and Measurements of Telephone Plant" for the following:

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Minimum Tensile Strength: 2400 lb./sq. in.</td>
</tr>
<tr>
<td>2.</td>
<td>Ultimate Elongation: 300% min</td>
</tr>
</tbody>
</table>

H. The cable shall conform to RUS Specification 7 CFR 1755.97 Bulletin 345-63 "RUS Standard for Acceptance Test and Measurements of Telephone Plant" for the following:

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mutual Capacitance 0.083_0.004 uF/mi.</td>
</tr>
<tr>
<td>2.</td>
<td>Mutual Capacitance 3% rms maximum Deviation</td>
</tr>
<tr>
<td>3.</td>
<td>Mutual Conductance (1000 Hz.) 3.3 micromhos/mi.</td>
</tr>
<tr>
<td>4.</td>
<td>Pair-to-Pair Capacitance 25 pF/1000 ft. Unbalance</td>
</tr>
<tr>
<td>5.</td>
<td>Pair-to-Ground Unbalance (maximum) 800 pF/1000 ft. max.</td>
</tr>
<tr>
<td>6.</td>
<td>Pair-to-Ground Unbalance (average) 175 pF/1000 ft. max.</td>
</tr>
<tr>
<td>7.</td>
<td>Far End Crosstalk (150 kHz) 63 db in 1000 ft. (RMS)</td>
</tr>
<tr>
<td>8.</td>
<td>Near End Crosstalk (772 kHz) 56 M-S db.</td>
</tr>
<tr>
<td>9.</td>
<td>Insulation Resistance 1000 megohm per mile.</td>
</tr>
<tr>
<td>10.</td>
<td>Maximum Conductor Resistance (@ 20N C) 45.9 ohms/mi.</td>
</tr>
<tr>
<td>11.</td>
<td>Maximum Average Attenuation (1000 Hz @ 20N C) 1.29 dB/mi.</td>
</tr>
<tr>
<td>12.</td>
<td>High Voltage Test 3,600 volts DC (3 secs.) (Between Conductors)</td>
</tr>
</tbody>
</table>
13. **High Voltage Test**

7,000 volts DC (3 secs.) (Between Conductor and Shield)

I. **Low Smoke Jacket:** Cable entering from an outside environment exceeding 50 feet in length inside a facility shall be low smoke. Low smoke jacket material for cables shall be flame retardant cross-linked polyolefin, as approved by DART. The jacket thickness shall be 60 mils minimum. Jacket material shall meet or exceed the following specifications:

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tensile Strength (ASTM D 470):</td>
<td>1100 psi.</td>
</tr>
<tr>
<td>2. Elongation (ASTM D 470):</td>
<td>200%</td>
</tr>
<tr>
<td>3. Tear Strength (ASTM D 470):</td>
<td>7 lb/in.</td>
</tr>
<tr>
<td>4. Oxygen Index (ASTM D 2863):</td>
<td>27</td>
</tr>
<tr>
<td>5. Smoke Density (ASTM E 662)</td>
<td></td>
</tr>
<tr>
<td>a. Flaming Mode Ds 4 min.:</td>
<td>50</td>
</tr>
<tr>
<td>b. Flaming Mode Dm 20 min.:</td>
<td>175</td>
</tr>
<tr>
<td>c. Nonflaming Mode Ds 4 min.:</td>
<td>65</td>
</tr>
<tr>
<td>d. Nonflaming Mode Ds 20 min.:</td>
<td>300</td>
</tr>
<tr>
<td>6. Smoke Index (MIL-DTL-915/1F):</td>
<td>25</td>
</tr>
<tr>
<td>7. Halogen Content (MIL-DTL-915/1F):</td>
<td>0.2%</td>
</tr>
<tr>
<td>8. Toxicity Index (MIL-DTL-915/1F):</td>
<td>8.0</td>
</tr>
<tr>
<td>9. Acid Gas Equiv. (MIL-DTL-915/1F):</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

J. **Outside communications cables** (e.g. those run in conduits, trough or ductbanks) shall be foam/skin insulated conductors that meet RUS Specification 7CFR 1755.890 and shall be rodent protected using armor taping or approved equivalent.

K. **Inside wire,** defined as wire from telephone terminals to communications devices, shall be 22 AWG or 24 AWG and have a characteristic impedance of 105 ohms plus or minus 16 ohms. Cable shall be low smoke and non-toxic.

L. **Cable lengths and slack allowances** shall be sized for at least three re-terminations on any connector or terminal block.

### 2.5 SPARE PARTS AND SPECIAL TOOLS

**A. Spare Parts.** The Contractor shall provide either the quantity specified below of the total installed quantity, rounded up to the nearest integer (example: if 15 elevator telephones total are installed under this contract, and 10 percent spare quantity is specified, provide two spare elevator telephones). Spare PECs and elevator emergency telephones shall be assembled, programmed, and ready to be fully installed.

1. Elevator Emergency Telephone instruments: qty. 10%
2. Passenger Emergency Call units: qty. 10%
3. Station protected terminal blocks: qty. 10%
4. Station protected terminal block modules: qty. 10%
5. Telephone Cable: qty. 2000 ft.
7. Complete Blue Light assembly: qty. 10%

**B. Special Tools.** The Contractor shall provide either the quantity specified below or 5 percent of the total installed quantity, rounded up to the nearest integer (example: if 30 elevator telephones are installed, provide two spare elevator telephones).

1. Tools needed to access tamper resistant screws or hardware: qty. 8
2. Tools necessary for wire wrapping or terminal connection: qty. 8
3. Special tools necessary for protector terminal block module replacement: qty. 8
4. External hand programmer (if not integral to device): qty. 3

### 2.6 TRAINING

**A.** The Contractor shall perform or provide manufacturer’s approved operations, administration, and maintenance training for communications devices furnished and installed under this contract.

**B.** Training shall be held at DART facilities and shall consist of two identical sessions, each eight hours in length. Each session shall accommodate up to twelve maintenance technicians and one supervisor.

**C.** Sessions shall include hands-on training, including troubleshooting steps, covering features and functions utilized in the installation and application of these products.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Field Installation:

1. The Contractor shall furnish, install, wire, and test communications devices. The devices shall be wired to a common station demarcation panel, as shown on Contract Drawings, from which each instrument can be integrated into the existing or new communications and control system.


3. Terminate telephone cable pairs within each telephone instrument, terminal block, and junction box according to color code. Terminate and label telephone location, tip, and ring for telephone cable pairs at the nearest communications interface or demarcation panel located on Contract Drawings. Each telephone instrument shall be wired independently on a unique cable pair to this demarcation panel. Parallel or daisy chain wiring on the same cable pair between any communications device is not permitted.

4. The Contractor shall coordinate with the elevator equipment supplier for details in routing communications cabling to the supplied telephone instrument and for telephone compartment dimensions.

5. Externally exposed mounting hardware, fixtures, buttons, ground connections, or enclosures shall be tamper-proof and vandal-resistant.

6. Conduit from the cableways or pullboxes to and from the protected terminal block enclosure and the telephone enclosure shall be 2 inches GRS conduit per Section 16111, “Conduits”.

7. Grounding:

   a. Passenger Emergency Call units, enclosures, and protectors shall be grounded to the station ground grid utilizing No. 6 AWG stranded, insulated ground wire and approved ground connection hardware.

   b. Communications devices located in elevators will be grounded to the elevator structure utilizing No. 6 AWG stranded, insulated ground wire and approved ground connection hardware.

   c. The telephone enclosure, junction box, and protected terminal blocks for each communications device shall be connected to station ground grid.

   d. Telephone cable jacket shields shall be grounded to the protected terminal block ground lug from which the cable signal pairs are terminated. At no time should cable shields be grounded at both ends of run.

3.2 TESTING

A. Factory Acceptance Testing: The Contractor shall perform or provide manufacturer’s certified testing results for RUS specified telephone cable satisfying the requirements of Section 2.4 of this specification and those detailed below. Include in this report any test measurement results. The Contractor shall notify the DART Communications Systems Element Manager (SEM) ten working days prior to testing so that he/she or a representative may be present during facilities telephone testing activities.

1. 1000 Hz attenuation, signal to noise ratio, and peak to average ratio.

2. Conductor to ground insulation resistance test for each conductor.

3. Conductor to conductor insulation resistance test between conductors of each cable pair.

B. Field Installation Testing: The following field installation tests shall be performed from the station local demarcation panel out to the individual communications devices using standard telephone line simulators and other equipment. The Contractor shall include in this report the results of test measurements. The Contractor shall notify the DART Communications Systems Element Manager (SEM) ten working days prior to testing so that he/she or a representative may be present during facilities telephone testing activities:

1. Cable pair continuity (DC loop resistance of each cable pair) between telephone protector terminal and station demarcation panel.

2. Audio performance of telephone from three feet directly in line with instrument speaker/microphone, including SPL and STI measurements under normal call operation.

3. Speaker volume and microphone sensitivity level adjustments to ensure no feedback.

4. Off hook ringer impedance.

5. Resistance to remote earth ground of no more than 25 ohms at each equipment, cable shield, and protector block ground connection.

6. Continuity of each protector block module installed.
7. Functional Testing:
   a. Verify off-hook primary auto-dial number connection to test unit / call simulator.
   b. Verify secondary auto-dial number connection(s) in the event of primary line non-availability.
   c. Verify full-duplex two-way communication once call is connected.
   d. Verify both auto-answer and standard ringing upon incoming call to the instrument.
   e. Verify disconnect function on calls initiated from the call simulator.
   f. Verify operation of ADA call acknowledgement visual indication.
   g. Verify remote programming capability.

8. Verify Blue Light operation at PEC locations.

C. Integrated System Field Testing Support: The following system field integration test shall be performed in coordination with the DART Systems Integration Consultant and Communications Systems Contractor after Systems installation is complete.

   1. Verify off-hook auto-dial, signaling, and connection to control center.
   2. Verify alternate number(s) auto-dial operation in the event of primary line non-availability.
   3. Verify loop current is sufficient for proper operation of telephone.
   4. Verify audio continuity from instrument to control center. Set transmission level points for specified audio levels.
   5. Verify remote password protection and programming capability.
   6. Verify operation of ADA call acknowledgement visual indication.
   7. Verify, from the OCC, the on-demand identification of the calling instrument.
   8. Verify correct extension and location display on train control center console phones.
   9. Verify full operation with remote maintenance PC system and equipment.

PART 4 - METHOD OF MEASUREMENT AND PAYMENT

4.1 GENERAL

   A. In accordance with Section 16001, "Electrical Systems - General"

END OF SECTION 16750
SECTION 16801
BASIC TECHNICAL REQUIREMENTS - COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section provides an overview of technical requirements, engineering guidelines, technical constraints, and general conditions to be followed by the Contractor throughout the design of the Authority Light Rail Communications System.

B. Technical requirements specific to each communications subsystem shall be found in each of the corresponding subsystem Specification Sections.

1. Section 16837 – Miscellaneous Components and Products – Communications System
2. Section 16838 – Communications Facilities – Communications System
3. Section 16839 – Communications Interface Cabinet – Communications System
4. Section 16841 – Communications Cable – Communications System
5. Section 16845 – Fiber Optic Cable Subsystem – Communications System
6. Section 16850 – Basic Electrical Materials and Methods – Communications System
7. Section 16851 – Telephone Subsystem – Communications System
8. Section 16852 – Public Address Subsystem – Communications System
9. Section 16853 – Visual Message Board Subsystem – Communications System
10. Section 16854 – Fire Alarm Subsystem – Communications System
11. Section 16855 – Intrusion Alarm Subsystem – Communications System
12. Section 16856 – Closed Circuit Television – Communications System
13. Section 16869 – Fare Collection Local Area Network – Communications System
14. Section 16876 – Grounding and Bonding – Communications System
15. Section 16877 – Communications Transmission Subsystem – Communications System
16. Section 16879 – Power Supplies and Distribution – Communications System
17. Section 16897 – Manuals and Training – Communications System
18. Section 16899 – Technical Support and Spares – Communications System

1.2 REFERENCED STANDARDS

A. American Society for Quality
1. ASQ Z1.11 – Quality Management System Standards - Requirements for Education Organization
2. ASQ Z1.11 – Quality Assurance Standards

B. Institute of Electrical and Electronic Engineers (IEEE)
1. IEEE 200 - Reference Designations for Electrical and Electronics Part and Equipment

C. Military Standard
1. MIL-STD-1472F - Human Engineering

1.3 SUBMITTALS

A. Design Review Submittals – General Requirements
1. This subsection defines the minimum set of design reviews to be conducted by the Contractor, and the minimum information and process requirements for Authority reviews.
2. Design Review Submittals shall be submitted to the Authority and shall consist of a complete design description, including detailed Drawings, Specifications, and Submittals of all subsystems and elements within the subsystem. Each calculation, test procedure, Final Design Review drawing and submittal shall be reviewed, signed and sealed by a Licensed Texas Professional Engineer. The final design document shall contain sufficient details for construction.
3. Contractor shall include in each submittal phase all materials, equipment, assembly
and installation required to carry out the functions and purposes indicated in these Specifications, and to make the system suitable for the purpose for which it is intended, whether or not such materials, equipment, assembly and installation are specifically indicated in the requirements of these Specifications.

4. The design proposed by the Contractor shall be subject to Authority approval. The Authority may disapprove the proposed design if it fails in any way to achieve the result intended by the requirements of these Specifications or is not in accordance with sound engineering principles. If the design or any portion of the design is disapproved by the Authority, the Contractor shall revise the design until it meets with Authority approval in accordance with the requirements of these Specifications.

5. No Authority approval or disapproval, or failure to approve or disapprove shall relieve the Contractor of any responsibilities under this Contract including the responsibility to provide a sound and practicable system design, suited for the intended purpose outlined in these Specifications.

6. Where requirements posed by individual subsystems, as defined in other sections of these Specifications, are different or greater than those specified in this subsection, those other requirements shall be deemed to augment the requirements specified herein.

7. Design Review requirements for each submittal – Preliminary and Final – are defined within the individual subsystem Specification Sections. Preliminary Design Review (PDR) packages shall be individual submittals for each subsystem, where the Final Design package is one complete submittal sufficient to provide all the required details for construction, overall system integration, and operation.

8. Contractor shall order the designated equipment and material only after Authority approval of the individual subsystem PDR submittal which includes design, calculations, operation, as well as the entire product data for that subsystem.

B. Preliminary Design Review Technical Requirements

1. Contractor shall submit PDR packages to satisfy the requirements outlined herein and the subject subsystem section of these Specifications. Communications PDR packages shall be required for the following subsystems:

a. Communications Facilities
b. Communications Interface Cabinets (CIC)
c. Communications Cable
d. Power Cable
e. Fiber Optics Cable Subsystem
f. Telephone Subsystem
g. Public Address (PA) Subsystem
h. Visual Message Board (VMB) Subsystem
i. Fire Alarm Subsystem
j. Intrusion Alarm Subsystem
k. Fare Collection Local Area Network (LAN)
l. Communications Transmission System (CTS)
m. Power Supplies and Distribution
n. Control Center Modifications
o. Supervisory Control and Data Acquisition (SCADA) Remote Terminal Units (RTU)
p. Miscellaneous Items
q. CCTV Subsystem

2. Each PDR package shall be organized to include the following headings and information:

a. PDR package Purpose and Scope: A brief description and introduction of the package.
b. Reference Material: List of relevant references and standards.
c. Specification compliance matrix table: Acknowledging and referencing the Contractor’s conformance to each technical requirement clause of every subsystem specification section.
d. Design Description: As a minimum shall include the subsystem description, detailed design and interface information, all performance, functionality and operational description, as well as details such as the cable and equipment identification.

e. Interface Requirements: Contractor shall identify all required interfaces with other communications and non-communications systems and subsystems. This section of the PDR shall include:

1) Interfaces between Work performed under this Contract and any other Communications contracts. For example, Supervisory Control Software, Control Center provisioning, Alarm Points and any other required interfaces.

2) Interfaces between the subsystems defined under this Contract. Examples are CTS and Fare Collection LAN, Telephone and CTS, and all the other required interfaces defined in these Specifications.

3) Identification and description of any required hardware and software modifications, or additions to existing subsystems equipment.

4) Identification of all external interfaces, including those to facilities and equipment provided by others. Interface examples include power, cable facilities, discreet signals, voice, and data.

5) Interfaces between the systems defined under this Contract. This includes Communications, Signals and Traction Electrification System (TES).

f. Equipment List: Contractor shall submit a table or list of model and part numbers for all proposed equipment and materials to be used for individual subsystems. Include the expected lead-time for each item while identifying in boldface type the equipment with greater than 30 days lead time. The table or list shall be grouped for each subsystem with functional descriptions of equipment or material included. Quantities and locations shall be included.

g. Product Data Sheet: Contractor shall submit product information in sufficient detail to determine if the component meets these Specifications.

h. Calculations: Contractor shall provide all the required signed and sealed calculations as outlined in the subject subsystem section.

i. Phasing and Cutovers: Identification and description of all major system cutover events or integration activities describing techniques, methods, duration and procedures.

j. Certifications, Registration, and Resumes: Contractor shall provide a copy of all the required certifications, registrations and resumes as outlined in the subject subsystem section.

k. Drawings: Electrical, mechanical, block and functional diagrams with corresponding parts list.

C. Final Design Review (FDR) Technical Requirements

1. Contractor shall submit one complete FDR package no later than 60 days after Authority approval of all the PDR submittals. The FDR submittal package shall not be submitted until the Authority approves all the individual PDR submittals.

2. The FDR Submittal Package shall be organized to include the following final design information:

a. Authority approved and updated versions of all previously submitted design review materials. Updated material shall represent complete design, final calculations; detailed product and component level parts list, drawings, phasing and interface details required for construction. All the new and revised sections
of the subsystem PDRs shall be marked with revision bars to reflect the changes.

b. Updated product submittals for all, materials and components for which product submittals were not previously submitted and Authority approved.

c. Complete Drawing index.

d. Complete cable identification and equipment labels.

e. Complete wiring diagrams for all equipment to be installed, modified, upgraded, or interfaced to under this Contract.

f. Top level mechanical drawings, if applicable.

g. Grounding details.

h. Power panel schedule and distribution.

D. Installation Work Plans and Detailed Documentation

1. Complete installation Work Plan and detailed documentation and drawings shall be submitted no later than 60 days prior to the scheduled installation date for each location and each subsystem.

2. Installation detailed documentation applicable to a subsystem shall not be submitted prior to Authority approval of the FDR submittal.

3. The Installation Work Plan package shall be organized to include the following headings and information:

a. Scope and description of Work

b. Prerequisites

c. Tools

d. Installation staff and their roles

e. Safety rules, regulations, procedures, and requirements

f. Permits, traffic plans, licenses, training including confined space, and certifications.

g. Planned access dates and times for each location, and the Authority resources required for each location and Operational Impact.

h. Daily Preparation and Clean-up Procedures.

i. Storage, staging facilities, security, and the overall job-site security.

j. Installation procedures shall include each subsystem hardware and software components including any software and configuration settings and changes.

k. Installation drawings:

1) Corresponding subsystem design review drawings with updates and details. Include detailed physical layout drawings with material list keyed to the layouts.

2) Cable and conduit schedules that show exactly where each cable is to be installed. Include and identify raceways, cable trays, conduit, junction boxes, pull boxes, manholes, hand-holes, and floor boxes.

3) Cable and wiring connectors and terminal assignments.

4) Wiring diagrams to include terminal blocks, power panel details, Local Distribution Frames (LDF), Main Distribution Frame (MDF), and any additional wiring required for a complete design.

5) Names and labels for all equipment including every wire, cable, connector, terminal and rack.

6) Electrical power diagrams and panel and power strip schedules.

7) Mounting, securing, and installation details for all equipment and materials.

8) For racks in which equipment will be installed,
rack face elevations with all intra-rack and inter-rack wiring and cabling to be installed.

9) Power connections, panel schedules and grounding connections.

10) Location of all safety and hazard warning signs and labels.

11) Site Survey detailed information.

E. Product Samples. As required in individual subsystem Specification Sections or where requested by Authority.

F. Testing and Inspection

1. A Test Program shall be submitted no later than 60 days after Authority approves FDR, outlining the Contractor’s overall testing strategy and schedule.

   a. The program shall include a list of all tests to be performed for all subsystems and integral equipment and materials to meet the requirements of these Specifications.

   b. The program shall include individual subsystem test plans.

   c. Contractor shall provide:

      1) Qualified personnel throughout all the required troubleshooting activities that may involve Communications System equipment provided under this Contract.

      2) All the required testing activities specified in these Specifications, specifically those defined under Communications subsystems test requirements including the System Integration tests.

   d. At a minimum, the test program shall cover the following testing activities:

      1) Factory Testing

      2) Inspection

      3) Field Equipment and Subsystem Testing

      4) End-to-End Acceptance Test

      5) System Integration Test

   e. The test program shall include a list of all the required tests per subsystem, to be performed in order to meet the requirements of these Specifications. This list shall be organized to include:

      1) Type of test

      2) Tools and Test Equipment

      3) Prerequisites

      4) Pass and fail criteria

      5) Personnel and laboratory requirements

      6) Required Cutover, Phasing

      7) Expected Impacts (Outages, Operational, Environmental, Traffic, and Revenue) and recovery Plan when required

      8) Authority resources

      9) Scheduled date and expected duration

      10) Additional comments and notes

2. Test and inspection procedures shall be submitted no later than 60 days prior to the scheduled activity. All the required test and inspection procedure submittals shall be detailed and organized to be consistent and include, but not be limited to the following headings and information:

   a. Scope and Purpose: Clearly state the scope, case, and conditions the procedure tests.

   b. Prerequisites: Describe test environment and the prerequisites, including access, availability, and equipment configuration for each group of functions.

   c. References.
d. Tools: List test equipment and tools, with calibration data for each item.

e. Personnel: List test participants and roles.

f. Procedure: Contain enumerated step-by-step procedures. This shall include regression test and Pass and Fail Criteria.

g. Drawings: Include detailed drawings depicting test setup. This shall include list of equipment, parts and material used and tested.

h. A Test Data Form that includes space to record the tools with calibration date, environmental condition during the test, i.e., rainy, cloudy, and temperature, test measurement, pass and fail criteria and space to record the pass and fail outcome and the signature of the test engineer and a test witness.

i. The Test Exception Form shall be used to record the identifier of the defect report and problem report generated as a result of faults or problems detected during the test. All the troubleshooting techniques and corrective actions shall be documented on this sheet.

G. Test and Inspection Records and Reports

1. All test and inspection records and reports shall be submitted within one week of completion of the corresponding test.

2. Test and inspection records shall be reviewed, signed and sealed by a Licensed Texas Professional Engineer to certify adherence to design requirements and standards.

3. Test and inspection report submittal shall be organized to include the following headings and information:

   a. Purpose/Introduction: Defines the submittal scope.

   b. Test/Inspection Results Summary: Including measurements, results, problem areas, workarounds, troubleshooting, and exceptions.

   c. Open Items: Identify any open items requiring resolution. Include the corrective action to resolve the open items.

   d. Conclusion: This Section shall document the Professional Engineer’s review and how the test and inspection meets the system design and performance requirements outlined in these Specifications.

   e. Completed Test and Inspection Records: Completed, signed, and dated test/inspection procedure sheets, as well as a defect/problem report for each fault/problem found during the testing.

H. As-Built Documentation

1. As-Built versions of the following documentation shall be signed and sealed by a Licensed Professional Engineer, who is registered in the state of Texas, and provided in accordance with these Specifications and as outlined herein for the communications system:

   a. Equipment inventory, with serial numbers including delivered, installed and spares.

   b. Drawings as a minimum shall include the ones submitted under FDR, installation and test procedure documents. The As-Built drawings shall be numbered and grouped in accordance with Authority standards for Communications System.

   c. Final software data and source codes.

   d. Final equipment configuration, provisioning, programming and settings.

   e. Technical Specification to reflect the final system design implemented in the field.

1.4 QUALITY ASSURANCE

A. Comply with:

1. Applicable Standards and Codes

2. IEEE 200
B. Material and Workmanship Requirements:

1. Requirements shall be provided as described in each Specification Section.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

Not Used

PART 3 - EXECUTION

3.1 INSTALLATION AND GENERAL DESIGN REQUIREMENTS

A. Information regarding Authority facilities and space in Authority facilities is provided in the Contract Drawings.

B. Environmental conditions to which equipment shall be designed is defined in these Specifications.

C. Operation and Maintenance

1. Operating and maintenance safety shall be the highest consideration in equipment and subsystem design, construction, and installation.

2. Human Factors for both operation and maintenance, equipment configuration and positioning shall:
   a. Support the reach and view of a person the size of the 5th percentile female, as defined in MIL-STD-1472.
   b. Fit a person the size of the 95th percentile male, as defined in MIL-STD-1472.
   c. User interface equipment and characteristics such as display devices, preferred viewing angles, lettering, control devices and their tactile characteristics, indicators, use of colors, and use of audible indicators shall be consistent with MIL-STD-1472.

3. Where applicable, equipment and design shall comply with ADA requirements.

D. Continued Operation of the Existing Light Rail System

1. The Authority Light Rail System conducts Revenue Operations between the hours of 3:00 AM and 1:00 AM, 7 days a week. The existing Communications and Central Control System is in use 24 hours per day, 7 days per week.

2. Installation, replacement, testing or modification of equipment or software during implementation of the new Communications System shall not disrupt continued operation of the Light Rail System, including operation of the Supervisory Control System (SCS).

3. During revenue or non-revenue hours, any disruption to the existing Communications and Central Control System shall be minimized.
   a. To the extent possible, no more than a single node shall be unavailable through the existing Communications and Central Control System at any point in time without the prior Authority approval.

4. Track access time is limited and shall be coordinated and approved through the Authority’s track allocation request process. Contractor shall follow Authority’s rules for access to and working in any rail operating territory.

5. Any work that could potentially interfere with the operating systems shall be coordinated and approved through the Authority’s track allocation request process. Contractor shall follow Authority’s rules for access to and working in any rail operating territory.

E. Design Review Meetings

1. Preliminary Design Review
   a. Contractor shall conduct a formal review of the PDR Submittal with the Authority.
   b. The review shall be conducted no less than 21 days, but no more than 45 days following an Authority “Approved” or “Approved As Noted – Confirm” status of all the PDR submittals.
   c. The meeting minutes shall be submitted by the Contractor to the Authority for concurrence no later
than 7 days after the PDR meeting.

2. Final Design Review
   a. Contractor shall conduct a formal FDR Submittal review with the Authority after the approval of all PDR submittals.
   b. The review shall be conducted no less than 21 days, but no more than 45 days following an Authority “Approved” or “Approved As Noted – Confirm” status of the FDR.
   c. The meeting minutes shall be submitted by the Contractor to the Authority for concurrence no later than 7 days after the FDR meeting.

F. First Article Inspections
   1. First Article Inspection (FAI) shall be performed by the Contractor for each subsystem and component that is custom-built, custom-assembled, or generally not accepted as a commercial off-the-shelf item or assembly. Examples of items for which an FAI should be performed include Communication Facilities and pre-wired Communications Interface Cabinets.
   2. The purpose of each FAI shall be to:
      a. Determine, based on inspection, measurement, and basic operation, whether the layout and mechanical aspects of the unit under inspection, e.g., Communications Facility, are consistent with Authority approved drawings, requirements of these Specifications, and other design documentation. If not, the subject unit shall be re-assembled and the FAI repeated. Where maintainability, e.g., accessibility, safety, status indicators, power indicators and control and exposure to power connector, are present in the unit, assessment of those maintainability aspects shall be included in the FAI.
      b. Determine whether an acceptable level of workmanship that is consistent with approved workmanship standards and practices, is present in the initial copy of the unit under inspection. Where wiring, wiring connections, cabling, cable management, labels, tags or grounding connections are present in the unit under inspection, the workmanship standards, practices and procedures associated with the respective element shall be included as part of the FAI.
      c. Determine whether an acceptable level of operating and maintenance safety is provided in the initial product submittal. If not, the unit shall be re-designed and re-assembled.
   3. For each subsystem and component, the FAI shall be conducted at the earliest possible time in the manufacturing stage.
   4. Contractor shall notify the Authority at least 21 days prior to each FAI so that the Authority may be present.
   5. The Authority may request a FAI on any subsystem or component at no cost to Authority. For those subsystems or components where the Authority requires a FAI:
      a. The Authority shall approve the level of workmanship deemed to be acceptable.
      b. The following, applicable to the subject subsystem or component, shall be available at the time of the FAI:
         1) Authority approved drawings and other design documentation
         2) Subsystem or Component Parts List
         3) Manufacturing and Quality Assurance Inspection Records
         4) Test Plan and Procedures
         5) Tools and staff to make measurements
         6) Tools and staff to remove covers and perform limited disassembly
3.2 TESTING AND INSPECTION

A. General

1. This subsection and the following subsections include basic testing requirements. Where requirements for these activities are present elsewhere, the requirements specified in this Section shall be augmented by those additional requirements.

2. Contractor shall:

a. Be responsible for successfully completing all tests required by these Specifications.

b. Provide all test instruments and any other materials, equipment and personnel needed to perform the tests.

c. Be fully responsible for the replacement of all equipment damaged as a result of the tests, and shall bear all associated costs.

d. Maintain comprehensive records of all tests.

e. Notify the Authority in writing, no less than 21 days prior to each test activity.

f. Provide test plans, procedures, records and reports for Authority approval.

3. The Authority reserves the right to:

a. Witness any and all tests and inspections required by these Specifications.

b. Inspect test records at any time.

c. Perform additional testing, beyond that specified herein, of any equipment or material at any time to determine conformance with these Specifications. Additional Authority testing is not to be considered as a replacement for any Contractor required testing or manufacturer producing materials for the Contract required testing.

B. Factory Testing

1. Contractor shall notify the Authority at least 21 days prior to each Factory Test so that the Authority may be present. Factory testing shall be conducted for:

a. All equipment provided for and installed under this Contract.

b. All components installed, integrated, and operated as a subsystem (to be tested as a subsystem).

2. Subsystem factory testing shall occur only after FDR submittal package approval for that subsystem.

3. Factory testing for a subsystem must be successfully completed prior to shipping any equipment for that subsystem to the Authority.

4. If the equipment for a location is assembled at the factory, factory testing for that equipment shall be conducted after all the racks and other subassemblies are integrated and rack interconnections are in place.

5. In order to show proper operation of all aspects, behavior, and characteristics, minimum requirements for equipment testing include:

a. Manufacturer’s Recommended Testing.


c. Power-up Testing.

d. Equipment burn-in of 72 hours, with concurrent operation of the equipment, for the full burn-in period.

e. After burn-in, comprehensive functional testing, including testing of all controls and indicators.

f. After burn-in, comprehensive diagnostic testing.

g. After burn-in, comprehensive performance testing.

h. After burn-in, comprehensive external interface testing, including verification of:

1) Electrical Interface

2) Functional Interface
3) Mechanical Interface

6. Minimum requirements for subsystem testing include:
   a. Comprehensive Functional Testing
   b. Comprehensive Performance Testing
   c. Comprehensive External Interface Testing, including verification of:
      1) Electrical Interface
      2) Functional Interface
      3) Mechanical Interface
      4) Rack-to-rack Interconnects

C. Installation Inspection and Test

1. Pre-Installation inspection shall include inspection for:
   a. Missing components and parts
   b. Correct serial numbers
   c. Damage to equipment
   d. All installed equipment shall undergo as a minimum, inspections for:
      1) Conformance to standards, methods, and quality
      2) Correct location, positioning, mounting, orientation, and labeling
      3) Damage to equipment
      4) Correct and secure external connections
      5) Correct and secure routing of cable and wires
      6) Correct and secure internal connections
      7) Proper grounding
      8) Verification of all configuration data and setting
      9) Correct labeling

D. Field Equipment and Subsystem Testing

1. The following equipment field tests shall be performed for all installed equipment. Additional field tests for each subsystem, listed in the subsequent subsections shall not be construed to limit or otherwise relieve the Contractor of the responsibility for performing comprehensive field testing of the following:
   a. Basic equipment operation
   b. Functional and performance testing
   c. All external interfaces such as mechanical, electrical, and functional
   d. Operation in the presence of equipment and software failures
   e. Operation in the presence of power failure and restart

2. Subsystem testing shall include:
   a. Tests for proper local operation
   b. Tests to confirm the installed equipment or subsystem meets performance requirements
   c. Validation of all data used to configure or operate the subsystem

E. End-to-End Acceptance Testing

1. To be defined within respective System Testing Section.

F. Support For Authority’s Systems Integration Testing

1. System Integration Testing (SIT) shall be conducted in accordance with Authority requirements.

2. Upon turn-up, interface, and integration of all required individual subsystems required for each line section cutover, the Contractor shall provide technical support for the Authority’s SIT. Technical support shall include providing engineer, technician, and installation staff, as well as tools, appliances, fixtures, expendable materials, supplies, and test equipment as needed to perform the SIT procedures or to develop and implement required corrective actions on the Contractor’s elements.
3. This testing shall involve the interaction of the Communications System operating with one or more other sub-systems and will be required through System Final Acceptance.

4. SIT shall include testing of all communications subsystems added to, modified, or integrated as a result of work performed under this Contract and integrated or interfaced to any other contract. Subsystem integration testing shall include:
   a. SCS indications and controls between intended field and control locations
   b. CTS node integration
   c. Proper operation and reporting between Fire Alarm Control Panel IP Communicators and IP Receiver (DACR) at the OCC from field transmitter sites and all other Fire and Intrusion subsystem indications.
   d. Proper local and remote operation of Station PA and VMB messaging and CCTV monitoring.
   e. Proper operation of all voice circuits
   f. Proper transport and operation of Signaling controls and indications
   g. Proper transport and operation of Traction Power Substation (TPSS) controls and indications
   h. Proper transport and operation of Fare Collection data and indications

5. Contractor shall verify the accuracy of the as-built documentation for each equipment location.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work described in this Section shall be full compensation for providing and installing the Communications System complete in place as specified including finalizing design, shop drawings, submittals, testing, and inspection; and for all Work as described in the Contract Drawings and in this Section and related Specification Sections; and for all operations, materials, tools, labor, equipment, and incidentals required to complete the specified Work.

4.2 PAYMENT

A. The Work described in this Section will be paid as a lump sum.
SECTION 16837
MISCELLANEOUS COMPONENTS AND PRODUCTS - COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Miscellaneous Components and Products to be designed, provided, installed, and tested under this Contract. Scope of work for the Authority Light Rail Communications System includes:

1. Contractor shall design, provide, install and test all Miscellaneous Components and Products to complement the communications subsystems as specified in these Specifications.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

1. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire


B. International Organization for Standardization

1. ISO 9001 – Quality Management Systems - Requirements

C. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

2. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials


D. Telecommunication Industry Association (TIA)/Electronic Industries Alliance (EIA)

1. TIA/EIA-606 – Administration Standards for Commercial Telecommunications Infrastructure

E. Underwriters Laboratories (UL)

1. UL 497 – UL Standard for Safety Protectors for Paired-Conductor Communications Circuits

PART 1.3 SUBMITTALS

A. Submittal format and content shall comply with the
general requirements of these Specifications, as
well as the specific technical requirements further
listed in this Section.

1. Manufacturer Qualifications: Any manufacturer differing from those specified
herein shall require a prequalification and
Authority approval. Acceptability of the
manufacturer shall be based on the
manufacturer’s experience, qualifications,
certifications (i.e. ISO-9001), equipment
reliability, compliance with standards
specified herein, and full compatibility with
the Authority’s current system.

2. Preliminary Design Review (PDR) Technical Requirements. Contractor shall include the following information as part of the PDR submittal package for the Miscellaneous Components and Products:

a. Product data including description and model number, catalog cuts and technical literature.

b. Design calculation for cable tray fill capacity per Specification requirement.

c. Communications Facilities Local Distribution Frame (LDF) mounting and equipment layout (on LDF).

d. Equipment cabinet and rack details.

e. Cable, wire and equipment tagging software, material and type schedule per Article 2.2 of this Section.

3. Final Design Review (FDR) Technical Requirements. Contractor shall include the following information as part of the FDR submittal package for the Miscellaneous Components and Products:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

b. Final equipment layout and mounting details.
4. Installation Work Plan. Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The installation work plan shall include:
   a. Equipment layout and plan views.
   b. Conduit installation to LDF.
   c. Wiring diagrams to LDF including all tagging identifiers.

5. Calculations and Certifications
   a. Calculations as listed in the PDR and FDR.
   b. Certifications: Copy of the following certifications shall be included:
      1) ISO certification for all proposed manufacturers.

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.


8. Test Records: Not required.

9. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for all Miscellaneous Components and Products. Reference Section 01785, “Project Record Documents”.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes
   1. Contractor’s design and installation shall comply with all applicable Standards and Codes as listed herein.
   2. All equipment and methods shall comply with the latest version of codes and standards as applicable in Article 1.2, Referenced Standards.

B. Material and Workmanship Requirements
   1. All equipment provided under this Section shall be UL listed.
   2. All products specified herein shall be subject to the Authority’s approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.

3. Discontinued product models, refurbished equipment, or products scheduled for either end-of-life, end-of-sale, or end-of-service within one calendar year of the installation date shall not be allowed.

4. All grounding shall be in accordance with the NEC, and specifications required by this Contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

PART 2 - PRODUCTS

2.1 CIRCUIT BREAKERS, FUSES, AND FUSE CLIPS

A. Capacity: Fuses and circuit breakers shall be suitable for protection of the equipment and cabling connected.

B. Fuse Type
   1. Fuses shall be non-renewable time lag fusion type.
   2. Protective resistance shall be used in branch circuits.

C. Fuse Clips: Positive contact pressure shall be applied to the fuses to ensure electrical continuity.

2.2 TAGGING

A. Cables and Wires
   1. Contractor shall install cable identification tags at both ends of each cable, including wires, where they terminate on terminals, punch-down blocks, and connectors. Communications cable identifiers shall comply with standard TIA/EIA-606. This includes all electrical power wires and cable for communication facilities and equipment.

   2. Contractor shall tag all cables at the entrance and the exit of each manhole, pullbox, handhole, junction box, splice-box, cable trough, or fiber-slack enclosure. Contractor shall tag all conduits as required in these Specifications.

   3. Contractor shall use water-resistant identification tags with lamination over its designation for all cables and wires. Permanently typed lettering shall be used.

   4. Contractor shall use sleeve type non-metal tags where cable diameter permits.

   5. Contractor shall use flat plastic tags for smaller cables as follows: Two holes in the
tag shall be provided for attachment with a dielectric tie.

6. Contractor shall purchase, populate, and deliver a dedicated cable-management software, including software license, to provide Class 4 administration of the communication cables per standard TIA/EIA-606. Prior to submitting, verify software compatibility with the Authority. The software shall be able to produce the following types of schedules:

a. Typed wiring interconnect schedule for all external and internal wires and cables listing wire (cable) tag identification, To and From locations, To and From termination terminals, wire (cable) size and type.

b. Typed wiring interconnect schedule for each location and each facility for the entire project.

c. Typed schedule of conduits, wires, or cables to include quantity of each.

7. Contractor shall submit typed schedule per items a, b, and c above for approval.

8. Contractor shall submit a complete list of cable and wire identification tags. The tags shall follow the sample format in the paragraph below. Each cable and wire shall have its own unique identification tag. If a wire is not terminated, then tag it “spare-1”, “spare-2”, “spare-3”.

a. Tag Scheme for External Cable:
   18P-COM-FDP / PPK-TPS-FDP–FS12-01
   1) 18P represents originating location (18th Place)
   2) COM represents originating facility type (Communication)
   3) FDP represents originating termination cabinet/panel (Fiber Distribution Panel)
   4) “/” represents “to”
   5) PPK represents ending location (Plano Parkway)
   6) TPS represents ending facility type (Traction Power Substation)
   7) FDP represents ending termination cabinet/panel
   8) FS12 represents cable type (Fiber Singlemode 12 strand)
   9) 01 represents cable number (01 through 99)

b. Tag Scheme for Internal Cable, PPK-COM-LDF / RTU-CAT5-01
   1) PPK represents Location
   2) COM represents facility type
   3) LDF represents originating cabinet/panel
   4) “/” represents “to”
   5) RTU represents ending cabinet, panel, or equipment
   6) CAT5 represents cable type
   7) 01 represents cable number (01 through 99)

c. Tag Scheme for Internal Wires and Wires of External Cables.
   1) CAT5-01-LDF-TB2-14 / RTU-TB5-11
   2) CAT5 represents cable type
   3) 01 represents cable number (01 through 99)
   4) LDF represents originating cabinet/panel
   5) TB2-14 represents originating termination block and termination terminal
   6) “/” represents “to”
   7) RTU represents ending cabinet, panel, or equipment
   8) TB5-11 represents ending termination block and termination terminal
B. Equipment

1. Label all terminal blocks, card cages, circuit cards, punchdown blocks, and jack fields. Communications equipment identifiers shall comply with TIA/EIA-606.

2. Permanent lettering scheme shall be utilized.

3. Labels shall be attached with a non-drying adhesive.

4. Contractor shall show the correct communication equipment identifier on every respective equipment drawing and schematic.

2.3 PUNCHDOWN BLOCKS

A. Type

1. Blocks shall be Krone IDC-Type 50 pair punchdown blocks. Blocks shall be configured with 2 columns of 25 pairs of 2 termination clips. Clips shall accept No. 20 AWG through No. 26 AWG insulated wire, and No. 18 AWG through No. 19 AWG bare wire.

2. Clips shall be pre-wired to an Amphenol type RJ21X connector socket, or approved equal.

3. Blocks shall be equipped with a base, standoff bracket, cover, and bridging clips.

B. Base

1. The base shall be impact resistant plastic.

2. Molded fanning strips shall be provided on each side of the split blocks.

3. Permanent numbering shall be applied to the fanning strips.

4. A standoff of 2 inches from the mounting surface shall be provided.

5. A removable cover with circuit designations permanently applied shall be provided.

6. Connector retention screws shall be provided.

2.4 PROTECTED ENTRANCE TERMINALS

A. Design

1. Protected entrance terminals (PETs) shall be used at the input for all signal circuits using metal cable and entering/exiting the facility (e.g. Communications Facilities and CIC). Connectorized PETs shall be used in all applications unless specifically stated otherwise in this Section or on the Contract Drawings.

2. PETs shall have a data throughput of 1 Gbps and clamping speeds of 2-3 nanoseconds.

3. PETs shall have a field splice line side connection stub pre-wired to 3 element (5 pin) protector sockets.

4. Blocks shall be 110 Cat 5/5e rated or approved equal.

5. PETs shall include an integral splice chamber.

6. Protected entrance terminals shall be provided in 25, 50, and 100 pair sizes and fully populated with protector modules as per the application shown on the Contract Drawings.

B. Protector Sockets: Protector sockets shall be UL standard 5 pin sockets, with 2-position (normal and detent) design. In the detent position, the protector shall be retained, the line side shall be disconnected, and the equipment side shall be protected. When fully inserted, the line and equipment side shall be protected.

2.5 MULTI-PAIR PROTECTED TERMINAL BLOCKS

A. Design

1. Multi-pair protected terminal blocks shall be utilized for applications requiring non-connectorized 25 pair or less terminal blocks, as specified on the Contract Drawings.

2. Types and pair counts for terminal blocks shall be in accordance with these Specifications and as shown on the approved Drawings.

3. Terminal blocks shall consist of pairs of brass binding posts imbedded in high impact plastic potted with a high dielectric polyurethane compound.

4. Binding posts shall be pre-wired to 2-element protector sockets. The ground of all protector sockets shall be wired to a common ground terminal.

5. Binding posts shall be equipped with 2 brass nuts and washers. Binding posts shall be sized to accept up to 2 No.14 AWG conductors.
2.6 PROTECTOR MODULES

A. Three Element (5-Pin) Protectors: Protectors shall be solid-state modules with fuses or heat coils specifically designed for lightning protection.

1. Modules shall plug into 5-pin protected entrance terminal sockets.
2. Each module shall protect both halves of a pair.
3. Protector modules shall be UL 497 listed for primary protection.
4. Modules shall have 2 ns to 3 ns response time and support 1 Gbps data transfer rates.
5. Modules shall protect for voltages over 300 V DC.

2.7 LOCAL DISTRIBUTION FRAMES

A. Communication Houses, CIC, Demarcation, and CCTV cabinets LDF per UL: Each LDF shall consist of the following equipment:

1. A wall mounted backboard 4 feet by 5 feet or as shown in Contract Drawings. Utilize 3/4 inch marine grade smooth surface plywood backboard for mounting all equipment described in paragraphs below and as shown in the Contract Drawings. The backboard shall have all finished sides primed and painted white with fire retardant paint that is compatible with wood treatment.
2. Protected entrance terminals fully equipped with protector modules for each active and inactive or unused circuit, as described herein. PET block shall be contained within a separate enclosure mounted on the LDF backboard. Enclosure shall have a fully removable cover in order to provide access to protected terminal modules.
3. A minimum of eight, or as shown on Contract Drawings; 110 Type CAT 6 50-pair connectorized punchdown blocks (as described in Article 2.3) utilizing 25 pair connectors as cross-connects.
4. A 110 Type CAT 6 patch panel for local Ethernet connections between the Ethernet switch and the VoIP phones and fire alarm. Quantity of connections shall at a minimum provide 100% spare capacity.
5. Binding post type terminal blocks shall be provided as described in Article 2.5 of this Section. Quantity of terminal blocks shall at a minimum provide 50% spare capacity.

B. Outdoor Communication Interface Cabinet (CIC) Local Distribution Frame. Each LDF for use in an Outdoor CIC or similar application shall consist of the following equipment mounted to the Lexan panel mounted on the interior side panel of the CIC:

1. One 100-pair connectorized protected entrance terminal contained within an enclosure. Enclosure shall have a fully removable cover in order to provide access to protected terminal modules.
2. A minimum of two 110 Type CAT 6 50-pair connectorized punchdown blocks (as described in Article 2.3) utilizing 25 pair connectors as cross-connects.
3. Multi-pair protected terminal blocks designed for a minimum of 36-pairs of PA speaker connections as described in Article 2.5 of this Section, and as shown on Contract Drawings.

2.8 CABLE TRAYS

A. Cable trays shall be of open ladder type, aluminum, or other suitable material commercially available and providing support spacing and strength of material characteristics equal to or greater than the aluminum.

B. The aluminum ladder type cable tray shall meet the following requirements:

1. Ladder rung spacing shall be approximately 6 inches.
2. Side stringer section shall be a minimum of 0.094 inches.
3. Top and bottom flange section shall each be a minimum of 2 inches.
4. Flange width shall be approximately 0.75 inches.
5. Height of rail shall be approximately 3.375 inches.
6. Rung thickness shall be a minimum of 0.062 inches.
7. Rung bottom width shall be approximately 2.20 inches.
8. Rung top width shall be approximately 0.75 inches.
9. Plastic tray insert barrier to separate power and signal cables.
C. Each cable tray shall be designed and fabricated with sufficient capacity to provide 50 percent of the cross-sectional area as free air space after the full number of cables and wires are installed. Corners shall have a minimum radius of 6 inches, for either horizontal or vertical turns. Sufficient overhead space must be available after installation to permit wires and cables to be inspected. Sufficient cable trays should be installed to allow for one row of racks to be added for future expansion (i.e., if one row is needed, a second cable tray row shall be added. If two rows are needed, a third cable tray row shall be added.

D. Where practical, the tray shall be constructed in straight sections joined with approved couplers. Electrical continuity of the tray shall be maintained across sections by bonding straps.

E. Using the manufacturer's standard, the tray shall be laid out using a minimum number of sections, but providing maximum continuous runs without gaps.

F. All fittings, supports, and accessories shall be provided in accordance with the manufacturer's recommendations.

G. Insofar as practical, cable trays shall be supported by cantilever type brackets in order that the cables can be laid into the tray without pulling.

H. Where the width of the tray, or the loading of cables is such that cantilever supports are impractical, other approved suspension methods may be used, but such application must be kept to a minimum.

I. At least 3 supports shall be provided for each length of tray. Supports shall be evenly spaced insofar as possible; in no case shall the spacing between adjacent supports exceed 5 feet.

J. To prevent damage to cables, no metal edges of any description shall protrude and no sharp corners shall exist in the completed layout.

K. Fiberglass support arms, where required to insulate the cable tray from the equipment racks, shall be flame retardant, reinforced polyester laminate Class "B" 266 degrees F electrical sheet, meeting NEMA GPO-2 requirements.

2.9 EQUIPMENT RACKS

A. Equipment racks shall be 19 inch wide floor mounted aluminum racks with a minimum of 40 rack units height, unless otherwise indicated on the Contract Drawings. The racks shall have EIA-310D standard 1 3/4 inch spaced single side drilled, tapped mounting holes.

B. The racks base shall have a minimum depth of 15 inches, with bolt hole spacing of 12 inches minimum, front to back.

C. Racks shall be painted Benjamin Moore No. 2125-20.

D. Racks shall be equipped with screw clamp connection for grounding.

E. Racks shall be grounded to the Chassis Grounding Bussbar (CGB).

F. Cabinet shelves (both fixed and slide-out type) shall be provided as shown in the Contract Drawings.

2.10 INDOOR COMMUNICATIONS EQUIPMENT CABINETS

A. Design

1. Cabinets shall be designed for server type equipment with the following features:
   a. Continuously welded seams
   b. Gasketed front and rear doors
   c. Steel mesh or fully ventilated front and rear doors

2. Construction. The materials and construction shall be as follows:
   a. 14 gauge or heavier steel frame.
   b. 16 gauge or heavier panels.
   c. 16 gauge or heavier struts.
   d. 16 gauge mounting rails with EIA-310D rack mount standard spaced holes for equipment mounting widths of 19 inches and 23 inches.
   e. Both front and rear doors shall be removable.
   f. Locking front and rear removable doors shall be provided. All keys shall be alike and master keys shall be provided to the Authority.
   g. Communications House cabinets shall be installed on insulating sills as shown on Contract Drawings.
   h. Cabinet shelves (both fixed and slide-out type) shall be provided as shown in the Contract Drawings.

3. Finish
   a. Cabinets shall be painted Benjamin Moore No. 2125-20 "Deep Space" or as directed by the Authority. All
cabinets shall be painted identically.

b. Contractor shall finish inside of each cabinet in flat white enamel.

B. Racks shall be grounded to the Chassis Grounding Bussbar (CGB) as shown in the Contract Drawings.

2.11 MULTI-PAIR DISCONNECT MODULE TERMINAL BLOCKS

A. Design: Multi-pair disconnect module terminal blocks shall be 110 Type CAT 6 Rated or approved equal. Terminal blocks shall provide normally closed 2-piece (line side and equipment side) insulation displacement contacts in 8 to 50 pair modules, as per the application shown on the Contract Drawings. Disconnection of the line side from the equipment side shall be by insertion of a disconnect plug.

B. Performance

1. Contacts shall accept No. 20 AWG through No. 26 AWG insulated conductors.

2. Contact resistance shall be less than $1 \times 10^{-3}$ ohms.

3. Insulation resistance shall be greater than $50 \times 10^{12}$ ohms.

4. Wire retention force shall be greater than or equal to 75 percent of wire breaking force.

2.12 RTU WIRING INTERFACE

A. Contractor shall provide 2 RTU wiring interfaces at each Communication Facility. The wiring interfaces shall be Allen Bradley 40-point feed-through digital interface modules with extra terminals for inputs, type 1492-IFM40F-2.

B. Each wiring interface module (IFM) shall include the following:

1. IFMs with adhesive label cards.

2. DIN rails and mounting panel.

3. Cable management and support hardware.

C. Each wiring interface shall be mounted on the RTU cabinet rack as shown on the Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: All parts of the Specifications pertaining to miscellaneous components and products shall be installed by Contractor as specified in this paragraph, or in any other part of this Specification and in accordance with the Contract Drawings.

B. Twenty-Five Pair Connectors

1. Cable Attachment Tool: Twenty-five pair connectors that are attached to cables in the field shall be made-up utilizing a connector attachment tool Manufacturer approved.

C. Terminal Blocks

1. All connections to terminal blocks shall be made in accordance with the connection details approved as a part of FDR or installation work plan. Twisted pair jumper wire shall be utilized for cross-connections.

2. All wiring on terminal blocks shall be neatly bundled, and restrained to prevent tracing wires by pulling.

3. Tags and labels shall be utilized to identify the terminal block designation and the pair number terminated on each terminal.

4. Protected terminal blocks shall be grounded with No. 6 AWG minimum ground wire.

D. Local Distribution Frames

1. Backboard mounting in Communications Facilities.

   a. The S4S plywood backboard shall be firmly affixed to the wall in such a manner that it will adequately support the weight of all equipment and cables that are attached to it. Cable termination and management devices shall be provided and subject to Authority’s approval.

   b. Fire retardant paint shall comply with the requirements of ASTM E84 (NFPA 255) and matching Federal Standard FS-595b, Color No. 27925, (Reference NFPA 255 and NFPA 703) shall be applied to the backboard prior to installation of any equipment.
c. Floor conduit stub-ups shall be extended to 2 feet above finished floor as shown on Contract Drawing.

2. LDF and miscellaneous equipment mounting in CICs shall be as shown on Contract Drawings.

3. Wiring
   a. Each LDF shall be wired in accordance with cross-connect and wire termination plan approved as a part of FDR or installation work plan.
   b. Tags and labels shall be utilized to identify the cross-connect module designation and the pair number terminated on each quick-clip. All tag and label designations shall be transferred to the as-built drawings. Method of tagging and labeling shall be in accordance with Article 2.2 of this Section.
   c. Cables and cross-connect wiring shall be neatly bundled and restrained using Velcro ties.
   d. Distribution frame racks and protected terminal block ground wires shall be grounded to the Communications Facilities, CIC, and Crew Room Chassis Main Grounding Buss bars/Chassis Grounding Buss bars (CMGB/CGB or earth ground buss bar) with No. 6 AWG minimum ground wire as shown on Contract Drawings.

F. Internal Wiring and Cabling
   1. Internal wiring shall be installed in wiring harnesses or cable trays.
   2. Wire and cable shall be secured within ducts or open wire ways to prevent chafing movement.
   3. Strain relief shall be provided where needed.
   4. Wire or cable splices will not be permitted.
   5. All wires and cables shall be fully protected against any contact with any surface other than that designed specifically to support or protect them.
   6. Wires and cables shall be laid in place with sufficient slack at the bends so that wires and cables will clear the inside bend surface of the wire way, thereby preventing the insulation from being crushed.
   7. All wire and cable shall be free of kinks and insulation damage. Wire installation shall not be subject to accumulations of moisture or foreign matter.
   8. Wire and cable dress shall allow for sufficient slack to provide for shock and vibration induced movements, movement of sliding racks, equipment shifting, alignment, cover removal, and component replacement.
   9. Wiring and cabling dress in harness arrangements shall be tied with a high strength approved Velcro type wire-tie.
   10. All wires and cables shall be free from metal edges, bolt heads, and other interference points, and shall have electrical clearance from the covers, regardless of the insulation properties of covers or doors.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. The Work specified in this Section will not be measured separately for payment.
4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements-Communications System.”

END OF SECTION 16837
SECTION 16838
COMMUNICATIONS FACILITIES – COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Communications Facilities to be designed, provided, installed, and tested. Communications Facilities are labeled into two types. See the Contract Drawings for more details on Communications Facilities.

B. Facilities Definition

1. Communications Facility, Type I – A stand-alone structure, situated near or remote from a passenger station, that will contain all the required communications equipment to service one or more passenger stations, as shown in the Contract Drawings and as described in this Section. Communications Facilities Type I may have two versions of equipment layouts, layouts I-A and I-B as described below:

a. Communications Facility, Type I-A: This Facility is typically remote to the Stations. It shall house the entire Communications node equipment (required for wayside Communications) except for the Public Address (PA), Visual Message Board (VMB), and Fare Collection (FC) equipment. In this configuration the PA, VMB and FC equipment shall be installed in a Communications Interface Cabinet (CIC) at each Station to serve the respective subsystems. Details and layout plans are shown in the Contract Drawings.

b. Communications Facility, Type I-B: This Facility is typically installed at each Station (or within 500 Feet of the Station). It shall house the entire Communications node equipment (required for wayside Communications) including the Public Address (PA), Visual Message Board (VMB), and Fare Collection (FC) equipment serving the respective subsystems at the station. The layout of this Facility (not the structure) is similar to the Communications Facilities TYPE II described herein. Details and layout plans are shown in the Contract Drawings. Type II includes a Communications room built onto the end of a Crew Room building.

c. Communications Facility, Type II – Type II Facility shall be a room within a combined structure to be built as an integral part of a station service building. This room will contain all the required communications equipment to service one or more passenger stations, as shown in the Contract Drawings and as described in this Section.

2. Scope of Work for the Authority Light Rail Communications Facilities includes:

a. Design, provide and install Type I Facilities as described herein and shown on Contract Drawings. Each Type I-A Facility shall be a prefabricated structure of reinforced concrete panels. Each Type I-B Facility shall be constructed on site of same structural materials as the Crew Room building. Each Facility shall be complete with electrical, fire and intrusion alarm and HVAC subsystems. Facilities shall be sized as shown on the Contract Drawings.

b. Type II Facility is a room within a combined electrical/mechanical/communications structure, typically located at aerial stations. The combined structure shall be equipped with normal and emergency power system, fire alarm system and HVAC system as shown on the Contract Drawings. Contractor shall design, provide and install all required communications equipment in accordance with this Section and the Contract Drawings.

c. Communications Facilities, Type I and II equipment shall include Fiber Slack Enclosure (FSE), Fiber Distribution Panel (FDP), Local Distribution Frame (LDF), Uninterruptible Power Supply (UPS), AC Distribution Panel, grounding, static dissipative tile (SDT) floor, and Intrusion Alarm Panel as described in detail in this Section.

d. Communications Facilities, Type I and II shall be equipped with proper fire extinguishers and fire monitoring systems as described in these Specifications specifically Section 16854, "Fire Alarm Subsystem – Communications System", and herein.

1.2 REFERENCED STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI TIA-568 Commercial - Building Telecommunication Cabling Standard
2. ANSI TIA-607 Commercial - Building Grounding and Bonding Requirements for Telecommunications

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM C150 - Standard Specification for Portland Cement
   2. ASTM B3 - Standard Specification for Soft Annealed Copper Wire

C. Institute of Electrical and Electronics Engineers (IEEE)

D. International Organization of Standardization (ISO)
      a. Recommended Practices and Procedures, Quality Assurance (QA) and Quality Control (QC) National Electrical Manufacturers Association (NEMA)

E. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

F. National Electrical Manufacturers Association (NEMA)
   1. NEMA CC1 – Power Connections
   2. NEMA FB1 - Fittings, Cast metal Boxes and Conduit Bodies for Conduit and Cable Assemblies
   3. NEMA VE1 - Metallic Cable Tray Systems

G. Underwriters Laboratories, Inc. (UL)
   1. UL 467 – Grounding and Bonding
   2. UL 497 - Protectors for Paired Conductor Communication Circuits
   3. UL 969 - Marking and Labeling Systems

H. Precast / Pre-stressed Concrete Institute
   1. Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products, Latest edition

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications.

1. Manufacturer Qualifications: Any manufacturer differing from those specified herein shall require a prequalification and Authority approval. A manufacturer’s acceptability shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, and compliance with standards specified herein, and full compatibility with the Authority’s current system.

2. Preliminary Design Review (PDR) Technical Requirements
   a. Contractor shall include the following information as part of the PDR submittal package for the Communications Facilities:
      1) Drawings showing the Facility dimensions, layout (plan and elevations), and external architecture.
      2) Architectural and Construction Details, including Facility drawings.
      3) Calculations signed and sealed by a Texas Licensed Professional Engineer including structural, heating/cooling, and electrical power requirements.
      4) Grounding arrangement such as ground grid and room halo.
      5) Cable Trays and battery racks.
      6) AC and DC power distribution and lighting.
      7) Fire and Intrusion Alarm Subsystems equipment locations. Including the fire extinguisher.
      8) Cable and conduit entrance/exit details.
      9) External interface details for power connections.
      10) Plan and elevation drawings for equipment cabinets, racks and cable trays.
COMMUNICATIONS FACILITIES – COMMUNICATIONS SYSTEM

11) Product specifications for lighting, cable trays, HVAC equipment.

12) Additional product data sheets, as required for subcomponents.

13) SDT data and details.

b. Contractor shall include the following information as part of the PDR submittal package for the Type II Communications Facilities:

1) Dimension drawings, plans and elevations, showing layout of equipment.

2) AC and DC power distribution, including interface details for power connections.

3) Product specifications for all provided materials.

4) Intrusion alarm panel.

5) Product specifications for lighting, HVAC, cable trays and battery racks.

6) Cable and conduit entrance/exit Details.

7) Grounding arrangement such as ground grid, room halo, Chassis Main Ground Buss (CMGB), and Telecommunication Main Ground Buss (TMGB).

8) SDT data and details.

3. Final Design Review (FDR) Technical Requirements: Contractor shall submit 60 days after PDR approval, the following information as part of the Communications Facilities FDR submittal package:

a. Updated PDR information. All drawings, calculations and design information required for the final design.

b. Final and detailed wiring drawings ready for construction and installation.

c. Final equipment list.

d. Final equipment installation details.

e. Final cable and equipment identification.

4. Installation Work Plans: Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activity. The Installation Work Plan shall include:

a. Site Plans shall include:

1) Drawings showing plan and elevation details of the ductbank, including the manhole and foundation interface.

2) Site plans for the Communications Facilities.

b. Traffic Plan shall include:

1) Planned access dates and times for each location.

2) Traffic control procedures based on size of the facilities with proper city approvals.

3) Jobsite security.

4) Storage/staging facilities.

5) Safety rules, regulations and procedures.

6) Authority resources required.

7) Daily preparation and cleanup procedures.

c. Delivery and Installation Procedures and Inspection Sheets:

1) The procedures submitted shall include descriptions of the equipment used for transport and setting of the Communications Facility, and shall include specific dates for installation of the Facility.

2) Inspection Sheets shall be completed by the Contractor and submitted to the Authority within 7 days after installation of the Facility.

3) Contractor shall develop and submit a Traffic Control Plan for authority having jurisdiction approval.
5. Calculations and Certifications
   a. Contractor shall provide calculations as listed in the PDR and FDR. All calculations shall be signed and sealed by a Texas Licensed Professional Engineer.
   b. Certifications: Copy of the following certifications shall be included:
      1) ISO certification for all proposed manufacturers.
      2) Certificates and permits for all facilities.

6. Product Samples:
   a. Contractor shall provide sample color chips of the facilities finish coat for Authority approval.
   b. Contractor shall provide pictures and facilitate factory visit for a typical sample Communications Facility for Authority approval.

7. Test Plan and Procedures: In accordance with these Specifications, specifically with the format and requirements detailed in Section 16801, “Basic Technical Requirements – Communications System”, as a minimum, the Contractor shall submit, 60 days prior to the scheduled test, the following plan and procedures to satisfy the Communications Facilities testing requirements:
   a. Test Program Plan: Contractor shall include all the required information for the Communications Facilities in the Test Program Plan as outlined in Section 16801, “Basic Technical Requirements – Communications System”.
   b. Factory and Inspection Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article 3.2 of this Section.
   c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in Article 3.2 of this Section.
   d. End-To-End Acceptance Test: There is no requirement for End-to-End Acceptance Test.
   e. System Integration Test: Contractor shall provide qualified staff to support this test as described in Article 3.2 of this Section. System Integration Test will be directed by the Authority’s System Integration Consultant.

8. Test Records: Contractor shall submit the test records and results for review 14 days after the completion of each test, in accordance with these Specifications.

9. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the Communications Facilities and the contents. Reference Section 01785, “Project Record Documents”.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes
   1. Contractor’s design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein.
   2. All equipment and methods shall comply with the latest version of the Standards as applicable in Article 1.2, Reference Standards.

B. Material and Workmanship Requirements
   1. Contractor shall monitor the fabrication of the Facility to ensure that all structural requirements are adhered to.
   2. All equipment provided under this Section shall be UL listed.
   3. All grounding shall be in accordance with local standards, and these Specifications except as modified herein. Each piece of equipment shall be grounded in accordance with the manufacturer’s recommendation.
   4. Discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service shall not be used.
   5. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the requirements of these Specifications and Authority approval of the manufacturer’s quality ISO-9001 process.

C. Inspection: Contractor shall inspect the Communications Facility prior to shipment to site. Contractor shall notify the Authority at least 21 days prior to this inspection so that an Authority representative may attend.
2.1 TYPE I COMMUNICATIONS FACILITY

A. Structural (excludes Type 1B Crew Building add-on facility)

1. Communications Facility structure shall be fabricated from reinforced concrete panels.

2. Double sealed joints shall be utilized.

3. Walls and roof shall have the following design:
   a. Panels shall have 4 inches minimum thickness.
   b. Panels shall be reinforced with No. 4 rebar and No. 4 welded wire fabric.
   c. Design loading of roof shall be at least 150 pounds per square foot and proper sloping for drainage and loading.
   d. Design loading of walls shall be adequate for 150 mph wind.

4. The floor shall be designed as follows:
   a. Floor panels shall be 8 inches minimum thickness concrete.
   b. Panels shall be reinforced with No. 6 rebar and No. 4 welded wire fabric.
   c. Design loading shall be at least 200 pounds per square foot.

B. Architectural

1. Outside walls (excludes Type 1B Crew Building add-on facility)
   a. Outside walls shall have a uniform, smooth finish. In accordance with the Precast/Pre-stressed Concrete Institute QC Manual referenced in these Specifications.
   b. Walls shall be painted as required by these Specifications utilizing Paint Specification System No. 7. The finish coat color to match Federal Standard 595b, Color Number 20372, Sierra Tan, semi-gloss, or as directed by the Authority. Contractor shall provide sample color chips for Authority approval.

2. Inside Walls
   a. Walls shall be foam insulated to R18, minimum.
   b. A 1/2 inch layer of plywood coated with white fiberglass reinforced plastic shall be utilized as the interior finish.
   c. Studs that measure 2-inch by 4-inch nominal and placed on 16 inch centers shall be utilized to support the inside walls.

3. Flooring
   a. Flooring shall be formed of STD, 1/8 inch thick by 12 inches square, Armstrong Excelon SDT or Authority approved equivalent.
   b. STD adhesive and grounding strips, followed by the tile, shall be placed directly on the concrete floor in the manner and under the conditions recommended by the manufacturer. Tile shall be polished using the SDT polish recommended by the manufacturer. Tile color shall be submitted for Authority approval.
   c. Grounding strips to be grounded to the CMGB in accordance with tile manufacturer’s recommendations.

4. Roof
   a. Roof shall be insulated to R23, minimum.

5. Steps: Reinforced concrete steps shall be provided if the lowest point of the doorway entrance is greater than 1 foot above ground level.

C. Foundation

1. The foundation shall be a monolithic pour for grade beam and slab on ground in accordance with the Standard Drawings.

2. Structural reinforced concrete shall use Mix S-2 or Authority approved equal.

3. ASTM C150 cement shall be utilized.

4. The slab shall be reinforced as shown on the Standard Drawings.

5. At each corner of the slab, a No. 2 AWG bare solid tinned copper ground wire shall be welded to the reinforcing bars. The other end of this ground wire shall be welded to the nearest ground rod as required by these specifications.
Specifications and as shown on the Contract Drawings.

D. Ductbanks

1. Contractor shall provide a ductbank from the Communications/Signals manhole to the Communications Facility penetrations for underground conduits. Ductbank shall be reinforced concrete, Mix M-1 or Authority approved equal.

2. Contractor shall locate a plastic warning tape between the ductbank and the finished grade surface and 12 inches above ductbank.

3. Conduit spacing within the ductbanks shall be accomplished with manufactured plastic conduit spacers.

4. All conduits within ductbanks shall be Schedule 40 PVC. Where conduits transition to occupied spaces (e.g. the Communications Facility), galvanized rigid steel conduits shall be used.

5. Contractor shall submit for Authority approval, a structural drawing showing all rebar placement within each ductbank.

6. The depth of the manhole will vary from site to site. Contractor shall be responsible for the excavation of ductbank as required to interface with the manhole. Contractor shall also provide the interface with the manhole as shown on Contract Drawings.

E. Doors

1. Doors shall be a minimum of 36 inches wide and formed of 18-gauge steel with a 16-gauge steel frame.

2. Doors shall be finished in corrosion inhibiting epoxy, with Authority approved color to match structure exterior.

3. A reinforced lock plate shall be provided with each lock set. Lock sets and cylinders for the Communications Facilities shall match those installed in existing Facilities. Existing cylinders are manufactured by Abloy Security. Refer to Section 08710, "Door Hardware", for keying schedule requirements.

4. Door shall open outward and shall use stainless steel hinges with non-removable pins and vandal-resistant hardware.

5. Doors shall have a drip cap installed at the top of the outside door frame. Drip cap shall have a minimum width of 2 inches and extend past each edge of the door.

F. Address Signage: Communications Facility shall be provided with an address sign on the side of the exterior door for identification.

1. The sign shall have a white, reflective background with 3 inch black lettering. Contractor shall submit sample for Authority approval.

2.2 TYPE I COMMUNICATIONS FACILITY EQUIPMENT

A. Electrical

1. Electric power for the Communications Facility shall be obtained from either a Traction Power Substation (TPSS) or the local electrical utility as shown on Contract Drawings. Contractor shall provide and install the cable and conduit required for the main AC feed to the Communications Facility as shown on the Contract Drawings.

2. Contractor shall equip the Communications Facility with a 120/240 VAC single phase, 125 Amp panelboard. A transient voltage surge suppressor, meeting the requirement of NEC Article 280, shall be provided for the panelboard. A 125 Amp main circuit breaker shall be provided. Provide 30 branch breaker slots with a minimum of 16 breakers equipped. Breakers shall be labeled with the corresponding equipment or system circuit feeds.

3. Duplex receptacles shall be provided at intervals of approximately 6 feet along walls. Electrical boxes shall be in accordance with these Specifications.

4. Interior lighting shall utilize dual LED tube fixtures; 48 inches in length. Fixtures shall be standard T8 type to accept retrofit LED lamps.

a. The light level shall be maximized but in compliance with IECC Green Building Code requirements.

b. A 6-Hour spring-loaded wall timer light switch located adjacent to the door shall operate the fixtures.

5. Exterior lighting shall be LED and utilize E26 standard socket and type A19 or A21 LED bulbs. Exterior lighting shall be in compliance with IECC Green Building Code requirements. The light level at the Communication Facility entrance shall be a minimum of 2 foot-candles.

6. All power cable runs shall be in electrical metallic tubing (EMT) conduit and secured with single hole straps.
7. Two electrotin plated solid copper grounding buss bars, the Chassis Main Grounding Busbar (CMGB) and the Telecommunications Main Grounding Busbar (TMGB), shall be installed at a height of 18 inches, attached with insulated brackets, as required by these Specifications. Equipment, cables, racks, and cable trays, shall be grounded to these buss bars as required by these Specifications and the Contract Drawings.

8. UPS and batteries as required by these Specifications.

9. A separate 120 VAC power panel shall be provided for power output from the UPS. Main lugs rated at 225 Amp shall be provided. Thirty breaker slots shall be provided with a minimum of 12 breakers equipped. All active slots shall be labeled with the equipment to which the circuit feeds. AC power to individual equipment racks shall be individual home runs from the UPS breaker panel, and shall be enclosed in EMT conduit.

10. A Local Distribution Frame (LDF) shall be provided at the entrance way for the cable entrance conduits as shown on the Contract Drawings. The LDF shall conform to these Specifications.

11. Equipment cabinets shall be provided for and equipped complete with communication equipment as required in the Contract. Cabinets shall conform to these Specifications and Contract Drawings.

12. FSE shall be provided as shown on the Contract Drawings. Enclosure shall conform to these specifications.

13. A room halo ground ring shall be provided. The halo shall be made from No. 4 AWG bare stranded copper conductor, and be bonded to the CMGB as required by these Specifications.

14. A 120 VAC battery backup green Light Emitting Diode (LED) type exit light shall be provided and installed over the doorway. The LED lamp life shall be rated for 25 years. The battery shall be a Ni-cad type and shall have 90 minutes capacity.

B. Heating, Ventilation and Air Conditioning (HVAC): The communications Facility shall be equipped with a thermostatically controlled heater and air conditioner sized to maintain temperatures within the Facility in the range of 60 degrees F to 80 degrees F with ambient temperatures in the range specified by these Specifications.

1. The temperature within the equipment cabinets shall not exceed ambient air temperature within the Facility by more than 10 degrees F.

2. The outside of each air conditioner shall be protected with a hinged, heavy gauge, hot-dipped, galvanized vandal-resistant security mesh cage. The cage shall be constructed with a slot on the frame that, when in its closed position, will not pinch the air conditioner’s condensation drainage tube.
   
   a. The cage shall be constructed of an angle iron frame and be enclosed with 1-1/2 inch by 10-gauge steel expanded metal to form a 5-sided box.
   
   b. The cage shall be hinged to swing horizontally open to allow for 90 degrees maintenance access. Prive 2 locking hasps to hold the cage in the closed position. A mechanical device shall be provided for securing the cage in the 90 degrees opened position. Cage design shall allow for a single maintenance technician to gain access and perform any maintenance activity on the HVAC unit. An open HVAC cage shall not impede on the right-of-way.
   
   c. The cage shall be attached to the wall using tamper-proof screw/bolts with anchors cast into the concrete wall during manufacturing to ensure mounting integrity.
   
   d. The cage shall have an oversized width, additional 1-foot minimum, on the hinged right side to accommodate air conditioner maintenance.

3. An exhaust fan with manual and thermostatic control shall be provided. The thermostatic control of the exhaust fan shall prevent simultaneous operation of the fan and air conditioner compressor. The exhaust fan shall include rainhood and controlled louvers with 1/4-inch wire mesh screen. The fan shall have 1000 CFM capacity.

4. All penetrations through the concrete walls shall be sealed to prevent water from entering the Facility.

5. The HVAC system shall provide separate alarm contacts for both high and low temperature, which will be connected to the local RTU and programmed for monitoring. An LED indication shall be provided within the Facility to show when the alarm is active.

6. The HVAC system, upon a Fire Alarm condition as detected by the Facility’s Fire
and Intrusion Alarm Subsystem equipment, shall automatically and within 4 seconds, initiate actions to:

a. Shut off the air conditioning unit(s).

b. Close dampers.

7. The HVAC condensation drain tube shall be installed so that it protrudes out the bottom of the security cage and away from the foundation.

C. Cable Tray: Cable trays shall be provided in accordance with the Authority approved layout plans. Cable trays shall be as required in these Specifications and Contract Drawings.

D. Fire and Intrusion Alarm Subsystems: The Fire and Intrusion Alarm Subsystems, including Fire Extinguisher shall be installed and tested as required by these Specifications specifically Sections 16854, “Fire Alarm Subsystem – Communications System”, and Section 16855, Intrusion Alarm Subsystem – Communications System”.

E. Communications System Equipment: Additional communications system equipment such as CTS, RTU and or PA/VMB cabinets, including all related hardware integral with the cabinets, shall be installed in the Communications Facility as shown on Contract Drawings and as described in these Specifications.

2.3 TYPE II COMMUNICATIONS FACILITIES EQUIPMENT

A. Contractor shall design, provide and install the following equipment at each Type II Facility:

1. UPS and batteries as required by these Specifications.

2. A 120V AC power panel fed from the output of the above UPS. Panel shall have 30 breaker slots and be provided with a minimum of 12 breakers sized as shown on the Contract Drawing.

3. An electrotin plated solid copper grounding buss bar, the Telecommunications Main Grounding Busbar (TMGB), shall be installed at a height of 24 inches, attached with insulated brackets as required by these Specifications

4. Equipment, cables, racks, and cable trays shall be grounded as required by these Specifications and Contract Drawings.

5. A Local Distribution Frame (LDF) shall be provided at the entranceway for the cable entrance conduits as required by these Specifications and as shown on the Contract Drawings.

6. FSE shall be provided as shown on the Contract Drawings. Enclosures shall conform to these Specifications.

7. Fiber Distribution Panel (FDP) shall be provided as required by these Specifications and as shown on the Contract Drawings.

8. A room halo ground ring shall be provided. The halo shall be made from No. 4 AWG bare stranded copper conductor, and be bonded to the CMGB as required by these Specifications.

9. Cable trays shall be provided in accordance with the Authority approved room layout plans. Cable trays shall be as required by these Specifications and Contract Drawings.

10. Equipment cabinets shall be provided for and equipped complete with communication equipment as required by these Specifications and Contract Drawings.

11. Intrusion Alarm Control Panel shall be installed and tested as required by these Specifications, specifically Section 16855, “Intrusion Alarm Subsystem – Communications System”.

12. Fire detection equipment (as an integral part of the combined Facility fire detection system), including the fire extinguisher, shall be provided in accordance with these Specifications.

13. Telephones shall be installed and tested as required by these Specifications specifically Section 16851, “Telephone Subsystem – Communications System”.

14. Finish flooring shall be formed from 1/8 inch thick by 12-inch square static dissipative tile, Armstrong Excelon Static dissipative tile (SDT) or equivalent. SDT adhesive and grounding strips, followed by the tile, shall be placed directly on the concrete floor in the manner and conditions recommended by the manufacturer. Tile shall be polished using the SDT polish recommended by the manufacturer. Tile color shall be subject to Authority approval. Grounding strips to be grounded to the CMGB in accordance with tile manufacturer recommendations.

15. All exposed wiring shall be run in conduits as required by these Specifications.

16. A 120 VAC battery backup green LED type exit light shall be provided and installed over each doorway. The LED lamp life shall be rated for 25 years. The battery shall be a
NiCad type and shall have 90 minutes capacity.

17. Electrical service equipment include the following:
   a. HVAC equipment.
   b. Interior lighting.
   c. Fire Detection and Alarm system.
   d. CMGB and related grounding cables.

B. Communications System Equipment: Additional communications system equipment such as CTS, RTU and PA/VMB cabinets, including all related hardware integral with the cabinets, shall be installed in the Communications Facility as shown on Contract Drawings and as described in these Specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Foundation and Placement of the Communications Facility:
   1. Site preparation shall be as required by these Specifications.
   2. Excavation and backfill for the Communications Facility site shall be as required by these Specifications.
   3. The foundation shall be of depth and size to support the prefabricated shelter. Concrete formwork and concrete reinforcement shall be as required by these Specifications.
   4. The Facility shall be installed level and plumb on the foundation.
   5. Contractor shall provide and install a ballast skirt surrounding the Facility. The skirt material shall be consistent with the ballast used on the Authority Light Rail System as required by these Specifications and in accordance with the Standard Drawings.
   6. A ballast path shall extend from the Communications Facility door to the nearest driveway, parking area, or improved access point. The path material shall be consistent with the ballast used on the Authority Light Rail System as required by these Specifications. The ballast shall be a minimum depth of 6 inches and at least 3 feet wide, and consistent with the other wayside structures sharing the common location.

B. Cable Entrance Conduits
   1. Contractor shall install eight 4-inch schedule 40 PVC conduits from a Communication System Manhole (CSMH) to the Facility, and stubbing up through the Facility floor foundation. As the conduits enter the Communications Facility, the Contractor shall provide a matching coupling and Galvanized Rigid Steel (GRS) conduit above the floor. Contractor shall also provide an additional conduit, for ground conductors, which will pass through the slab and extend approximately 18 inches beyond the edge of the slab. These conduits shall be installed in the pattern provided on Contract Drawings and as required by these Specifications.
   2. The cable entrance conduits shall sweep into the Facility through the foundation. The sweep radius at the entrance conduits shall be greater than the minimum radius required for the fiber optic cable as required by these Specifications.
   3. The entrance conduits shall be encased in a concrete reinforced ductbank as shown on Contract Drawings and as required by these Specifications. Contractor shall provide the interface with the CSMH as shown in Contract Drawings.
   4. Contractor shall seal around the conduits with a permanent, waterproof and fire-stopper sealing compound as required by these Specifications. After all cables have been installed, the Contractor shall fill the conduit openings with fire-stopper duct sealant in order to prevent moisture from entering the Facility.
   5. The cable entrance conduits shall be as required by these Specifications.

C. Grounding
   1. Contractor shall install, as a minimum, one ground rod outside each corner of the Facility, and the connecting ground wire, as shown on Contract Drawings.
   2. Grounding shall be as required by these Specifications and the Contract Drawings.
   3. The electrical power systems shall be grounded as required by these Specifications, and as shown in the Contract Drawings.

3.2 TESTING AND INSPECTION

A. Contractor shall perform the following inspections and tests on all Communications Facilities. The Authority shall be given at least 21 days written notification prior to each test and inspection so that the Authority may be present as desired.
1. Factory Inspection (Communications Facilities, Type I only):
   a. Contractor shall provide Factory inspection procedure for Authority approval at least 21 days prior to scheduled inspection.
   b. Contractor shall inspect the Facility at the Factory for cracks and other damage, and repair as directed by the Authority.
   c. Contractor shall inspect the Facility at the Factory for level and plumb; proper operation of doors and dampers; proper location and installation of HVAC equipment breaker panels, lighting fixtures, electrical outlets, fire and intrusion sensors and equipment; cable trays, and other equipment.
   d. Inspections shall verify:
      1) Conformance to standards, methods, and quality.
      2) Correct location, positioning, seating, mounting, orientation, and labeling.
      3) Secured cable and wire connections.
      4) Proper routing and termination of wire and cable.
      5) Proper equipment grounding.
      6) Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.
      7) Conformance to installation requirements.
   e. Contractor shall, 14 days after the completion of an inspection, provide inspection results for Authority approval.

2. Field Inspection
   a. Prior to installation, the Contractor shall inspect, with an Authority Inspector the foundation, conduit stub-ups, and anchors to verify that they conform to Contract Drawings. Discrepancies shall be recorded on a discrepancy list and the Contractor shall immediately submit the list to the Authority and proceed to correct discrepancies.
   b. Field inspection shall include inspection of each installed Communications Facility. Process inspections are required.
   c. The inspection shall confirm that:
      1) The installation drawings and procedures define the installation adequately and in sufficient detail, such that if the procedures are followed, the resulting installation will meet Authority approved standards, practices and procedures for workmanship, maintainability, referenced installation standards, installation requirements, these Specifications, the Contract Drawings, and the installation requirements of local jurisdictions.
      2) Should the Authority decide that the installation drawings and procedures are inadequate; the Contractor shall revise any such drawings and procedures to the Authority’s satisfaction prior to performing installation Work.
      3) The installation drawings and procedures adequately provide for the safety of installation personnel. If not, the installation procedures shall be revised prior to performing installation Work.
   d. Inspection shall verify:
      1) Conformance to installation requirements.
      2) Conformance to standards, methods and quality.
      3) Proper routing and termination of wire and cable.
      4) Secured cable and wire connections.
      5) Proper grounding of all equipment.
      6) Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.
COMMUNICATIONS FACILITIES – COMMUNICATIONS SYSTEM

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16838
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the detailed technical requirements for the Communications Interface Cabinets (CIC) to be designed, provided, installed, and tested under this Contract. See the Contract Drawings for more details on CIC. Scope of work for the Authority Light Rail Communications System includes:

1. Designing, providing and installing CIC as indicated at locations as shown on Contract Drawings.

2. Contractor shall provide the following equipment and mount it inside the CIC: Station Controller, Public Address (PA) audio, incremental amplifiers and control equipment, Data Switch, Media Converter, fiber distribution panel (FDP), local distribution frame (LDF), local input device, pull-out shelf for laptop computer, Uninterruptible Power Supply (UPS) and power distribution equipment. Contractor shall provide all wiring including between rack equipment and terminal blocks for a complete installation.

3. Contractor shall provide termination and electrical protection for all power, indication, control, audio, and communications cables that enter the CIC.

4. Contractor shall provide Heating, Ventilation and Air Conditioning (HVAC) to maintain the temperature as specified in this Specification, under the ambient conditions specified in these Specifications.

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

1. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire

B. International Organizations for Standardization (ISO)

1. ISO 9001 - Quality Management Systems - Requirements

C. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)

D. National Electrical Manufacturers Association (NEMA)

1. NEMA FB1 - Fittings, Cast Metal Boxes and Conduit Bodies for Conduit and Cable Assemblies

2. NEMA VE1 - Metal Cable Tray Systems

E. Telecommunications Industry Association (TIA)/Electronics Industry Alliance (EIA)

1. TIA-568-C Commercial - Building Telecommunications Cabling Standard

2. TIA 607-B Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

F. Underwriters Laboratories, Inc. (UL)

1. UL 497 - Protectors for Paired Conductor Communications Circuits

2. UL 969 - Marking and Labeling Systems

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements further listed herein.

1. Manufacturer Qualifications: Any manufacturer differing from those specified herein shall require a prequalification and Authority approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, compliance with standards specified in herein, and full compatibility with Authority’s current system.

2. Preliminary Design Review (PDR) Technical Requirements

a. Contractor shall include the following information as part of the PDR subsystem package for the CIC:

   1) Drawings showing the communications interface cabinet dimensions, layout (plan and elevations).

   2) All calculations including heating/cooling and power requirements.

b. Equipment arrangement for all equipment racks, including but not limited to, side panels, LDF’s and disconnect switches (e.g. rack face elevation view).
c. Cable and conduit Entrance/Exit details including ID (tagging).

d. Grounding arrangement.

e. Intrusion switch and automatic lighting wiring.

f. Product specifications for HVAC equipment, intrusion device, LDF and switches.

g. External Interface Details for Power Connections.

3. Final Design Review (FDR) Technical Requirements: Contractor shall include the following information as part of the FDR submittal package for the CIC:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

b. Final and detailed wiring drawings ready for construction and installation.

c. Final equipment list.

d. Final equipment installation details.

e. Final cable and equipment ID.

4. Installation Work Plans

a. Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activity in accordance with these Specifications and the technical specifications. The installation Work plan shall include the following:

1) Drawings showing plan and elevation details of the foundation and the duct bank, including the interface with the manhole.

2) Site plan information shall include site-specific layout (plan and elevation) and detailed grounding drawings for each CIC.

3) Delivery and Installation Procedures and Inspection Sheets: The procedures submitted shall include descriptions of the equipment used for transport and setting of the CIC, and shall include specific dates for installation.

b) Inspection Sheets shall be completed by the Contractor and submitted to the Authority within 1 week after installation of the CIC. The report shall include details of cable terminations and equipment wiring diagrams marked-up with as-wired conditions.

5. Calculations and Certifications

a. Calculations as listed in the FDR.

b. ISO certification for all proposed manufacturers.

6. Product Samples: Product Samples shall be provided and demonstrated when required by these specifications.

7. Test Plan and Procedures: In accordance with the format and requirements described in these Specifications, as a minimum, the Contractor shall submit the following plan and procedures to satisfy the CIC testing requirements:

a. Test program plan: Contractor shall include all the required information for the CIC in the Test Program Plan as outlined in these Specifications.

b. Factory and Inspection Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article 3.2 of this Section.

c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in Article 3.2 of this Section.

d. End-To-End Acceptance Test: There is no requirement for an End-to-End Test performed on the CIC’s.

e. System Integration Test: Contractor shall provide qualified staff to support this test as described in Article 3.2 of this Section. Authority System Integration group will direct system Integration Test.

8. Test Records: Contractor shall submit the Inspection and Test Records and Results for review 14 days after the completion of each test, in accordance with format described in these Specifications.
9. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the CIC and the contents. Reference Section 01785, “Project Record Documents”.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes

1. Contractor’s design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein.

2. All equipment and methods shall comply with the latest version of the standards.

B. Material And Workmanship Requirements

1. All equipment provided under this Section shall be UL listed.

2. All grounding shall be in accordance with these Specifications, and with the recommendations of the equipment manufacturer.

3. Discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service shall not be used.

4. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process (i.e. ISO-9001).

C. Inspection

1. Contractor shall perform a pre-installation inspection for defects and verify that the CIC shall physically and dimensionally support the CIC equipment. This inspection shall take place before the CIC leaves the factory.

2. Contractor shall notify the Authority at least 21 days prior to this inspection so that the Authority representative may attend.

3. Contractor shall inspect the CIC for defects after it is installed in the field. This inspection shall verify proper installation and sealing of the CIC, and also ensure that there are no sharp edges that could pose a hazard to the public or the Authority personnel.

4. Contractor shall check that all cables and wires are properly terminated and the terminations are correctly labeled.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. Physical Characteristics:

1. The CIC shall be a custom enclosure.

2. Rated NEMA 4X.

3. Dimension: 72 inches (Wide) by 74 inches (High) by 30 inches (Deep).

4. Equipped with a BARD CT241-A04 air conditioner, or approved equal.

5. The CIC shall have 2 doors on the front side and 2 doors on the rear side.

6. Doors shall provide seal via foam-in-place gasket, and shall be hinged and equipped with a 3-point lockable handle.

7. CIC shall be fabricated from 12-gauge stainless steel.

8. LDF shall be provided within the CIC for cable termination and circuit protection in accordance with these Specification, and Contract Drawings.

9. FDP shall be provided with a minimum of 48 connections for termination of multimode fiber cables.

10. Lexan Polycarbonate panels, painted white in accordance with these Specifications, specifically Section 09970, shall be provided for mounting manual disconnect switches, LDF, and cross-connect terminal block.

11. Contractor shall install standard EIA-310D racks. Racks shall be zinc-plated steel and located so that equipment does not interfere with cable path to the LDF. Blank panels shall be provided and installed in locations where equipment is not present; as depicted in the Contract Drawings

12. Where access to rack-mounted equipment is not convenient from either the front or rear, a zinc-plated steel pullout shelf shall be provided for that equipment.

13. A zinc plated steel pull out shelf shall be provided for supporting a local VMB input device.

14. UPS support hardware shall be provided.

15. A UL approved rack-mounted power strip and light bulb holder (with light bulbs) shall be provided for each side of the CIC. The light bulbs shall be protected with a heavy-duty wire cage.
16. All cables routed within the CIC shall be organized and routed in conduit or flex tube for cable protection.

17. The inside cabinet floor shall be at least 6 inches above the concrete pad on which the cabinet is located.

18. Power line filter shall be provided for improvement in processor immunity to high frequency noise. Ferrite sleeve shall also be provided for incoming AC power cable to reduce electromagnetic field interference.

B. Painting: Internal CIC members (such as racks, channels, LDF panels) that are not stainless steel shall be painted white with corrosion inhibiting paint in accordance with Specification 09970, “Coatings for Steel”.

2.2 HVAC

A. The CIC shall be equipped with a thermostatically controlled heater, sized to maintain the CIC internal temperature above 50 degrees F with ambient temperatures as specified in these Specifications.

B. The CIC shall be equipped with an air conditioner, which shall provide cooling when the internal temperature rises above 85 degrees F. The cooling device shall be sufficient to maintain cabinet temperature below 100 degrees F, with ambient conditions as specified in these Specifications. The air conditioner condensation drain tube shall be installed so that it protrudes out the bottom of the cage and away from the CIC foundation.

C. Any vents shall include vandal resistant 12-gauge wire mesh screens and rain hoods designed to prevent horizontally driven windblown rain from entering the CIC.

D. The CIC temperature controller shall provide an adjustable high/low temperature alarm. Alarm contacts shall be hardwired to the LDF for monitoring.

2.3 CABLE ENTRANCES

A. The CIC concrete base shall be sealed with fire stop in accordance with these Specifications including around the conduits where they leave the base to stop moisture and fire.

B. The conduit/CIC joint shall be completely sealed where the conduit penetrates the CIC bottom. After all cables have been installed, conduits openings shall be filled with duct sealant in order to stop moisture and fire.

2.4 VANDAL PROTECTION AND SECURITY

A. Steel plates shall be installed as backing to the lockset or hasp.

B. Contractor shall provide locks for each CIC so as to secure the entire cabinet. The locks shall be Abloy Padlocks whose locking cylinders match those used for CIC in the existing Build-Out System. Two keys shall be provided to the Authority for each CIC prior to project closeout. Refer to Section 08710, “Door Hardware” for keying schedule requirements.

C. An exterior skirt located at the bottom of the cabinet between the cabinet floor and the concrete pad shall be provided. The skirt shall be attached with vandal resistant stainless steel fasteners, and be designed to prevent trash from blowing or being forced under the CIC.

2.5 GROUNDING

A. CIC shall be equipped with 2 copper grounding buss bars (for Chassis and Telecommunications grounding) as specified in these Specifications. Buss bars shall be located in the bottom of the cabinet and be mounted on insulators that electrically isolate the cabinet from the buss bars (see Contract Drawings).

B. The grounding buss bars shall each be bonded to a No. 4 AWG copper conductor, which shall be connected to a single point ground grid per Contract Drawings.

C. The CIC shall be equipped with a 3/8-inch high tensile strength bronze stud, which shall be connected to the Chassis grounding buss bar using a No. 6 AWG conductor per Contract Drawings.

D. Internal chassis grounding arrangement shall utilize No. 6 AWG insulated, stranded ground wire connected to the Chassis Grounding Buss Bar (CGB) per Contract Drawings.

E. Ground wire from the station AC supply panel shall be grounded to the CGB using No. 6 AWG ground wire per Contract Drawings.

F. Protected Terminal Block ground shall be connected to the CGB using No. 6 AWG ground wire per Contract Drawings.

G. All electronic equipment signal and telecommunications grounds shall be grounded, using No. 10 AWG insulated stranded copper conductors, to the Telecommunications Grounding Buss Bar (TGB) per Contract Drawings.

H. Shields from signal cables shall be grounded to the TGB in accordance and Contract Drawings.

I. Grounding not described above shall be in accordance with these Specifications.

2.6 TERMINAL BLOCKS

A. Terminal blocks and Protected Terminal Blocks (PTB’s) shall be as specified in these Specifications.
B. Terminal block and PTB types and pair counts shall be in accordance with the approved Contract Drawings.

2.7 **CIC CABINET LIGHTS AND INTRUSION ALARM**

A. Contractor shall provide an interior cabinet light on each side of the CIC enclosure. Each light shall turn on when the corresponding door is opened and turn off when it is closed.

B. Contractor shall provide a simple intrusion detection circuit that shall utilize magnetic switches and be activated when any panel door is opened. Dual dry alarm contacts shall be wired to the LDF, cross-connected and terminated at the Communications Remote Terminal Unit (RTU), and reported to the Operation Control Center (OCC) via the Communications Transmission Subsystem (CTS) and Supervisory Control System (SCS).

**PART 3 - EXECUTION**

3.1 **INSTALLATION**

A. CIC shall be installed at locations in stations as indicated on the Contract Drawings

B. CIC Mounting

1. Prior to mounting the CIC the Contractor shall verify that the CIC foundation, conduit stub-ups and anchors are correctly configured as per the approved design.

2. Contractor shall install the CIC level and plumb on the CIC manufacturer’s provided support feet. Contractor shall verify that all parts of the CIC (including open doors) are outside the dynamic envelope of the trains.

3. Plants, foliage, or other impediments shall be placed at least 8 feet away from the installed Communications Interface Cabinet.

4. Contractor shall provide a 3-foot wide concrete skirt around the CIC.

5. After all cables have been installed and terminated, the Contractor shall fill the conduit openings with an Authority approved fire stop duct sealant to prevent fire and moisture from entering the CIC.

6. Contractor shall seal the bottom of the CIC, where the conduits penetrate, with an Authority approved sealant to stop fire and moisture.

C. Cable Termination: Cables shall be dressed, tagged and terminated in accordance with these Specifications.

D. All grounding and cable wiring shall be field installed, labeled, and tested for continuity.

E. All equipment shall be installed according to Contract Drawings and manufacturer’s requirements.

F. Terminal blocks, PTB’s and cross-connects shall be mounted to internal panels and shall be arranged as shown on the Authority approved Contract Drawings. Equipment layout and mounting shall be done such that Terminal block, and PTB equipment shall not be impeded or obstructed by other equipment and shall allow technicians to make moves, adds, and changes with ease.

G. Contractor shall make all CIC equipment and LDF/terminal block connections, including all cross-connections, as shown on the Contract Drawings.

H. All connections and cross-connections shall use required wire in accordance with these Specifications, and the Authority approved Contract Drawings.

I. CIC AC power shall be conditioned by an UPS, capable of maintaining backup power to all AC-powered CIC equipment, for no less than 1 hour under full load of all connected devices.

J. Power strips with no less than 8 receptacles shall be installed in each rack within the CIC to provide UPS power to rack-mounted equipment.

K. Power strip shall be installed in accordance with Contract Drawings and oriented to provide the highest density of receptacles to the rear of rack-mounted equipment.

L. Contractor shall install a clear plastic document pouch attached to the inside door frame containing a detailed parts list inventory of all equipment contained in the CIC and as-built drawings or diagrams showing equipment interconnections, wiring, power connections, and equipment configurations.

M. Once installation is complete, Contractor shall remove any disposable installation materials including empty equipment containers, wrappers, wire fragments, or other items and thoroughly clean enclosure of dirt, dust, and all other contaminants.

3.2 **TESTING AND INSPECTION**

A. Contractor shall perform the following inspections and tests on CIC’s, where applicable. The Authority shall be given at least 21 days written notification prior to each test and inspection so that the Authority may be present as desired.

B. Contractor shall provide testing and inspection submittals 45 days prior to each scheduled work for Authority approval.

C. Contractor shall provide Authority with each test or inspection report within 14 days after each test or inspection.

1. Factory Test and Inspection:
a. Contractor shall inspect the CIC at the Factory for cracks and other damage, and repair as required.

b. Contractor shall inspect the CIC at the Factory for level and plumb, proper operation of doors and locks, proper location and installation of HVAC equipment, and other miscellaneous equipment.

c. Inspections shall verify:
   1) Conformance to standards, methods, and quality.
   2) Correct location, positioning, seating, mounting, orientation, and labeling.
   3) Secured internal cable and wire connections.
   4) Proper routing and termination of internal wire and cable.
   5) Proper grounding of all equipment.
   6) Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.
   7) Conformance to installation requirements.
   8) Conformance to inventory data.

d. Contractor shall provide inspection results for the Authority approval.

2. Field Inspection

a. Prior to installation, the Contractor shall inspect the CIC foundation, conduit stub-ups and anchors to verify that they conform to Contract Drawings. Discrepancies shall be corrected prior to commencement.

b. Field inspection shall include inspection of the CIC including lighting fixtures, intrusion sensors, equipment racks.

c. The inspection of the CIC installation shall confirm that:
   1) The installation drawings and procedures define the installation adequately and in sufficient detail, such that if the procedures are followed, the resulting installation shall meet approved standards, practices and procedures for workmanship, maintainability requirements, referenced installation standards, installation requirements defined within these Specifications and the Contract Drawings, and the installation requirements of local jurisdictions. If not, the installation drawings and procedures shall be revised prior to subsequent installations.

2) The installation drawings and procedures adequately provide for the safety of installation personnel. If not, the installation procedures shall be revised prior to subsequent installations.

3) Inspections of subsequent communications interface cabinet installation shall ensure that drawings and procedures are met.

4) Inspection shall verify:
   a) Conformance to installation requirements.
   b) Conformance to standards, methods and quality.
   c) Proper routing and termination of wire and cable.
   d) Secured cable and wire connections.
   e) Proper grounding of all equipment.
   f) Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment

3. Field Tests and Records

a. Contractor shall perform the following field tests:
   1) Test the electrical continuity of the connections within the CIC by measuring the resistance from the line side to the equipment side for each
2) Verify operation of main circuit breaker and all feeder circuit breakers.

3) Measure resistance to ground from all ground points, including those located in equipment cabinets. Measured resistance shall not exceed 3 ohms (see “Grounding and Bonding-Communications”.

4) Verify operation of all lighting.

5) Verify operation of HVAC equipment, including heaters, air conditioner, and all thermostatic controls.

6) Verify operation and reporting of all CIC alarm indications both locally and at the Communications RTU terminal block.

7) Verify operation of all equipment controls and indicators.

8) Verify that all cables and wires are labeled properly and all color codes have been observed.

9) Contractor shall provide records of all electrical tests for Authority approval.

4. End-To-End Acceptance test: End-To-End testing shall be a part of other subsystem testing.

5. System Integration Test: Contractor shall provide qualified technical staff to support this test as directed by the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 "Basic Technical Requirements - Communications System.”

END OF SECTION 16839
PART 1 - GENERAL

1.1 DESCRIPTION

A. To provide and install the internal and external single and multi-pair copper conductor cables required for the communications subsystems.

1.2 REFERENCED STANDARDS

A. Contractor’s design and installation shall comply with the latest editions of all applicable Standards and Codes included herein. Contractor shall be familiar with and adhere to the latest editions of these codes, regulations, specifications and standards. Work shall meet or exceed the standards and procedures specified.

1. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   a. ASTM B 3 - Standard Specification for Soft or Annealed Copper Wire
   b. ASTM D 470 – Standard Test Methods for Crosslinked Insulations and Jackets for Wire and Cable
   d. ASTM D 4101 - Standard Specification for Polypropylene Injection and Extrusion Materials
   e. ASTM E 662 - Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
   f. ASTM E 814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops

2. Insulated Cable Engineers Association (ICEA)
   a. ICEA S-84-608-2002 – Filled Telecommunications Cable, Polyolefin, Insulated, Copper Conductor

3. Military Standards (MS)
   a. MIL-C-24643 - Cable Assembly, Aircraft Electrical Service

4. National Fire Protection Association (NFPA)
   a. NFPA 70 - National Electric Code (hereinafter referred to as NEC)
   c. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

5. Occupational Safety and Health Administration
   a. 29 CFR 1910 – Occupational Safety and Health Standards
   b. 29 CFR 1926 – Safety and Health Regulations for Construction
      1) 29 CFR 1926 Subpart P - Excavations

6. Telecommunications Industry Association (TIA)/Electronics Industry Alliance (EIA):
   a. TIA-758-B - Customer-owned Outside Plant Telecommunications Infrastructure Standard
   b. TIA-568-C - Commercial Building Telecommunications Cabling Standard
   c. TIA-569-C - Commercial Building Standard for Telecommunications Pathways and Spaces.
   d. TIA/EIA-606-B - Administration Standard for Telecommunications Infrastructure of Commercial Buildings
   e. TIA-607-B - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises.

7. Underwriters Laboratories (UL)
   a. UL 444 - Communications Cables
   b. UL 1581 - Reference Standard for Electrical Wire, Cable, and Flexible Cords
c. UL 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

d. UL 1690 - Data-Processing Cable

8. United States Department of Agriculture, Rural Utilities Service (RUS)


b. 7 CFR 1755.390, RUS Specification for Filled Telephone Cables


1.3 SUBMITTALS

A. Manufacturer Information: Contractor shall submit information for each proposed manufacturer describing relevant experience in manufacturing optical cable for rapid transit and railroad applications and quality assurance program and warranty.

B. Preliminary Design Review (PDR) Technical Requirements

1. Cable Product Data: Submit cable product data, including the following:

a. Cable cut sheets or shop drawings.

b. Certificates of Compliance confirming that wire and cable provided meets or exceeds the requirements of these Specifications.

2. Cable Terminations: Submit product data and cable termination details, including the following:

a. Ring-type solder-less wire terminals.

b. Crimping tools.

c. Calibration certifications for crimping tools.

C. Final Design Review (FDR) Technical Requirements. Contractor shall include the following information as part of the Final Design Review (FDR) Technical Requirements submittal package for the Communications Cables:

1. Updated PDR information for drawings, calculations and design information shall reflect a final design.

D. Installation Work Plans and Detailed Documentation. In accordance with these specifications, the Contract Drawings, and this Section submit as part of the Installation Plan cable installation details, including the following:

1. Pulling layout including distances and tension calculations, for each section of installation.

2. Pulling equipment and tension monitoring devices.

3. Procedures and materials for terminating the cable and preparing it for connection to the termination points.

4. Cable labeling including ID scheme, ID of each cable, and location of each tag.

5. Proposed installation procedures including:

a. Hardware.

b. Attachment.

c. Routing.

d. Conduit fill.

e. Pull locations and equipment.

6. Proposed cable splicing procedures including:

a. Material.

b. Equipment.

c. Testing.

7. Chronological plan for installing cable, including estimated time for each pull and plan for protecting cable on-reel and in slack loops during installation. Where staging of cable is required (e.g., UPRR crossing warning systems), identify details.

8. Contractor shall submit 1 original plus 10 copies of the projected loads and voltage drop calculations and optical loss calculations.

9. Contractor shall provide to the Authority 1 original plus 10 copies of the cable manufacturer's instructions and procedures for potheading of each type underground cable to be provided.
10. The manufacturer shall supply 1 original plus 10 copies of instructions for splicing for each type of cable specified. The instructions shall be forwarded with the certified test results for each reel of cable. The instructions shall specify the exact nature of splicing materials to be employed, and the manner they are to be spliced.

11. Conduit and Cable Schedule.

12. Cable Entrance Sealant - Add fire stop prior to filling with foam sealant.

E. Certifications. Submit cable qualification data, including the following:

1. Listing of Railroads and Transit Authority Customers: Provide a list of names of 5 railroads and transit properties to which the manufacturer has provided cables similar to those required by these Specifications.

2. Cable Manufacturer's Quality Plan.

3. Cable Manufacturer Qualification Report.

4. Insulation Qualification Test Documentation.

F. Contractor shall, provide to the Authority sample specimens in 1200 mm (4 foot) lengths similar to that which the manufacturers propose to provide for each type cable specified herein. The sample specimens shall remain the property of the Authority.

G. Test Plan, Procedures, and Results

1. Cable Production and Factory Test Documentation: Submit cable production test documentation, including certified test results indicating clear indication of pass/fail criteria and cable performance.

2. Submit test reports verifying compliance with field-testing requirements, per Part 3 requirements, within 14 days of completion of each test.

3. Submit cable installation details, including the following:
   a. Pull Tension Calculations, and the actual pull tension during the cable installation showing the maximum pulling tension limits are not exceeded.
   b. Update Conduit and Cable Schedule.
   c. Conduit and Mandrel Report.

H. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings including cable routing, termination details, connection diagrams, cable labeling and cable schedules. Reference Section 01785, “Project Record Documents”.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes.

B. Cable Flammability, Toxicity, and Smoke Characteristics.
   a. Low smoke, halogen-free, jacketed cables shall be utilized for all applications required by code.
   b. Communications cables specified herein shall meet the following flammability requirements:
      1) As a minimum, all communications cable shall meet UL 1581 vertical tray test and shall be type CM listed with Underwriters Laboratories. Type CMR, or CMP may be used as substitutes.
      2) Cables used in a riser environment shall meet UL 1666 flame test and shall be CMR listed with UL. Type CMP may be used as a substitute.
      3) Plenum rated cable shall be used when cable is installed in an air plenum environment. The cable shall meet NFPA 262-2002 and shall be type CMP listed with UL.

C. Material and Workmanship Requirements: Material and workmanship of all cables specified in this section shall be consistent with the following requirements:

1. Life expectancy of the cable shall be 40 years in a railroad and transit environment.

2. Cable shall be constructed for continuous operation at 90 degrees Celsius, in a wet or dry environment.

3. Conductor to conductor and conductor to ground resistance shall be equal or greater than 1 meg-ohm (1MΩ).

4. Cable shall be constructed for continuous operation at negative 40 degrees F without cracking or becoming brittle.
D. Manufacturer Pre-Qualification Requirements:
Any manufacturer differing from those specified herein shall require a prequalification and Authority approval. Manufacturer acceptability shall be based on the manufacturer’s experience, qualifications, certifications such as ISO-9001, equipment reliability, and compliance with standards specified herein, and full compatibility with the Authority’s existing system.

PART 2 - PRODUCTS

2.1 CONTRACTOR FURNISHED MATERIALS

A. Telephone, Public Address (PA), Visual Message Board (VMB), and Data Cable

1. Local inside facility distribution of low-level voice circuits shall, at a minimum, be by standard Category 6 cable.

2. Wire conductors shall be composed of soft or annealed copper, meeting insulating, sensitivity and elongation requirements of ASTM B3, latest edition.

3. The insulation shall be colored virgin propylene copolymer meeting the requirements of ASTM D4101, or equivalent, for propylene plastic. High molecular weight polyethylene is also acceptable.

4. Insulated conductors shall be in twisted pairs. Each pair shall be individually colored. The average length of pair twist shall not exceed 6 inches. To minimize noise and crosstalk, each pair of a multi-pair cable shall have a different average length of twist from any other pair in the cable.

5. Inside wire (wiring run within any building) from telephone terminals to telephone instruments shall be No. 22 AWG and meet Category 6 Specification TIA 568.C.2. Cable shall be low smoke and non-toxic.

6. All main riser cables shall be No. 22 AWG and shall meet RUS Specifications 7 CFR 1755.890. RUS Specification 7 CFR 1755.390 cables shall not be used as a substitute for 7 CFR 1755.890 cables.

7. All main and riser paired cables shall be shielded.

8. No cable shall contain less than twelve pairs unless otherwise indicated in the Contract Drawings and shall have at least 50 percent spare pairs. In addition to the requirements listed herein, all cables shall meet the requirements of NEC and NFPA 130 latest editions and shall be manufactured to telephone industry standards.

B. Low-Smoke Jacket

1. Telephone, Supervisory Control and Data Acquisition (SCADA) I/O or data cable entering from an outside environment exceeding 50 feet in length inside a facility shall be low smoke.

2. Low-smoke jacket material for cables shall be flame retardant cross-linked polyolefin, as Authority approved. The jacket thickness shall be 60 mils minimum.

3. Jacket material shall meet or exceed the following specifications:
   a. Tensile Strength (ASTM D470) 1100 psi minimum
   b. Elongation (ASTM D470) 200 percent minimum
   c. Tear Strength (ASTM D470) 7 lb/inch minimum
   d. Oxygen Index (ASTM D2863) 27 minimum
   e. Smoke Density (ASTM E662)
      1) Flaming Mode Ds 4 minute 50 minimum
      2) Flaming Mode Dm 20 minute 175 minimum
      3) Non-flaming Mode Ds 4 minute 65 minimum
      4) Non-flaming Mode Ds 20 minute 300 minimum
   f. Smoke Index (MTL-DTL-32180) 25 minimum
   g. Halogen Content (MTL-DTL-32180) 0.2 percent minimum
   h. Toxicity Index (MTL-DTL-32180) 8.0 minimum
   i. Acid Gas Equiv. (MTL-DTL-32180) 2.0 percent minimum
   j. Ozone Resistance (ASTM D470) Pass (150 ppm at 25C)

4. All outside communications cables (e.g. those run in conduits, trough or duct-banks) shall be foam/skin insulated conductors that meet RUS Specification
COMMUNICATIONS CABLE – COMMUNICATIONS SYSTEM

7CFR 1755.890 and shall be protected using armor taping or approved equivalent.

2.2 PUBLIC ADDRESS CABLE
A. Contractor shall provide and install loudspeaker wiring for connection of all speakers at all stations. Loudspeaker cables shall be twisted pairs, foil-shielded, and stranded No. 14 AWG minimum.
B. Local distribution cables for the PA System shall be placed in separate conduit or raceways from low-level voice and data circuits. Cable jacket shall have a 600-volt rating.
C. Contractor shall provide and install cable for connection of all ambient sensing microphones. Cable shall be No. 18 AWG, shielded twisted pairs.
D. All grounding conductors for public address cables shall be insulated.

2.3 DATA CABLE
A. RS-232D Data Communications Cable
   1. Serial data cables used for RS-232 applications shall meet the following characteristics:
      a. Jacket: NEC CL2P, Low Smoke
      b. Wires: Uniquely Color Coded
      c. Cable Type: Twisted pair
      d. Conductor gauge: No. 24 AWG (7 X 32 AWG) stranded, minimum.
      e. Shield: 1 overall foil shield, with a braided shield minimum.
      f. Capacitance: 12 pf/feet
      g. Resistance: 30 ohms/1000 feet
      h. Conductors: 6 to 12-1/2 pairs

2.4 RS-422 DATA COMMUNICATIONS CABLE
A. Serial data cables used for RS-422 balanced electrical transmission of data shall have a 600-volt insulation rating and meet the following characteristics:
   1. Jacket: NEC CL2P, Low Smoke
   2. Wires: Uniquely Color Coded
   3. Cable Type: Twisted Pair
   4. Conductor gauge: No. 24 AWG (7 X 32 AWG) stranded, minimum.
   5. Shield: Individually foil shielded pairs each with a drain wire. One overall foil shield, with a braided shield minimum.
   6. Capacitance: 13 pf/feet
   7. Resistance: 16 ohms/1000 feet
   8. Conductors: 2 to 12 pairs

2.5 T1 DATA COMMUNICATIONS CABLE
A. The cable for connection of DSX-1 compatible signals shall be Western Electric type ABAM or approved equivalent.
B. The cable shall also meet the following requirements:
   1. Jacket: NEC CMR, Low Smoke
   2. Wires: Conforms to PIC color code.
   3. Cable Type: Twisted Pair
   4. Conductor gauge: Solid annealed
   5. Shield: Individually shielded pairs each with a drain wire.
   6. Characteristic Impedance: 100 ohms @ 772 KHz
   7. Average mutual capacitance: 90 nf/mi.
   8. Conductors: Two pair per T1 connection.

2.6 OUTDOOR TELEPHONE, SCADA I/O AND DATA CABLE
A. Contractor shall provide, install and terminate outdoor telephone and I/O data cabling as indicated in the Contract Drawings.
B. The multi-pair No. 22 AWG, filled cable shall conform to RUS Specification 7 CFR 1755.890 except as noted herein.
C. The conductors shall be solid annealed bare copper conforming to the latest requirements of ASTM-B-3.
   1. Conductors shall be individually insulated with a colored, solid insulating grade, high density-polyethylene or polyolefin of ICEA S-56-434.
2. The insulating material color shall be coded per U.S. telephone industry standards with color concentrates chosen for permanency and electrical balance of individual circuits. The colors of insulated conductors shall be provided in accordance with ICEA S56-434, Section II-7 and shall comply with the requirements of EIA TIA-359.

3. The insulated conductors shall be twisted into pairs. The length of pair twists shall be designed to meet ICEA S45-434 latest edition.

4. The average twist length of any pair in the finished cable shall not exceed 6 inches.

5. The insulated pairs shall be twisted into specified color combinations to provide pair identification as well as low susceptibility to noise pick-up and with varying lay lengths to minimize crosstalk.

6. The insulated pairs shall be assembled into a cable core. Cable cores of 25 or less pairs shall be assembled concentrically.

D. The filling compound, a petroleum jelly base multicomponent, shall be applied to the cable core in such a way as to provide as near to 100 percent fill of the available air space within the core is commercially practicable. The filling compound shall be applied in a manner to fill all voids and conductor interstices under the core to restrict the migration of moisture. The filling compound shall be compatible with the insulation and other cable components.

E. The filled core shall be completely covered with a layer of non-hygroscopic, non-wicking polymeric tape applied with overlap over the cable core to ensure high dielectric strength from cable core to shield.

F. A 0.008-inch thick corrugated aluminum tape shall be applied over the core. The tape shall be coated with a 0.002-inch thick copolymer compound and shall be applied longitudinally with overlap.

G. The outer jacket shall be of virgin, black high molecular weight polyethylene copolymer except low-smoke jacketed cables that shall be as specified below. The overall jacket shall be sequentially marked at 2-foot intervals with cable type, year of mfg., footage, pair count, conductor size and manufacturer. The jacket shall be free from holes, splits, blisters or other imperfections and shall be smooth and concentric.

PART 3 - EXECUTION

3. INSTALLATION

A. Field Installation

1. Contractor shall inspect cables at time of delivery to the construction site to assure that no damage was done in shipping and that the specified cable was received. Contractor shall inspect every reel for physical damage such as nails driven into reels to secure shipping blocks, lagging, or reel covering missing and cable and seals missing or damaged. A copy of these inspection reports shall be submitted to the Authority. Contractor shall replace all damaged or rejected cables promptly, at no cost to the Authority.

2. Wires and cables shall be stored on solid surfaces that shall adequately support the cable reels, but which shall be well drained and not allow accumulation of liquids, oils, or chemicals.

3. The cable reels shall be aligned and protection provided so as not to allow the reel flanges to damage other reels. Adequate aisles and barricades shall provide accessibility but prevent construction equipment from damaging the cable reels.

4. Cable ends shall be resealed promptly when a length is cut from the reel. Cable reels shall be properly handled, i.e., by using a sling and spreader attached to a shaft through the reel hubs, or by cradling both flanges between lift truck forks. The reels shall not be lifted by the top reel flange or dropped from any height. Lift truck forks shall not touch cable surfaces on the reel. Reels shall always be rolled in the direction opposite the cable wind on the reel. Reels shall not be laid flat.

5. Contractor shall verify that the installation design is correct and adequate for the cables to be installed. Contractor shall assure that conduit size, conduit fill, conduit bend radii, manhole spacing, manhole size, raceways, ducts, and associated hardware are proper for the intended installation.

6. Contractor shall be responsible for verifying the required cable length for each cable run prior to installation. Civil stationings appearing on referenced drawings may be used for defining locations and estimating cable lengths. However, no existing drawings shall be used to determine final lengths and cuts. Actual lengths shall be determined by
making on-site inspections and measurements.

7. Wires and cables shall be continuous without splices between junction boxes, terminals, pull boxes, manholes and hand holes. Cables shall not be bent to a radius less than the greater of 20 times the diameter of the cable or the manufacturers’ recommended minimum bending radius, during installation or as finally installed.

8. Develop a written cable installation procedure and check-off list for approval prior to cable installation. This procedure shall be prepared based on Contractor’s review of the conduit plans, and field site survey and shall include a cable plan and installation information for each cable pull. The installation plan shall include proper procedures for feeding cable into conduit, to maintain proper bend radii, and to minimize friction.

9. Contractor shall give the Authority at least 48 hours notice prior to installing cables.

10. Install cable per the approved installation and cable plan. Contractor shall provide any installation hardware required to route, support, terminate, or protect any cable installation.

11. Crimp-on connectors or lugs shall not be used on solid conductors.

12. Provide additional conduit as required to access equipment enclosures or apparatus.

13. Contractor shall provide sufficient slack in cable conductors at all terminating points to enable 3 re-terminations of each conductor without re-servicing or re-potheating the cable.

14. In certain types of installation, the cable cannot be constrained; therefore, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

15. Tags to identify cables shall be of plastic material. Tags shall be lettered to correspond with the cable destination and number of pairs in the cable.

16. All cables shall be terminated in order according to the color code. Individual cable pairs shall be identified at each cable termination with plastic tags. All spare pairs in each cable shall be terminated and identified. Cable tags shall be placed on all cables at termination points and 1 label applied to each cable at manholes, pull-boxes, junction boxes, and similar facilities.

17. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E814. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct-bank. All spare conduits shall be sealed or plugged in an approved manner.

18. Where cable transfers from trays or troughs to conduit the ends of the conduit shall be fitted with plastic end bells to prevent damage to the cable.

19. Wherever cables are terminated the outer sheath of the cable shall be carefully removed to the point of cable entrance. At the end of the cable sheath or covering, 2 layers of plastic electrical tape shall be applied.

20. OSHA’s "Confined Spaces" procedures shall be followed in all installation activities.

B. Contractor shall install wayside cables in the buried duct-bank, trough, and conduit currently in place along the right-of-way.

1. Contractor shall review civil segment Referenced Drawings, and verify that all ducts are correctly configured for Work to be performed, stub-ups are in the proper locations, and conduits are free of obstruction and/or extraneous material. During the installation, if Work areas are exposed to heavy equipment, the Contractor shall take appropriate actions to protect exposed sections, covering such areas with heavy steel plate or other suitable material. Cable/express trough shall remain with lids installed during the times when Work not performed.

2. Contractor shall utilize only installers who are qualified and experienced in handling and installing underground cable in conduit. Experienced supervision shall be provided to ensure that all required precautions are taken and that the installation is in accordance with the requirements of this Section.

3. Contractor shall install wires and cables in accordance with cable handling and pulling practice as defined by the cable manufacturer’s recommendations.
4. Contractor shall establish the maximum allowable length of cable, which may be safely pulled into each conduit after obtaining the wire and cable manufacturer’s recommendations regarding pulling limits for the cables. Consideration shall be given to the following parameters - fill, friction, clearance, configuration, jam ratio of the cables and conduit, weight correction factor, bend radii, training of the cables on entering and exiting the conduits, maximum allowable tension, sidewall load, and weight of the cables. These factors shall be calculated for each pull as required and Contractor shall not exceed the maximum allowable values of sidewall pressure, pulling strain on conductors or sheath, limits of pulling device and pulling tension. If the pulling tension for any cable exceeds the maximum allowable, that cable shall be removed and replaced with new cable. Calculations shall be signed, sealed and dated by a Texas Licensed Professional Engineer.

5. Pulling tensions shall be calculated by Contractor from both directions to determine which will be easier and result in less pulling tension on the cable. The lower tension direction shall be utilized. Calculations shall be signed, sealed and dated by a Texas Licensed Professional Engineer.

6. Proper procedures for feeding cable into the conduit shall be established by Contractor. Feed-in tubes, sheaves, cable reel jacks, and other required tools required to provide proper bending radii and minimal friction during installation shall be used. Direction or training of the cables on entering and exiting the conduit shall coincide with other parts of the installation arrangement so that the cable is not damaged or over-stressed.

7. Contractor shall use only the wire and cable manufacturer's approved pulling compound or lubricant compatible with the cable. The lubricant shall be used in ample quantity to reduce friction and applied in such a manner that the cable is lubricated throughout the entire length being pulled through the conduit.

8. Cables installed in manholes and pull boxes shall not interfere with the future use of or access to unused conduit.

9. Cables shall be mounted and dressed on cable racks. Where the provided racking is not sufficient to properly support and dress the cable, the Contractor shall supply and install additional racks, matching those already installed to complete cable installation.

10. All exposed wires and cables entering or leaving all equipment housings, junction boxes, and cable transition points shall be protected from abrasion. Chase nipples and/or split ring plastic grommets shall be provided in drilled or punched openings in equipment housings and junction boxes.

11. The installation shall be in accordance with Contractor's approved installation procedure and check-off list which shall include the following considerations:

a. Spare wires and cables shall be installed at the same time that the active wires and cables are being installed.

b. The cables shall not be pulled through manholes.

c. Cables shall not be pulled into a conduit that already contains conductors. If it becomes required to remove a cable from a conduit, all cables in that conduit shall be removed. Cable removed from conduit shall not be used elsewhere. Cable removed from conduit shall be reinstalled under the Authority's direction. The restoration of all functions supported by the removed and reinstalled cables shall be the responsibility of the Contractor and under the Authority direction.

d. Two-way communication between pulling and feed ends shall be established before and during the installation.

e. In pulling cable, an approved wire cable grip extending not less than 18 inches back from the end of the cable shall be used. The clutch on the pulling device shall be set to slip at 50 percent of the weight per 1,000 feet of the cable to be pulled. The equipment used for pulling cable shall be equipped with a dynamometer, which shall indicate the pulling force in pounds.

f. Pulling shall be done at a constant velocity between 15 and 50 feet per minute. The pull shall not be stopped once started unless absolutely required.

g. Crossovers and kinks shall be avoided at feed end.

h. Cable shall be protected after installation and prior to terminating or splicing.
COMMUNICATIONS CABLE – COMMUNICATIONS SYSTEM

i. After pulling, the tension end of the cable damaged in the pulling process shall be cut off.

j. All cables shall be identified.

k. The cable installation in manholes and pull boxes shall not interfere with the future use of or access to unused conduit.

12. Each existing conduit to be used for cable installation shall be blown or swabbed dry to ensure cleanliness, rodded and mandreled to ensure no obstructions and to minimize chafing. Each new conduit shall be mandreled in accordance with these specifications.

13. Cables shall be placed in the duct identified to the Contractor by the Contract Drawings. All cables to be placed in 1 duct shall be installed simultaneously. Extreme care shall be used in installing cables so as to avoid twisting, kinking, or in any way injuring the cable or its sheath.

14. When required, the Contractor shall pump water out of manholes, cable pits, and pull chambers before installing any cables and shall be responsible for maintaining manholes and pull chambers in a dry condition while the cables are being pulled.

15. Cable installation in conduit shall not exceed 40 percent fill per conduit, unless otherwise allowed by the Authority.

16. Cables installed in manholes shall be properly constrained and fastened to the walls of the manhole in accordance with the approved installation drawings.

C. Non-Buried Installation

1. Routing of wires and cables in the Train Control Center (TCC), signals, Traction Power Substation (TPSS) and communications facilities shall be within Contractor-provided cable trays.

2. Cable installed in trays or troughs shall be laid loosely, neatly and with a minimum of crossovers, and not pulled into place. They shall have a minimum amount of crossover and shall not be pulled tightly around bends.

3. Cabling between racks or cabinets shall be routed via the overhead cable trays, with 1 foot of slack between the cable tray and each rack to which the cable is connected. Cables shall be secured to the last strap of the cable tray before transitioning to equipment racks or cabinets.

4. Where transfers of cable from trays to conduit occur, conduit ends shall be fitted with plastic end bells to prevent damage to cable.

5. Cable identification tags shall be installed at each termination.

6. Installation in Conduit or Pipe

a. Contractor shall have all communications conduits, including the Authority provided conduits inspected, mandreled, swabbed, and cleaned prior to cable installation. Manholes shall be cleaned and the location of pulling eyes shall be determined.

b. Contractor-provided conduits shall have a clean, smooth concentric interior surface. Conduits shall be painted to match the color of the column or wall on which they attached.

c. Crossover of cables shall be avoided when cables are pulled into conduits. Care shall be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes. All cables to be installed in a single conduit shall be pulled and installed simultaneously.

d. Special Protection: Contractor shall provide required special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. Cables damaged due to Contractor's neglect while installing cables shall be replaced by the Contractor at no additional cost to the Contract.

e. Multi-Pair Cables: Multi-pair cables shall be continuous without splices, between termination locations. Termination locations shall be located within indoor communication interface cabinets (CIC) and wayside equipment enclosures, as shown on the Contract Drawings. No terminations of any kind shall be acceptable at other locations, except as Authority approved.

1) The shield of each section of communication cable shall be electrically
continuous between terminations on terminal blocks. Each section of communications cable shall have its shield grounded at the terminal block location at one end of the cable section only. The shield shall be grounded with the use of tin plated brass shield connectors and No. 6 AWG insulated ground wire, in a manner as recommended by the cable manufacturer. The shield connectors shall be compatible with the cable’s aluminum binder tape. The ground wire shall be connected to the terminal block housing ground grid.

2) Pairs shall be maintained intact, and shall terminate in order following the color code. Cable pairs from different pair units shall not occupy the same line terminal block.

3.2 TESTING

A. Contractor shall present to the Authority, for approval, a cable test plan showing the tests to be made and the limiting values to be used.

B. Contractor shall provide test or inspection procedures for Authority approval, 45 days prior to each scheduled test or inspection.

C. Contractor shall provide test or inspection records within 14 days after each test or inspection.

D. Factory Tests

1. Conductor insulation shall be tested per RUS Specification 7 CFR 1755 Bulletin 1753F-201 (PC-4) for the following:
   a. Minimum Tensile Strength 2400 lb./sq. inch minimum
   b. Ultimate Elongation 300 percent minimum
   c. Maximum Shrink-back 3/8 inch minimum

2. The jacket material shall be tested per RUS Specification 7 CFR 1755 Bulletin 1753F-201 (PC-4) for the following:
   a. Minimum Tensile Strength 1700 lb./sq. inch minimum
   b. Ultimate Elongation 400 percent minimum
   c. Environmental Stress Cracking 20 percent maximum
   d. Maximum Shrink-back 5 percent minimum
   e. Impact Failure 20 percent maximum

3. The provided multi-pair shall be tested per RUS Specification 7 CFR 1755 Bulletin 1753F-201 (PC-4) for the following:
   a. Mutual Capacitance: 0.083+0.004 uF/mi.
   b. Mutual Capacitance Deviation: 3 percent RMS maximum
   c. Pair-to-Pair Capacitance Unbalance: 25 pF/1000 feet max (RMS).
   d. Pair-to-Ground Unbalance (maximum): 800 pF/1000 feet max.
   e. Pair-to-Ground Unbalance (average): 175 pF/1000 feet max.
   f. Equal Level Far End Crosstalk (150 kHz): 63 db/kft minimum
   g. Near End Crosstalk (772 kHz): 47 db/kft minimum
   h. Insulation Resistance: 1000 meg-ohm per mile.
   i. Maximum Conductor Resistance (at 20C): 91 ohms/mi.
   j. Maximum Average Attenuation (772 Hz at 20C): 4.5 dB/mi.
   k. High Voltage Test (3 seconds. between conductors): 3600V DC
   l. High Voltage Test (3 seconds. between conductors and shield) 10,000V DC
   m. Cable Bend Test: No Shield Cracks

E. Field Tests

1. Insulation Resistance Tests
   a. Tests shall be performed on all cables entering or leaving houses, after the cables are terminated.
b. Disconnect external apparatus prior to performing the test.

c. Contractor shall verify conductor-to-ground resistance.

d. Contractor shall verify conductor-to-conductor resistance for each pair.

e. Record all data on an approved test form.

2. Attenuation, S/N, Peak-To-Average Tests: Utilize transmission impairment measurement sets to determine the 1000 Hz attenuation, signal to noise ratio, and peak to average ratio.

3. DC Loop Resistance Test

4. Utilize Volt OHM Meter (VOM) to measure DC loop resistance of each cable pair.

F. End-To-End Test: Tests shall be performed end-to-end on all cables where the cables enter or leave cases, communication houses or other facilities.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16841
PART 1 - GENERAL

1.1 DESCRIPTION

A. Contractor shall design, provide and install a complete fiber optic cable subsystem as specified herein, and as shown on the Contract Documents.

1. Contractor shall provide, install, splice, terminate and test Fiber Optic cable in accordance with the Contract Documents.

2. Scope of Work for the portion of the work where the Authority provides fiber optic cable does not include Factory Tests; however, additional Authority approved tests shall be required for the Contractor to take possession of the cables.

B. Ancillary Devices

1. Additional equipment to be provided with the fiber optic cable shall include the following:
   a. Fiber Slack Enclosures (FSE)
   b. Fiber Distribution Panels (FDP)
   c. Optical patch cords
   d. Pigtails
   e. Splices
   f. Attenuators (as required)
   g. Field splice and connector kits
   h. Media converters
   i. Wire pulling lubricant

1.2 REFERENCED STANDARDS

A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

1. ASTM D1248 - Standard Specification for Polyethylene Plastic Extrusion Material for Wire and Cable

2. ASTM E814 - Standard Test Method for Fire Tests of Through - Penetration Fire Stops

B. Electronic Industries Alliance (EIA)/Telecommunication Industry Association (TIA)

1. TIA/EIA 455-25-C, FOTP-25 - Impact Testing of Fiber Optic Cables

2. TIA/EIA 455-3-A, FOTP-3 - Standard Test Procedure for Fiber Optic Fibers, Transducers, Sensors, Connecting and Terminating Devices and other Fiber Optic Components

3. TIA - 455-3-A, FOTP-3 - Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components

4. TIA - 455-13-A, FOTP-13 - Visual and Mechanical Inspection of Fiber Optic Components Devices and Assemblies

5. TIA - 455-33-A, FOTP-33-B - Fiber Optic Cable Tensile Loading and Bending Test

6. TIA/EIA 455-37-A, FOTP-37 - Low or High Temperature Bend Test for Fiber Optic Cable

7. TIA/EIA 455-41-A, FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables

8. TIA - 455-78-B, FOTP-78-B - Optical Fibers: Measurement Methods and Test Procedures - Attenuation

9. TIA/EIA 455-81-B, FOTP-81 - Compound Flow (Drip) Test for Filled Fiber Optic Cable

10. TIA - 455-82-B, FOTP-82 - Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable

11. TIA/EIA 455-85-A, FOTP-85 - Fiber Optic Cable Twist Test

12. TIA/EIA 455-88, FOTP-88 - Fiber Optic Cable Bend Test

13. TIA - 455-91, FOTP-91 - Fiber Optic Cable Twist-Bend Test

14. TIA - 455-104-A, FOTP-104 - Fiber Optic Cable Cyclic Flexing Test


FIBER OPTIC CABLE SUBSYSTEM - COMMUNICATIONS SYSTEM

18. TIA-472C000-B, Standard for Optical Fiber Premises Distribution Cable
19. TIA/EIA 455-181, FOTP-181 - Lighting Damage Susceptibility Test for Optic Cables with Metallic Components
20. TIA/EIA 492-AAAA-A, Detail Specification for 62.5-µm Core Diameter/125 µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers
21. TIA 492-CAAB - Detail Specification for Class IVa Dispersion - Unshifted Singlemode Optical Fibers with Low Water Peak
22. TIA-526-7 - OFSTP-7 Measurement of Optical Power Loss of Installed Singlemode Fiber Cable Plant
23. TIA-526-14-A, OFSTP-14 - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
24. TIA-568-B.1-3 - Commercial Building Telecommunications Cabling Standard
25. TIA-598-B - Optical Fiber Cables Color Coding
26. TIA/EIA-606 - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

C. Institute of Electrical and Electronic Engineers (IEEE)
   1. IEEE 802.3u - Supplement to Local and Metropolitan Area Networks Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100 Mb/s Operation, Type 100BASE-T (Clauses 21 - 30)-Supplement to ISO/IEC 8802-3:1993 (ANSI/IEEE 802.3, 1993 Edition)

D. Insulated Cable Engineers Association (ICEA)
   1. ICEA S-87-640-2011 - Standard for Optical Fiber Outside Plant Communications Cable

E. International Organization for Standards (ISO)
   1. ISO 9001 - Quality Management Systems - Requirements

F. National Electric Manufacturers Association (NEMA)
   1. NEMA Standards Publication 250, Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)
   2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces

H. Occupational Safety and Health Administration (OSHA)
   1. 29 CFR 1910 - Occupational Safety and Health Standards
   2. 29 CFR 1926 - Safety and Health Regulations for Construction

I. Underwriters’ Laboratories, Inc. (UL)
   1. UL 910 - Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
   2. UL 1581 - Reference Standard for Electrical Wires, Cables, and Flexible Cords
   3. UL 1666 - Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
   4. UL 2024 - Standard for Optical Fiber and Communication Cable Raceway

J. United States Department of Agriculture (USDA)
   1. USDA Rural Utilities Service (RUS) 7 CFR 1755.900

K. Telcordia
   1. Telcordia GR-196-CORE - Generic Requirements for OTDR-type Equipment
   2. Telcordia SR-4731 - Special Requirements for Optical Time Domain Reflectometer (OTDR) Data Format

1.3 SUBMITTALS

A. Qualifications:
   1. Manufacturer Information:
      a. Contractor shall submit information for each proposed manufacturer describing relevant experience in manufacturing optical cable and quality assurance program and warranty.
2. Installer Information:
   a. Submittal shall demonstrate previous successful experience in installation and testing of fiber optic cable specified herein.
   b. Submittal shall include a list of 3 recently completed projects of similar type and size with contact names and telephone numbers for each.


1. Product Technical Data: Contractor shall submit complete technical data for the cable and all ancillary devices he proposes to provide. The data submitted shall demonstrate compliance with all properties specified herein:
   a. Performance data and descriptions of all products shall be submitted for the List of Proposed Products and Materials submittal.
   b. As a minimum the following shall be provided: manufacturer model number, UL listing or rating, critical dimensions and mounting arrangement, technical specifications, and replacement parts list.

2. Complete end-to-end fiber optic subsystem splice and termination diagrams.

3. Equipment enclosures, panels, and material shop drawings including description and model numbers of all fiber splice and termination distribution equipment to be installed.


1. Contractor shall include the following information as part of the Final Design Review (FDR) Technical Requirements submittal package for the fiber optic subsystem:
   a. Update the PDR information, including drawings. Information shall include location specific final designs.

D. Product samples: Contractor shall submit 2 samples (4 feet long) for each one of the proposed cables for Authority approval.

E. Authority Provided Cable Acceptance Tests: Acceptance tests shall be performed on the Authority provided outside plant singlemode cable prior to the release of the cable from the Authority. Contractor shall submit the following:

   1. Procedures shall be submitted within 120 days after NTP.
   2. Certified copies of test results in accordance with the reporting requirements of Article 3.2 shall be submitted within 14 days after test completion for Authority approval.
      b. A certification by the Contractor of acceptability of the Authority provided cable for installation. For rejected cables, the Contractor shall submit justification for the rejection of the cable based on both visual inspection and test results.

F. Cable Factory Tests: Factory tests shall be performed in accordance with TIA/EIA-455-B and Article 3.2 of this Specification. Contractor shall submit the following:

   1. Test procedures shall be submitted 30 days prior to any scheduled test.
   2. Results with reporting requirements of Article 3.2 of this Specification shall be submitted within 14 days of test completion for authority approval.
      a. Optical Time Domain Reflectometer (OTDR) (1310/1550/1625 nm singlemode and 850/1310 nm multimode).
      b. Chromatic Dispersion (singlemode only).
      c. Attenuation in dB/km.

3. Contractor shall submit a certification statement confirming compliance with all mechanical testing requirements of these specifications.

G. Cable Field Tests: Field tests shall be performed in accordance with TIA/EIA-455-B and Article 3.2 of this Section. Contractor shall submit the following:

   1. Test procedures, 60 days prior to any scheduled test.
   2. Results in with reporting requirements of Paragraph 3.2.A through 3.2.D within 14 days after test completion for Authority approval:
a. Attenuation in dB/km for all terminated fibers
b. Optical Time Domain Reflectometer (OTDR) Testing

H. Installation Plan: Contractor shall submit, at least 60 days prior to installing cable, the following information for each segment of cable to be installed:

1. Pulling layout, including distances and tension calculations, for each section of installation.
2. Pulling equipment and tension monitoring devices.
3. Chronological plan for installing cable, including estimated time for each pull and plan for protecting cable on-reel and in slack loops during installation.
4. Contractor shall submit link budget calculations showing all intended links to be used by the submitted media conversion devices as required by Article 2.3 of this Section. This link budget will be used to compare and qualify actual loss measurements to acceptable loss measurements for pass/fail evaluation.

I. Termination Procedures: Contractor shall submit, prior to installing cable, the following information:

1. Procedure for terminating cable within the FDP, including fusion splicing of pigtails.
2. Fusion splice equipment description.
3. Splice and termination testing procedure.

J. Test Records. Contractor shall provide all test records within 14 days after completion of each test for Authority approval.

1.4 QUALITY ASSURANCE

A. Contractor’s materials, design, installation, and testing shall comply with all applicable Standards included herein. Contractor shall be familiar with and adhere to the latest editions of these codes, regulations, specifications and standards. Work shall meet or exceed the standards and procedures specified.

B. In the event of conflicts between reference standards, the most stringent provisions shall apply to the Work of this Section.

C. Manufacturer Pre-Qualification Requirements

1. Cable manufacturers and Contractors shall be Authority approved. Contractor shall provide all data required for Authority evaluation and shall make the arrangements for any required demonstrations and tests. Such compliance shall promote a thoroughly tested and properly installed cable subsystem.

2. Qualifications shall be based on the following criteria:

a. Past Performance and Experience: Cable manufacturers shall demonstrate previous successful experience in supplying, testing and installation of fiber optic cable specified herein.

b. Quality Assurance Program:

1) The manufacturer of cables, in accordance with the requirements of these Technical Specifications, is required to have in place or implement, an effective quality assurance program adhering to the requirements of ISO 9001 to ensure purchase control performance.

2) The cable manufacturer shall be ISO 9001 certified and Contractor is to submit ISO 9001 Certification Number.

c. Warranty

1) The manufacturer shall warrant that the design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with the established, and generally accepted, standards for fiber optic cable for transit applications; and that each such item and every part and component thereof shall comply with these Specifications.

2) Contractor shall monitor the manufacturers of the cable to assure that the approved Quality Assurance Program is being closely adhered to and that the fiber optic cable is being manufactured in accordance with these Technical Specifications.
3) If the cable supplier is not the manufacturer of the fiber, the fiber manufacturer shall be identified.

D. Point of Origin: The cable and the fibers shall be American-made.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Packing - Cable shall be shipped on non-returnable wooden reels. The diameter of the drum shall be at least 20 times the diameter of the cable. Cable shall be shipped on reels substantial to withstand reasonable handling and shall be so designed that the inner end of the cable be accessible, but protected from injury. All ends of the cable shall be sealed to prevent entrance of moisture and securely fastened to prevent them from becoming loose during transit.

B. Marking - Each reel shall contain on the outside flange, the following information:

1. Manufacturer's name.
2. Contract name and number.
3. Cable identification number.
4. Cable length.
5. Date of manufacture.
6. Copy of the factory test results.

PART 2 - PRODUCTS

2.1 FIBER OPTIC CABLE

A. General

1. The life expectancy of the cable shall be no less than 25 years for service in a railroad and transit environment.

2. The cable shall be designed for installation in underground conduit, wet or dry environments, including alternating wet and dry conditions.

3. All fiber optic cable run in conduits or duct banks shall be listed with USDA Rural Utilities Service (RUS) 7 CFR 1755.900 and meet the requirements of ICEA S-87-640-2011.

4. The number of fiber cable strands are noted on the Contract Drawings. A minimum of 50 percent spare fibers shall be provided.

B. Outside Plant (OSP) Cable

1. All OSP fiber optic cable shall be certified to meet applicable tests of TIA-455, but as a minimum shall meet the following:

a. When tested in accordance with TIA 455-3-A, FOTP-3, the change in attenuation at extreme operational temperatures (negative 40 degrees F and 185 degrees F) shall not exceed 0.15 dB/km at 1550 nm for singlemode cable and shall not exceed 0.30 dB/km at 1300 nm for multimode cable.

b. When tested in accordance with TIA-455-82-B, FOTP-82, a 1-meter length of unaged cable shall withstand a 1-meter static head or equivalent continuous pressure of water for 1 hour without leakage through the open cable end.

c. When tested in accordance with TIA/EIA 455-81-B, FOTP-81, the cable shall exhibit no flow (drip or leak) of filling and/or flooding material at 158 degrees F.

d. When tested in accordance with TIA/EIA 455-41-A, FOTP-41, the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of the sample. The 220 N/cm (125 lbf/in) load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm (63 lbf/in). Alternatively, it is acceptable to remove the 220 N/cm (125 lbf/in) load entirely and apply the 110 N/cm (63 lbf/in) load within 5 minutes at a rate of 2.5 mm (0.1 in) per minute. The 110 N/cm (63 lbf/in) load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm (63 lbf/in) load. The change in attenuation shall not exceed 0.15 dB/km at 1550 nm and 0.30 dB/km at 1300 nm for multimode cable.

e. When tested in accordance with TIA-455-104-A, FOTP-104, the cable shall withstand a minimum compressive load of 220 N/cm (125 lbf/in) applied uniformly over the length of the sample. The 220 N/cm (125 lbf/in) load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of 1 minute. The load shall then be decreased to 110 N/cm (63 lbf/in). Alternatively, it is acceptable to remove the 220 N/cm (125 lbf/in) load entirely and apply the 110 N/cm (63 lbf/in) load within 5 minutes at a rate of 2.5 mm (0.1 in) per minute. The 110 N/cm (63 lbf/in) load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm (63 lbf/in) load. The change in attenuation shall not exceed 0.15 dB/km at 1550 nm and 0.30 dB/km at 1300 nm for multimode cable.
f. When tested in accordance with TIA/EIA 455-25-C, FOTP-25, except that the number of cycles shall be 2 at 3 locations along a 1-meter cable length and the impact energy shall be at least 4.4 Nm (in accordance with ICEA S-87-640). The change in attenuation shall not exceed 0.15 dB/km at 1550 nm and 0.30 dB/km at 1300 nm for multimode cable.

g. When tested in accordance with TIA 455-33-A, FOTP-33-B, using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a rated tensile load of 2670N (601 lbf) and residual load of 30 percent of the rated installation load. The axial fiber strain shall be less than or equal to 60 percent of the fiber proof level after completion of 60 minute conditioning and while the cable is under the rated installation load. The axial fiber strain shall be less than or equal to 20 percent of the fiber proof level after completion of 10 minute conditioning and while the cable is under the residual load. The change in attenuation at residual load and after load removal shall not exceed 0.15 dB/km at 1550 nm and 0.30 dB/km at 1300 nm for multimode cable.

h. When tested in accordance with TIA/EIA 455-85-A, FOTP-85-A, a length of cable no greater than 2 meters shall withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.15 dB/km at 1550 nm and 0.30 dB/km at 1300 nm for multimode cable.

i. When tested in accordance with TIA/EIA 455-181, FOTP-181, the cable shall withstand a simulated lightning strike with a peak value of the current pulse equal to 105 kA without loss of fiber continuity. A damped oscillatory test current shall be used with a maximum time-to-peak value of 15 μs (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz. The time to 1/2 value of the waveform envelope shall be from 40 to 70 μs.

j. When tested in accordance with TIA/EIA 455-37-A, FOTP-37, the cable shall withstand 4 full turns around a mandrel of less than or equal to 20 times the cable diameter after conditioning for 4 hours at test temperatures of negative 22 degrees F and 140 degrees. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears, or other openings. The change in attenuation shall not exceed 0.15 dB/km at 1550 nm and 0.30 dB/km at 1300 nm for multimode cable.

2. Construction

a. Optical fibers shall be placed inside a loose buffer tube. The nominal outer diameter of the buffer tube shall be either 2.5 mm or 3.0 mm. Each buffer tube shall contain up to 12 fibers. The fibers shall not adhere to the inside of the buffer tube. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrink-back requirements of USDA RUS 7 CFR 1755.900.

b. Each fiber shall be distinguishable by means of color-coding in accordance with TIA-598-C. The fibers shall be colored with ultraviolet (UV) curable inks.

c. Buffer tubes containing fibers shall be color-coded with distinct and recognizable colors in accordance with TIA-598-C. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1.0 mm. In buffer tubes containing multiple fibers, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.

d. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes. In dual layer cables, any fillers shall be placed in the inner layer. Fillers shall be nominally 2.5 mm or 3.0 mm in outer diameter.

e. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to provide tensile strength and prevent buckling. The central member shall be over coated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/fillers.
FIBER OPTIC CABLE SUBSYSTEM - COMMUNICATIONS SYSTEM

f. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents. Buffer tubes shall be stranded around the dielectric central member using the reverse oscillation, or “S-Z”, stranding process. Water swellable yarn(s) shall be applied longitudinally along the central member during stranding.

g. Two polyester yarn binders shall be applied contra-helically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.

h. For single layer cables, a water swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.

i. For dual layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a 2 layer core. A water swellable tape shall be applied longitudinally over both the inner and outer layer. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.

j. Cables shall contain 2 ripcords under the steel armor for easy armor removal. Additionally, armored cables that have an inner sheath shall also contain 1 ripcord under the inner sheath.

k. Tensile strength shall be provided by the central member, and additional dielectric yarns as required. The dielectric yarns shall be helically stranded evenly around the cable core.

l. Cables shall have an inner sheath of Medium Density Polyethylene (MDPE). The minimum nominal jacket thickness of the inner sheath shall be 1.0 mm. The inner jacket shall be applied directly over the tensile strength members (as required) and water swellable tape. A water swellable tape shall be applied longitudinally around the outside of the inner jacket. The armor shall be a corrugated steel tape, plastic-coated on both sides for corrosion resistance, and shall be applied around the outside of the water blocking tape with an overlapping seam with the corrugations in register. The outer jacket shall be applied over the corrugated steel tape armor. The outer jacket shall be a MDPE with a minimum nominal jacket thickness of 1.4 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.

m. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C Category 4 and Grades J4, E7 and E8. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metal elements and shall be of a consistent thickness.

n. The outer surface of the jacket of each shipping length of cable shall be permanently identified by printing (in a contrasting color) descriptive information on the outer surface of the jacket at intervals of 1500 mm (5 feet) or less. The information shall include identification (Authority Communications System), country of origin (made in), count of fibers, fiber type, date of manufacturing (month and year), manufacturer's part number, manufacturer's name, sequential meter or foot markings, a telecommunication handset symbol as required by NESC Section 350G, fiber count, and fiber type. The actual length of the cable shall be within plus or minus 0 to 1 percent of the length markings. The print color shall be white, with the exception that cable jackets containing 1 or more co-extruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5 mm.

o. If the initial marking fails to meet the specified requirements, i.e., improper text statement, color, legibility, or print interval, the cable may be remarked using a contrasting alternate color. The numbering sequence shall differ from the previous numbering sequence, and a tag shall be
attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking color shall be yellow, with the secondary choice being blue.

p. Size and construction shall recognize the nature of fiber optic cables regarding installation, especially at manholes. Allowance for such fiber characteristics shall be made in cable pull budgets.

q. The fiber colors shall meet the centroid colors and tolerances as specified in TIA/EIA-598. Since TIA/EIA-598 is specified for opaque colors, local injection/detection (LID) compatible inks, which are translucent, shall make the best fit with the centroid colors. Fiber coloring shall be compatible with LID systems.

3. Singlemode Optical Fiber Characteristics. Singlemode (Dispersion Un-shifted) with Low Water Peak fiber utilized in the optical fiber cable shall meet TIA-492-CAAB, and ITU recommendation G.652.C. These fibers shall have the same specified performance and geometry values as noted below.

a. All fibers shall be usable fibers and shall meet the following requirements:

1) Fiber and cable protective coverings shall be continuous with no factory splices.

2) All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet optical, mechanical and environmental requirements of this Specification.

3) The attenuation specification shall be a maximum value for each cabled fiber at 23 within plus or minus 73.4 degrees F on the original shipping reel.

b. Glass Composition: SiO$_2$, which may include small amounts of germanium (Ge), fluorine (F), or phosphorous (P) to control the index of refraction or to assist in fiber manufacture.

c. Operational Wavelength: 1310 nm, 1550 nm, and 1625 nm.

d. Cutoff Wavelength: Less than 1260 nm.

e. Maximum Optical Attenuation:

1) At 1310 nm: Less than or equal to 0.35 dB/km at 73 degrees F

2) At 1383 within plus or minus 3 nm: Less than or equal to 0.35 dB/km at 73 degrees F

3) At 1550 nm: Less than or equal to 0.2 dB/km at 73 degrees F

4) At 1625 nm: Less than or equal to 0.23 dB/km at 73 degrees F

f. Attenuation vs. Wavelength

1) $\lambda_{ref} = 1310; 1285 \leq \lambda \leq 1330; \Delta = 0.03$ dB/km

2) $\lambda_{ref} = 1550; 1525 \leq \lambda \leq 1575; \Delta = 0.02$ dB/km

g. Water Peak Attenuation: At 1383 within plus or minus 3 nm; less than or equal to 2.1 dB/km.

h. Fiber Macro-bend

1) 1 Turn at 32 within plus or minus 2mm; less than or equal to 0.10 dB at 1550 nm

2) 100 Turns at 50 within plus or minus 2mm; less than or equal to 0.05 dB at 1310 nm

3) 100 Turns at 50 within plus or minus 2mm; less than or equal to 0.05 dB at 1550 nm

4) 100 Turns at 60 within plus or minus 2mm; less than or equal to 0.10 dB at 1625 nm

5) 100 Turns at 50 within plus or minus 2mm; less than or equal to 0.05 dB at 1625 nm

i. Point Discontinuity: No point discontinuities greater than 0.05 dB at either 1310 nm or 1550 nm.
j. Total Optical Dispersion
   1) At 1285-1330 nm: Less than or equal to 3.5 ps/(nm·km)
   2) At 1550 nm: Less than or equal to 18 ps/(nm·km)
   3) At 1625 nm: Less than or equal to 22 ps/(nm·km)

k. Zero Dispersion Slope: Less than or equal to 0.089 ps/(km·nm²).


m. Maximum Polarized Mode Dispersion: less than or equal to 0.5 ps/(km)½.

n. IEEE 802.3 GbE - 1300 nm Laser Distance: Up to 5000 m.

o. Fiber Core Diameter: 8.3 µm nominal.

p. Fiber Coating Diameter: 245 µm within plus or minus 5 µm.

q. Coating-Cladding Concentricity: Less than 12 µm.

r. Colored Fiber Nominal Diameter: 253-259 µm.

s. Coating Strip Force
   1) Dry: 0.6 lbs
   2) Wet: 0.6 lbs

t. Fiber Curl Radius of Curvature: Greater than 4.0 m.

u. Fiber Cladding Diameter: 125.0 µm within plus or minus 0.7 µm.

v. Cladding Non-circularity: Less than or equal to 0.7 percent.

w. Core/Cladding Concentricity: Less than or equal to 0.5 µm.

x. Mode Field Diameter
   1) 1310 nm: 9.2 within plus or minus 0.4 µm
   2) 1550 nm: 10.4 within plus or minus 0.5 µm

y. Effective Group Index of Refraction
   1) 1310 nm: -77 dB
   2) 1550 nm: -82 dB

z. Refractive Index Difference: 0.3 within plus or minus 0.0011 percent.

4. Multimode Optical Fiber Characteristics. Multimode fibers shall meet TIA/EIA-492-AAAA-A "Detail Specification for 62.5-µm Core Diameter/125-µm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibers." These fibers shall have the same specified performance and geometry values as noted below:

a. All fibers in the cable shall be usable and meet required specifications.

b. Each optical fiber shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this Specification.

c. Each optical fiber shall consist of a germanium-doped silica core surrounded by a concentric glass cladding. The fiber shall be a matched clad design.

d. The attenuation specification shall be a maximum value for each cabled fiber at 23 within plus or minus 41 degrees F on the original shipping reel.

e. Geometry
   1) Core Diameter 62.5 within plus or minus 3.0 µm
   2) Core Non-Circularity less than or equal to 5 percent
   3) Cladding Diameter 125.0 within plus or minus 2.0 µm
   4) Cladding Non-Circularity less than or equal to 2.0 percent
   5) Core-to-Cladding Concentricity less than or equal to 3.0 µm
   6) Coating Diameter 245 within plus or minus 5 µm
   7) Colored Fiber Nominal Diameter 253 to 259 µm
f. Optical

1) Cabled Fiber Attenuation
   a) 850 nm less than or equal to 3.5 dB/km
   b) 1300 nm less than or equal to 1.0 dB/km

2) Point discontinuity
   a) 850 nm less than or equal to 0.2 dB
   b) 1300 nm less than or equal to 0.2 dB

3) Macro-bend Attenuation
   a) Turns - 100; Mandrel OD -75 within plus or minus 2 mm, less than 0.5 dB at 850 nm
   b) Turns - 100; Mandrel OD - 75 within plus or minus 2 mm less than 0.5 dB at 1300 nm

4) Cabled Effective Modal Bandwidth
   a) 850 nm, greater than 385 MHz•km

5) IEEE 802.3 GbE Distance
   a) 1000BASE-SX Window (850 nm), up to 500 m
   b) 1000BASE-LX Window (1300 nm), up to 1000 m

6) OFL Bandwidth
   a) 850 nm, greater than 200 MHz•km
   b) 1300 nm, greater than 500 MHz•km

7) Numerical Aperture 0.275 within plus or minus 0.015

5. Mechanical Specifications:

   a. Each optical fiber shall be proof tested by the fiber manufacturer at a minimum of 100 kpsi (0.7 GN/m2).
   b. The fiber shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
   c. Crush Resistance: 10 kN/m (685 lb/ft) length of cable.
   d. Cable Outside Diameter: Less than 0.65 inch.
   e. Weight per 1000 linear foot:
      1) Less than 160 lbs.
   f. Minimum Bending Radius
      1) Installation, 15X Diameter
      2) Static, 12X Diameter
   g. Temperature: Operational
      1) Negative 22 degrees F to 140 degrees F
      2) Continuous operation at negative 22 degrees F without cracking or becoming brittle
   h. Storage: Negative 40 degrees F to 158 degrees F on reel.
   i. Humidity: 0 to 100 percent, inclusive
   j. Tensile Strength
      1) Installation: 2,700 N (600 lbf)
      2) Static: 890 N (200 lbf)

2.2 FIBER CONNECTORS

A. FDP connectors shall be SC type, unless otherwise directed.

B. Connectors for media converter equipment shall be SC type. Jumper cables shall be provided that match the connectors at each end of the cable.

C. Optical parameters of the connectors shall meet the requirements of TIA/EIA-568.

D. Singlemode connectors shall be Ultra Physical Contact (UPC) factory polished. Typical optical return loss for UPC polish is 50 dB.
E. Multimode connectors shall be Physical Contact (PC) factory polished. Typical optical return loss for PC polish is 30 dB.

2.3 MEDIA CONVERTER

A. LAN media converters shall convert the 10/100 BASE-T/TX ports of the ADM Ethernet module at stations to 10 BASE-FL and 100 BASE-FX to the attached devices for media transmission. Contractor shall install and test these media converters.

B. Media converters shall be installed in a rack mounted card cage in CICs, and Communications Facility equipment cabinets. At Signals Houses and Traction Power Substations (TPSS), media converters shall be mounted separately on shelves as shown on Contract Documents. The converters shall comply with the following requirements:

1. 10/100 BASE-T/TX to 10 BASE-FL Converter
   a. Interfaces: RJ-45 to SC singlemode optical
   b. Minimum power link budget 16 dB over singlemode cable at 1310 nm operating optical wavelength
   c. Protocol Compatibility: 10 Base-T, 100 Base-TX, and 10 Base-FL standards
   d. 802.3u compliant auto-negotiation
   e. Operating Distance: 100 m for 10/100 Base-T/TX, 15 km for 10 Base-FL
   f. Data Flow: Half or Full Duplex Support
   g. LEDs: Power, Link, Transmit, Receive
   h. Store and forward switching mode. Data packet forwarding and filtering at a minimum of 148,000 pps at 100 Mbps or 14,880 at 10 Mbps
   i. Automatic address learning and aging
   j. Input power requirement as shown on Contract Documents.

2. 10/100 BASE-T/TX to 100 BASE-FX Converter
   a. Interfaces: 100 Base-TX (RJ-45), 100 Base-FX (SC)

b. Protocol Compatibility: IEEE 802u 100 Base-TX and 100 Base-FX Standards

c. Operating Distance: 100 m for 100 Base-TX, 2 km for 100 Base-FX MM, 15 km for 100 Base-FX SM

d. Data Flow: Half or Full Duplex Support

e. LEDs: Power, Link, Transmit, Receive

f. Fiber Requirements: Multimode, and singlemode fiber cabling with SC connectors

3. Contractor shall submit link budget calculations showing all intended links to be used by the submitted media conversion device. In addition to all fiber, splice, component aging, and connector losses, the calculation shall yield a minimum of 6 db of margin over the specified worst-case budget of the conversion device.

2.4 FIBER SLACK ENCLOSURES

A. Enclosure
   1. Enclosures shall be NEMA-12 type with hinged cover and securing mechanism.

2. Enclosures shall be sized for 300 feet of cable slack.

B. Hardware
   1. Hooks shall be provided to hold cable slack, with coils of required bend radius.

2. Velcro ties to restrain cable shall be utilized.

2.5 FIBER DISTRIBUTION PANELS

A. Enclosure
   1. The enclosure shall house the splice shelf and connector sleeve panels for all optical connections. As a minimum, the enclosure shall be capable of providing connections for all singlemode and multimode fibers and in accordance with the Contract Documents.

2. All OSP cable jackets and central strength members shall be secured to relieve strain.

B. Distribution Panels
   1. Distribution panels shall be a complete system of components by a single manufacturer.
2. Rack mountable connector housings shall be available for cross-connecting or interconnecting purposes. The units shall provide for direct connectorization and pigtail splicing.

3. Housings shall be mountable in an EIA-310 compatible 18.3 inch rack.

4. The unit shall meet the design requirements of TIA-568.

5. Molded plastic parts shall meet the flammability requirements of UL 94 V-0.

6. The connector housings shall have a labeling scheme that complies with TIA/EIA-606. The housing shall incorporate labeling via an adhesive backed label and a retractable sliding label panel that pulls out from the bottom front of the housing.

7. Housings shall be manufactured using 16-gauge aluminum and shall be finished with a two-tone gunmetal grey and/or anodized silver for durability. Installation fasteners shall be included and shall be black in color.

8. The unit shall be capable of connectorization and jumper management. The unit shall be capable of splicing or combination connectorization/splicing with the use of an additional splice tray kit.

9. Fiber Cable Routing: The unit shall have a fiber routing guide platform located in the rear of the housing. The fiber routing guide platform shall be removable using 2 plunger style latches so that room can be made for an optional splice tray kit.

10. Jumper Routing
   a. The unit shall have a hinged top jumper management panel capable of locking in the horizontal or vertical position. When the top panel is locked in the horizontal position, it shall act as a jumper routing area in the top front of the housing and shall enclose the top of the housing.
   b. When the hinged panel of the unit is locked in the vertical position it shall serve as a horizontal jumper management panel capable of routing jumpers out of the top of the housing. Total height of the housing shall be 5U or less.

11. Fan-Out Devices
   a. Provisions for mounting fan-out devices shall be incorporated into the housing if direct terminations are required.
   b. Splice capacity shall be 12 splice trays.

12. Units shall include a clamshell-type cable clamping mechanism to provide cable strain relief. The cable clamp shall accept 1 cable from 0.37 inches to 1.12 inches in diameter. The cable clamp mechanism shall also handle multiple smaller fiber count cables when used with a multiple cable insert. The total cable capacity per clamp shall be 5 cables (0.4 inches) OD when used with the multiple cable insert. Housing cable clamp capacity shall be 2 clamps. Additional cable clamps shall be available as an accessory kit.

13. The housing shall have 4 grommet openings for cable entry in the rear of the housing. The unit shall have 2 removable panels on both the left and right rear of the housing if more than 4 cable entries are required.

14. Front and rear doors of the connector housings shall be hinged and removable for ease of cable installation.

15. Access Doors
   a. The front doors shall be made from tinted polycarbonate.
   b. Front and rear doors shall utilize a single slide latch to provide ready access and closing. An opening shall be provided in the front and rear doors so that an optional key lock kit may be used. The opening shall be filled with a removable plastic insert so that dust may not enter if the optional lock kit is not used. There shall be a removable retaining bracket to prevent the door from being unintentionally slid off the hinges.

16. The housing shall accommodate the future installation of SC, ST, FC, D4, or MTRJ, type connector modules. Each module shall provide twelve connector sleeves.

17. Where armored cable is utilized, the armor shall be grounded to the main chassis ground bus at 1 termination location. Contractor shall not ground the armor at both ends of the cable, regardless of the length.

C. Splice Shelf

1. The splice shelf shall accept slide in/out splice trays for a maximum number of
connectors and for the fiber types to be installed.

2. Each splice tray shall restrain and protect fusion splices. Mechanical splices shall not be utilized.

D. Connector Sleeves

1. Connector sleeves shall be the SC type. The connector sleeve shall meet TIA-568-B.1-3 requirements when connecting mated pairs.

2. The FDP shall be fully populated with connector panels, each consisting of 12 connector sleeves.

3. Dust Caps shall be provided for all sleeves.

4. Loss across connection shall not exceed the following, with optical attenuators removed:
   a. Singlemode: 0.5 dB
   b. Multimode: 0.5 dB

5. The FDP sleeves shall be capable of accepting optical attenuators as required for maintaining the Optical Loss budget.

E. Slack Retention

1. Slack in pigtails and patch cords shall be neatly coiled and retained such that the minimum-bending radius shall not be exceeded.

2. Slack shall be sufficient for accessing splice shelves and connectors.

2.6 OPTICAL FIBER PATCH CORDS AND PIGTAILS

A. Patch cords and pigtails shall be cable assemblies consisting of flexible optical fiber cable with SC compatible connectors. Patch cords shall be complete factory fabricated assemblies from manufacturer's standard product lines. Fiber optic jumper cables shall meet the following requirements:

1. Patch Cord Assemblies
   a. The cable construction shall allow a small bend radius for installation in space-constrained areas. The cable shall contain a dielectric strength member and a protective outer jacket.
   b. The Patch Cord shall comply with the requirements of TIA-568-B.1-3.

2. Connectors
   a. Two duplex connectors shall be provided on patch cords.
   b. One duplex connector shall be provided on pigtails, with the other end prepared for splicing.

3. Fiber Cable
   a. Patch cords and pigtails shall utilize a 2-fiber zip-cord type jacketed cable, in lengths required to meet minimum bend radius while connected and routed through cable management hardware but no less than 6 feet in length. The cable jacket color shall be orange for multimode and yellow for singlemode cable. The fiber core size shall also be identified on the outer jacket.
   b. The optical fiber shall meet the same characteristic requirements of the distribution panel terminated cable to which it mates.
   c. Tensile strength of the jacketed cable shall be greater than or equal to 20 lbs.

2.7 INNERDUCT

A. Constructed of flame retardant PVC, FCP, or HDPE material and shall meet the following flammability requirements:

1. Outside Plant (OSP) innerduct, (General-purpose optical fiber cable raceway) shall meet the UL 2024 (raceways) Vertical Flame Test (General Use) for being resistant to the spread of fire.

2. Inside Plant (ISP) innerduct, inside building horizontal, and inside building riser innerduct shall meet the UL 2024 (raceways) Test for Flame Propagation (Riser) for having fire-resistant characteristics capable of preventing the spread of fire from floor to floor.

3. ISP Innerduct installed in any air plenum environment shall meet the UL 2024 (raceways) Test for Flame Propagation and Smoke-Density Values for having adequate fire-resistant and low smoke-producing characteristics.

B. Inside building horizontal and riser innerducts shall be flexible and corrugated type.

C. Compatible with the fiber optic cable installed within.
D. Inner diameter shall be 1-1/4 inch minimum.

E. Couplers, if used, shall not reduce the inside diameter of the innerduct.

F. All unused innerduct shall be pre-installed with lubricated pull tape or line.

2.8 WIRE PULLING LUBRICANT

A. Wire Pulling Lubricant shall have the following characteristics:

1. Polymer-based

2. Average Coefficient of Friction: Less than or equal to 0.055

3. Temperature Range: Negative 28 degrees F to 180 degrees F

4. Compatible with all cable types

PART 3 - EXECUTION

3.1 INSTALLATION

A. All optical cable installation shall be accomplished in accordance with the approved plan:

1. OSP fiber optic cable shall be installed in innerduct. No more than 1 OSP fiber optic cable shall be installed in a single innerduct without Authority approval. The innerduct shall be installed without coils or twists.

2. Pull locations shall be selected to protect the cable on the reel and in slack loops. Contractor shall be responsible for protecting cable after working hours where cable installation is not completed during a single shift. Cables damaged due to Contractor's negligence while installing cable shall be replaced by the Contractor at no additional cost to the Authority.

3. Pull lengths shall be designed to allow a 20 percent margin in cable tensile strength. The Contractor shall not exceed the lesser of 80 percent of the cable’s maximum tensile rating or 600 lbs during installation. No residual tension shall remain on the cable after installation except that due to the cable's weight in the vertical rise. Wire pulling lubricant shall be used to reduce tension on the cable during the installation process.

4. Fiber optic cables shall not be pulled into a conduit that already contains conductors, unless otherwise allowed by the Authority or shown on the Contract Drawings.

5. In case, due to the actual site condition and/or conflicts with existing or proposed utilities, it becomes required to pull fiber optic cable in existing conduit system, that already have cables in them, 21 days prior to installation, contractor shall submit a request for approval. Provide working drawings and shop drawings showing plan and scheduling for performance of the Work.

6. If a winch or pulling machine is used during installation, a dynamometer shall be used to monitor the tension on the cable. The dynamometer shall be certified as calibrated and shall hold the peak value of the cable pull. The peak value shall be recorded and forwarded to the Authority as part of the installation test data submittals.

7. Contractor shall exercise caution during construction to protect existing cable, express trough/manholes and any other utilities and elements that are located in areas of work. If necessary, the Contractor is responsible for relocation of existing utilities as per project requirements and/or replacement of damaged utilities/elements as caused by performance of this work.

8. The maximum vertical rise shall be defined as the distance over which the cable is self-supporting. Cable strain relief shall be used at the top of each vertical rise and no less than every time that 80 percent of vertical rise rating of the cable is exceeded.

9. Contractor shall not exceed the cable’s minimum bend radius for cable under tension or long-term installation/storage.

10. Continuity of cable shall be maintained between termination or splice locations shown on the Contract Drawings. Additional splices shall not be allowed without the prior written Authority approval.

11. Contractor shall notify the Authority in writing at least 48 hours in advance of installation of each section of optical cable.

12. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E814. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an approved manner.

13. Protect and maintain existing utility service in accordance with Section 02760,
“Maintenance, Support, and Restoration of Existing Utility Facilities”.

B. Termination

1. Slack in FSE's shall be carefully coiled in order to avoid violating the short and long-term minimum bend radius. Contractor shall supply a minimum slack of 150 feet of fiber optic cable at each end of the cable span inside the FSE.

2. Only hook and loop fasteners shall be used for strain relief and support of patch cords. Zip ties shall be used to mount pig tails in the splice tray.

3. The outer jacket of the cable shall be attached to the FDP with a manufacturer's clam shell cable clamp.

4. All fiber optic splices shall be fusion splices. Fusion splices shall be performed by qualified personnel only.

5. Mechanical optical splices are not permitted. This includes all mechanical fiber assemblies, crimp-on connectors, and connectors that do not require epoxy or field polishing.

6. At all wayside and communications facilities, all fibers shall be terminated. Terminations shall utilize fiber optic pigtails with factory installed connectors and shall be fusion spliced to the main fiber optic cable.

7. Contractor shall notify the Authority in writing at least 1 week in advance of terminating each section of optical cable.

8. Where armored cable is utilized, the armor shall be grounded to the ground bus at 1 termination location at 1 end of each cable span only.

9. All routing of fibers within fiber distribution panels (FDPs) and enclosures shall be neatly organized and retained such that the minimum bending radius shall not be exceeded. A slack or service loop shall be made inside the panel to be sufficient to re-prepare and re-splice the fibers if they are ever severed at the entry to the splice tray without removing the cable clamp to the FDP and un-jacketing additional cable.

10. Fusion splicing equipment shall be equipped with local injection and detection (LID) or core alignment system to optimize splices and to minimize return trips to repair unacceptable splices. The fusion machine estimated loss across each spliced fiber shall be less than or equal to 0.04 dB.

11. A heat shrinkable splice protection sleeve with a bracing strength member shall protect each fusion splice. Each splice tray shall restrain and protect fusion splices.

12. All splices shall be sequentially organized in a fiber splice tray. All fiber shall be clean and neatly wrapped in the tray and shall not be tangled, knotted, or curved in a non-flowing manner.

13. Contractor shall label all pigtail splices stored in the FDP splice tray as well as the FDP front panels. Labels shall indicate the cable terminated fiber numbers, and unique equipment assignments.

3.2 CABLE PLANT TESTING

A. Factory Cable Tests

1. Cable shall be tested on-reel prior to shipment.

2. End to end loss shall be recorded for each fiber at 1310 nm, 1550 nm and 1625 nm.

3. End to end loss shall be recorded for each multi-mode fiber at 850 nm and 1300 nm.

4. OTDR with hardcopy record shall be provided for each singlemode fiber, at 1310 nm, 1550 nm and 1625 nm.

5. OTDR with hardcopy record shall be provided for each multimode fiber, at 850 nm and 1300 nm.

6. Polarized Modal Dispersion (PMD) for each singlemode fiber shall be measured using a PMD analyzer and polarized light source.

7. Chromatic optical dispersion shall be tested for each singlemode fiber.

8. Certified copies of tests results shall be submitted to the Authority as described in these Specifications 14 days after completion of each test.

9. Original manufacturer’s factory test results, certifications, and statements confirming compliance with all of the requirements of Article 2.1 of these Specifications may be submitted for Authority approval in lieu of performing these factory tests.

B. Cable Plant Field Tests

1. Tests shall be performed after installation is complete.

2. Notice shall be provided to the Authority 7 days in advance prior to the start of testing.
3. Optical attenuation from FDP to FDP shall be measured and recorded in compliance with TIA 526-7 for singlemode fibers and TIA-526-14-A for multimode fibers.

4. Every fiber optic cabling link installed by the Contractor shall be tested in accordance with the field test specifications defined by the TIA standard TIA-568-B.1-3 (or by the required network application standards) whichever is more stringent. See Paragraph 3.2.D of this Specification.

5. TIA-568-B.1-3, shall be used to define the passive cabling network, to include cable, connectors, and splices (if present), between 2 optical fiber patch panels (connecting hardware). This TIA document shall be used to describe all applicable link segments. Tests shall include the representative connector performance at the connecting hardware associated with the mating of patch cords but not the performance of the connector at the interface with the test equipment.

6. All of the cabling links installed shall be tested and shall pass the requirements of the standards mentioned in Paragraphs 3.2.A and 3.2.B above and as further detailed in Paragraphs 3.2.C and 3.2.D. Any failing link shall be diagnosed and corrected prior to the system acceptance. The corrective action shall be followed with a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation in accordance with Paragraph 3.2.D below.

7. Every fiber optic cabling link installed by the Contractor shall be tested in accordance with the field test specifications defined by TIA standard TIA-455-133-A and TIA 455-78-B (or by the required network application standards), whichever is more stringent. See Paragraph 3.2.C of this Specification.

8. Optical Time Domain Reflectometer (OTDR) equipment used shall be Telcordia GR-196-CORE and SR-4731 compliant.

9. Trained technicians who have successfully attended a required training program and have obtained a certificate, as proof thereof shall be used to execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

a. The manufacturer of the fiber optic cable and/or the fiber optic connectors.

b. The manufacturer of the test equipment used for the field certification.

c. Training organizations authorized by BiCSi (Building Industry Consulting Services International with headquarters in Tampa, Florida) or by the ACP (Association of Cabling Professionals™) Cabling Business Institute located in Dallas, Texas.

d. Technician resume with appropriate experience and references may be submitted in lieu of training programs for Authority review and approval.

10. Field attenuation test instruments for multimode fiber cabling shall meet the requirements of TIA-526-14A. Field attenuation test instruments for singlemode fiber cabling shall meet the requirements of TIA-526-7.

11. The test instrument calibration date shall be within the calibration period recommended by the vendor in order to achieve the vendor-specified measurement accuracy.

12. The fiber optic launch cables and adapters shall be of high quality and the cables shall not show excessive wear resulting from repetitive coiling and storing of the test instrument interface adapters.

13. An Authority representative shall be invited to perform field-testing. The representative shall be notified of the start date of the testing phase 5 business days before testing.

14. The Authority representative shall select up to 5 percent of the links installed. The representative (or authorized delegate) shall test these selected links and the results are to be stored in accordance with the prescriptions in Paragraph 3.2.D. The results obtained shall be compared to the data provided by the Contractor. If the sample results differ in terms of the pass/fail determination, the Contractor under observation of the Authority representative shall repeat testing of the affected link.

C. Cable Plant Performance Test Parameters

1. In compliance with TIA-568-B, the single performance parameter for field-testing of fiber optic links shall be link attenuation (insertion loss).

2. The maximum acceptable link attenuation for each span of cable shall be calculated
by the following formulas specified in TIA-568-B:

a. Link Attenuation = Cable Attenuation + Connector Attenuation + Splice Attenuation

b. Cable Attenuation (dB) = Attenuation Coefficient (dB/km) \times \text{Length (km)}

c. Connector Attenuation (dB) = \text{number of connector pairs} \times \text{connector loss (dB)}

d. Splice Attenuation (dB) = \text{number of splices (S)} \times \text{splice loss (dB)}

3. The values for the Attenuation Coefficient are listed below:

a. Singlemode (outside plant), 1310nm: 0.5 dB/km

b. Singlemode (outside plant), 1550nm: 0.5 dB/km

c. Multimode, 850 nm: 3.5 dB/km

d. Multimode, 1300 nm: 1.5 dB/km

4. The following values listed below are to be used in the Link Attenuation formula:

a. Attenuation Coefficient (dB/km) Singlemode, 1310 nm = 0.4 dB/km

b. Attenuation Coefficient (dB/km) Singlemode, 1550 nm = 0.3 dB/km

c. Attenuation Coefficient (dB/km) Multimode, 850 nm = 3.5 dB/km

d. Attenuation Coefficient (dB/km) Multimode, 1300 nm = 1.5 dB/km

e. Splice loss (dB) Singlemode = 0.1 dB

f. Splice loss (dB) Multimode = 0.05 dB

g. Connector loss (dB) Singlemode = 0.5 dB

h. Connector loss (dB) Multimode = 0.5 dB

i. “Number of splices (S)” and Number of connector pairs are based on physical characteristics of the span of fiber being tested

j. “Length (km)” is based on the OTDR measurement of the fiber

5. Link attenuation shall not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation shall not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

6. The value calculated by the above maximum acceptable Link Attenuation formula for each fiber span is to be used as one of the determining factors regarding the pass/fail acceptance of each fiber based on the measured attenuation for each fiber using the One Reference Jumper Method specified by TIA-526-7, Method A.1, TIA-526-14-A, Method A, or the equivalent method. The user shall follow the procedures established by these standards or application notes to accurately conduct performance testing.

7. All multimode fiber cables shall be attenuation (power meter) tested in one direction at both 850 nm and 1300 nm wavelengths to account for attenuation deltas associated with wavelength in accordance with TIA-526-14-A.

8. All singlemode fiber cables shall be attenuation (power meter) tested in one direction at both 1310 nm and 1550 nm operating wavelengths in accordance with TIA-526-7, Method A.1. One Reference Jumper or the equivalent method.

9. OTDR Testing

a. All singlemode fiber cables shall be bi-directionally OTDR tested at 1310 nm and 1550 nm operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss. All multimode fiber cables shall be bi-directionally OTDR tested at 850 nm and 1300 nm operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.

b. OTDR tests shall be performed utilizing a launch cable such that the FDP termination or first test link shall be clearly shown.

c. Optical Return Loss (ORL) for each link shall be measured.

d. Fiber Length shall be measured.

e. OTDR range, resolution, pulsewidth, and index of refraction
settings should be appropriate for the fibers being tested. Contractor must scrutinize and correct the traces (in the field) for testing-related issues, including but not limited to; ghost reflectance, noisy traces, excessive dead-zones, low launch levels, bad launches, and bad connections.

f. Test Results

1) Reflective events shall not exceed negative 40 dB.

2) Attenuation of mated connections (connector pairs) shall not exceed 0.5 dB for multimode fiber, and 0.5 dB for singlemode fiber.

3) Non-reflective events (splices) shall not exceed 0.05 dB for multimode fiber and 0.1 for singlemode fiber.

4) Point discontinuities shall not exceed 0.1 dB in continuous fiber.

5) ORL shall be less than negative 30 dB.

g. OTDR Test results shall include OTDR link and channel plots, OTDR settings, user heading information, and complete event tables at the required wavelength(s) for each optical fiber as by the OTDR. The event table shall indicate distances and measurements of all connections and splices performed.

D. Cable Plant Test Result Documentation

1. The test result information for each fiber and link shall be recorded in the memory of the field tester upon completion of the test.

2. The test result records saved by the test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee shall be made that these results are transferred to the PC unaltered, i.e., “as saved in the tester” at the end of each test. The popular ‘csv’ format (comma separated value format) does not provide adequate protection and shall not be acceptable.

3. The database records of all fiber shall be stored and delivered on CD-ROM or DVD. This CD-ROM or DVD shall include the software tools required to view, inspect, and print any selection of test reports.

4. General Information to be provided in the electronic database containing the test result information for each link:

a. The identification of the testing site, including address, building, rack, panel, and fiber information.

b. The overall pass/fail evaluation of the link-under-test.

c. The name of the standard selected to execute the stored test results.

d. The cable type and the specified value of the index of refraction (IOR) used for the fiber.

e. The date and time the test results were saved in the memory of the tester.

f. The initials or name of the technician who performed the testing.

g. The brand name, model and serial number and calibration data of the tester.

h. The revision of the tester software and the revision of the test standards database in the tester.

5. The detailed test results data to be provided in the electronic database for each tested optical fiber shall contain the following information:

a. The identification of the link/fiber in accordance with the naming convention defined in the overall system documentation.

b. The attenuation measured for each fiber at each wavelength (using TIA-526-14-A or TIA-526-7), the reference value used, and the attenuation test limit calculated for the corresponding wavelength.

c. The OTDR trace plots and associated settings and headers shall be reported for each optical fiber for which the test limit was calculated based on the formulas in Paragraph 3.2.C.

6. A paper copy of the OTDR and attenuation test results shall be provided that lists all the links and fibers that have been fully
FIBER OPTIC CABLE SUBSYSTEM - COMMUNICATIONS SYSTEM

tested with the following supporting information.

a. The identification of the link in accordance with the naming convention defined in the overall system documentation.

b. The identification of the testing site, including address, building, rack, panel, and fiber information.

c. The initials or name of the technician who performed the testing.

d. The date and time the test results were saved in the memory of the tester.

e. OTDR trace plots (dB vs. km) indicating all events with their associated range, resolution, pulsewidth, index of refraction, number of averages, and wavelength settings.

f. OTDR numerical event table per trace plot showing loss and reflectance measurements for all events. The overall pass/fail of the OTDR event measurements shall be based on the measured values versus the criteria in Paragraph 3.2.C.9.f.

g. The attenuation measured for each fiber at each wavelength (using method TIA-526-14-A or TIA 526-7), the reference value used, and the attenuation test limit calculated for the corresponding wavelength.

h. The overall pass/fail evaluation of the measured attenuation results shall be based on the maximum acceptable link attenuation value as defined in Paragraphs 3.2.C.3 and 3.2.C.4.

E. Authority Provided Cable Tests

1. Optical Time Domain Reflectometer (OTDR) testing for each strand of fiber in the cable.

   a. Unidirectional bare fiber OTDR test at 1550 nm only unless an anomaly is detected. If an anomaly is detected on a fiber during the unidirectional reel test, testing shall be performed in both directions and at both 1310 nm and 1550 nm wavelengths. Indicate in the trace information section if testing is performed in the inner or outer end of the reel.

b. Attenuation in dB/km as measured by placement of the A and B cursors inside the launch end reflection spike respectively on the traces.

3.3 MEDIA CONVERSION LINK TESTS

A. Contractor shall measure and record output power at the optical port of each media converter’s transmitter output and at the fiber cable connector serving each media converter’s receiver input.

1. Received power through the fiber link cable shall be no less than 6 dB above the converter’s worst-case minimum sensitivity specification.

2. Transmitted power shall be no less than the manufacturer’s worst case transmitted output power specification.

B. Contractor shall perform and report on Ethernet link testing between media conversion devices from twisted pair interface to twisted pair interface. The field tests shall include all applicable test requirements of RFC 2544, as a minimum shall include the following tests to verify compliance with the manufacturer’s specifications:

1. Throughput testing to find the highest rate at which the media converter can forward frames.

2. Frame Loss tests to show how the media converter responds to streams with different gaps separating the frames.

3. Back-to-back tests to show how the media converter responds to different quantities of frames, with the frames separated at the minimum gap allowed by IEEE 802.3 protocol specifications.

4. Latency testing to show how much processing overhead the media converter requires for forwarding frames.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System”.

END OF SECTION 16845
PART 1 - GENERAL

1.1 DESCRIPTION

A. Contractor shall be responsible for completing an expansion of the existing communications system that performs as intended, is easy to operate and maintain, and includes inherent protection against certain deleterious ambient conditions that are anticipated in a railroad environment. Contractor shall bear total responsibility for system elements that are designed, provided, installed, tested, and commissioned under this Contract.

B. Contractor shall deliver complete operable systems that comply with performance and availability requirements in these Specifications notwithstanding any errors or omissions in these Specifications or Drawings, which might otherwise render such delivery uncertain or impossible.

C. In providing equipment and systems, the Contractor shall accept responsibility for development, design, fabrication, equipment selection and configuration, material, parts and details, wiring and cabling, software, documentation, testing, and all other related hardware and services.

D. Contractor shall bear total responsibility for the correction of any damage, malfunction, or degradation in equipment performance if the difficulty is caused by Contractor's system design, interfacing equipment, software, connection details, site work, or such other factors under Contractor's control.

E. Specification requirements and Contract Drawings are intended as the baseline (elementary) requirements for the Work under this Contract.

1. Specification requirements and Contract Drawings are not to be construed as a complete outline of or a limitation on the Work. The Specifications and Drawings include specific mention of all materials, equipment, installation details and other things required to be included in the design or to be provided or accomplished by the Contractor.

2. Where plans and these Specifications describe portions of the Work in general terms and where details are incomplete or silent, it is understood that only the best general practice is to prevail and that only new materials and first-quality workmanship are to be used.

3. Omissions of Work details that are customarily performed or are standard practices shall not relieve the Contractor from the obligation to perform such Work and to provide a fully functioning system which satisfies the operational and performance requirements in the Contract Documents and these Specifications.

F. Systems and equipment that do not meet performance requirements of these Specifications, and Authority approved submittals shall be corrected at the Contractor's expense until conformance with the governing requirements is achieved.

1.2 REFERENCED STANDARDS

A. Federal Communications Commission (FCC)


B. IPC Guidelines (IPC)

1. IPC-CM-770E – Guidelines for Printed Board Component Mounting
2. IPC-2221B – Generic Standard on Printed Board Design

C. Joint Electronic Device Engineering Council (JEDEC)

D. Military Standard

1. MIL-M-14F – Plastic Materials, Molding and Plastic-Parts Molded; Thermosetting
2. MIL-STD-275 – Printed Wiring for Electronic Equipment
3. MIL-STD-461E - Requirements For The Control Of Electromagnetic Field

E. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

F. National Electrical Manufacturers Association (NEMA)

1. NEMA Standards Publication 250, Enclosures for Electrical Equipment

G. Society of Automotive Engineers (SAE)

1. SAE Recommended Practice ARP 1393

H. Urban Mass Transit Association (UMTA)

1. UMTA-MA-06-0153-85-6 - Conductive Interference in Rapid Transit Signal Systems- Vol. II: Suggested Test Procedures
1.3 SUBMITTALS

A. Workmanship standards, practice, and procedures for assembly and installation shall be submitted at least 30 days prior to the earlier of:

1. The planned date for any assembly work.
2. The planned submittal date for installation drawings or procedures.
3. Shall include standards, practices and procedures applicable to:
   a. Wiring, cabling, cable management, connectors and termination of wire and cable.
   b. Color-coding standards.
   c. Grounding
   d. Labeling, including labels for:
      1) Equipment and material identification
      2) Operating and maintenance instructions and data
      3) Safety / Hazard warnings

B. At least 30 days prior to communications equipment installation, submit the following for each basic electrical and electronic assembly which is custom designed and fabricated:

1. Assembly bill of materials
2. All printed circuit board layouts
3. Enclosure and connector designs
4. Pertinent design details required for the complete assembly fabrication and its interfaces
5. Product information for all wiring and printed circuit components and standard assemblies shall be submitted to the Authority in an organized, sorted, and indexed listing. Contractor list shall include supplementary information or specific references to aid the Authority in replacement procurement.
6. Product information for special tools needed for assembly, maintenance, and testing.

C. Submitals for basic mechanical components and devices:

1. At least 30 days prior to communications equipment installation, submit product information and specification sheets for all mechanical components, devices and associated appurtenances.
2. Identify external controls, indicators, test points, ports, terminals, and connectors. Identify product salient characteristics to the Authority for procurement of replacement components.
3. At least 30 days prior to communications equipment installation, submit the following information about each device, module, or similar item:
   a. General assembly outline drawings
   b. Internal circuitry schematic diagrams

D. Identification and numbering scheme, and use and format of labels, tags, sleeves, and equivalent, for all types of equipment and material identification shall be submitted at least 30 days prior to the planned date for any installation detailed documentation submittal.

E. Prior to issuing purchase specifications for any apparatus, submit an Electromagnetic Compatibility (EMC) and Electromagnetic Interface (EMI) Control Plan that outlines a strategy of ensuring compliance with the requirements of Paragraph 2.1.C of this Section.

PART 2 - PRODUCTS

2.1 GENERAL

A. Equipment Maintainability. The design and construction of all systems provided shall be such to be routinely maintainable by Authority personnel, on site or at the Authority maintenance facilities. Replaceable and repairable assemblies and modules shall be provided to facilitate troubleshooting.

1. Equipment Assemblies
   a. Cable-connected or pullout modules shall be designed for direct access and quick replacement and shall weigh less than 15 pounds.
b. Assemblies weighing 15 pounds or more shall be provided with rollout slides, hinges, or other devices to permit moving assemblies to test or maintenance positions without manual lifting.

c. Packages, which weigh more than 15 pounds, shall be provided with lifting devices.

d. Assemblies requiring removal for shop maintenance shall weigh less than 40 pounds.

e. Assemblies requiring removal for preventive maintenance or replacement shall have quick disconnect plug connectors and flexible cabled leads.

f. Assemblies and subassemblies shall be designed to be handled in normal work positions without damaging or displacing any component parts, and shall require no mechanical readjustment before installation.

g. All assemblies, subassemblies, and circuit or hardware components shall have permanently affixed labels giving manufacturer and part number. Color-coding to designate value and ratings of components shall be used only where it has been accepted as an industry standard.

h. All equipment shall be mounted in racks, cabinets or consoles, and shall be fabricated, finished, and arranged to present a uniform and coordinated appearance.

2. Equipment Accessibility. All components, modules, and subassemblies shall be accessible for testing, removal, or replacement without removal of other parts. Where this is not possible, other parts shall be of a pullout or plug-connected type.

a. All components requiring adjustment or replacement shall be visible and identifiable.

b. Access openings shall be covered where required to protect internal parts, safeguard personnel, or restrict access for adjustments not normally performed in the field. Covers shall be labeled to indicate their purpose, or the hazard involved. Hardware or fasteners used to secure covers shall be captive.

c. Structural braces, supports or enclosure sheets shall not hamper access to components or subassemblies. Overhanging edges or exposed corners that could hamper access or cause injury to personnel shall not be allowed.

d. All components, modules or subassemblies that may require maintenance access, shall be located with sufficient room for effective use of required tools and test equipment for required maintenance. Any installed security enclosures, frames, or cages shall allow the same access and shall be accessible for servicing by a single technician.

3. Test Points. Test points shall be provided to support troubleshooting and maintenance for checking essential voltages, wave forms, pulse codes, register content, software/firmware, or for injecting test signals or codes. All hardware related test points shall be permanently labeled with alphanumeric identifiers for reference.

a. Selected test points or ports essential for regular in-service checks shall be accessible on a test sub-panel. Test points, for in-service or off-line tests of plug-in modules or assemblies, shall be readily accessible on the module or assembly in the operating position.

b. Test points shall be capable of accepting probes and connectors used with standard test equipment required for specified tests, except where special test equipment and connectors are provided by the Contractor. In lieu of test points, the Contractor may supply test sets that can plug into a subassembly to identify faults.

4. Recurring maintenance adjustments shall be minimized by the use of wide-tolerance circuits, stable components, and automatic re-calibration or adaptation. Components that are manually adjustable shall be used only if there is no other choice.

a. When frequent observations or adjustments are required, built-in indicators, meters, or other readouts shall be provided. GO/NO-GO type indicators shall be
b. Adjustable devices shall have locking screws or shall be self-locking to prevent inadvertent operation or drift.

c. Wherever practicable, points requiring preventive maintenance adjustment together shall be located within 12 inches of each other so maintenance can be performed by one person. Interacting adjustments shall be avoided if possible.

d. The replacement of a module or subassembly with a spare unit shall not require adjustment to the associated external input or output circuits or modules. If adjustments are required, such adjustments shall be provided on, and limited to, the device being replaced or repaired.

5. Safety and Hazard Warnings. Safety and hazard warnings shall be placed on equipment which, when installed, can pose a danger to maintenance personnel factors to which its equipment may be sensitive that are not listed below. Contractor shall insure that no equipment damage occurs during manufacture, storage, and shipment as a result of climatic conditions which differ from those below:

a. Temperature and Solar Load:

1) Minimum ambient air temperature external to equipment is 4 degrees F

2) Maximum ambient air temperature external to equipment is 115 degrees F

3) Maximum solar radiation: 275/BTU/hr*ft²

4) Maximum daily temperature range is 50 degrees F

5) Average days under 32 degrees F is 38

b. Precipitation:

1) Maximum rainfall rate is 7 inches an hour and this rate may occur simultaneously with wind.

2) Maximum snowfall is 12 inches in 24 hours

3) Measurable quantities of ice infrequently occur

4) Average relative humidity

a) Morning: 82 percent

b) Afternoon: 56 percent

c) Maximum average: 87 percent

c. Wind:

1) Average speed: 11 mph

2) Maximum sustained for 1 minute: 73 mph

3) Maximum gusting: 100 mph

d. Air Contamination. The equipment shall operate as specified in the atmosphere commonly found in rail vehicle environments and the

B. Environmental Protection Design

1. Equipment and material covered by this Contract will be designed for indoor and outdoor locations along the Authority System right-of-way (ROW), at elevations of approximately sea level to 100 feet above sea level, in a suburban environment. The areas adjacent to Authority ROW are urban or suburban zones, some of which are occupied by industrial or commercial developments. Authority rail lines run parallel with major freeways along several lengthy sections, run through the downtown mall area and run through a tunnel on the North Central line.

2. The following particular climatic conditions shall be used as design guidelines and shall be considered as operational requirements. Actual localized temperatures and conditions within spaces and enclosures may be more severe than the ambient climatic conditions and the Contractor shall be responsible for evaluating these during the design effort. Additionally, the Contractor shall be responsible for advising the Authority if there are any special environmental
3. Enclosures
   a. Outdoor Locations:
      1) Equipment and enclosures installed in outdoor locations shall be designed to operate properly in the extremes of local weather conditions, including heavy winds, rain, hail, outside air temperatures, and relative humidity up to 100 percent.
      2) Where equipment is installed in outdoor enclosures and subject to temperature extremes caused by exposure to direct sunlight plus heat from internal electrical losses, the enclosures shall be equipped with sun shields and convection vents so that maximum internal temperature rise above ambient air does not exceed 25 degrees F. Equipment intended to be installed in outdoor enclosures shall be designed and tested for continuous service at 140 degrees F.

   b. Indoor Wayside Locations:
      1) Equipment and enclosures installed in indoor wayside locations shall be designed to operate continuously, properly, and safely in a temperature range of 32 degrees F to 120 degrees F, at relative humidity ranging up to 95 percent.

   c. Cooling Devices:
      1) Cooling devices shall be provided by the Contractor. Such devices shall be internal to the associated enclosures, and shall be included in the determination of conformance to reliability and maintainability requirements.
      2) Unless otherwise specified, cooling devices shall be sized to maintain temperatures within enclosures between 60 degrees F to 80 degrees F while outside ambient temperatures are in the range specified previously in Paragraph 2.1.B.2.
      3) More specific requirements for climate-controlled facilities may be found in these Specifications.

   d. Heater Devices
      1) Heater devices shall be provided by the Contractor.
      2) Such devices shall be internal to the associated enclosures, rooms or houses, and shall be included in the determination of conformance to reliability and maintainability requirements.
3) Heating devices shall also meet the requirements of these Specifications.

e. All equipment shall be designed to operate in an environment subject to the following vibration limits:

f. Wayside equipment

1) Equipment located adjacent to track on direct fixation or tie-and-ballast sections, and mounted anywhere within the Authority ROW except as indicated herein below, shall be designed to operate in an environment subject to the following vibration levels: all frequencies less than 12 Hz, 0.02 inches peak-to-peak amplitude; all frequencies from 12 Hz to 1000 Hz, 0.14 g peak or 0.1 g rms.

2) Equipment located adjacent to and within 20 feet of special track work on direct fixation or tie-and-ballast construction shall be designed to operate in an environment subject to the following vibration levels: all frequencies less than 12 Hz, 0.2 inches peak-to-peak amplitude; all frequencies from 12 Hz to 1000 Hz, 1.4 g peak or 1.0 g rms.

g. Equipment located in communications equipment spaces at Operation Control Center (OCC), Communication Interface Cabinet’s (CIC’s), Communications Facilities, Signal Houses, or Yards:

1) For all frequencies less than 12 Hz: 0.02 inches peak-to-peak amplitude; and

2) For all frequencies from 12 Hz to 100 Hz: 0.14 g peak or 0.1 g rms.

C. EMI Design. Contractor shall ensure that the electrical, electronic, and communications systems design can perform in the Authority transit system EMI environments with vehicles and other equipment without being functionally affected by them; and without affecting the system operation, safety, or other car borne or wayside installations because of conducted, induced, or radiated emissions.

1. Methods and Equipment. Contractor shall employ design techniques, construction methods, and whatever equipment is required to prevent interference caused by external and internal sources from affecting the proper operation of the equipment and systems specified herein. To contain EMI emissions wherever possible, the suppression of transients shall be at the source of the transient. The following design requirements shall be included in the Contractor’s design:

a. In addition to coordinating frequencies, the Contractor shall provide required balancing, filtering, shielding, modulating techniques, and isolation to maintain signal to noise ratio (S/N) above limits required to operate all equipment installed under this contract. Shielding, isolating, balancing, and grounding shall be used, as required, to reduce the undesirable effect of interference.

b. Electrostatic and magnetic shielding methods shall be employed to minimize the effect of stray signals and transient voltages on interconnecting cables.

c. Interconnecting power and signal cables shall be physically separated.

d. Equipment and facilities shall be located and arranged to minimize voltage induction into circuits due to the Light Rail Transit (LRT) vehicle’s propulsion system, auxiliary power, and overhead catenary system current transients.

e. Suppressors shall be incorporated across inductive devices to minimize switching transients.

f. All relay coils and contactor coils shall have freewheeling diode or metal-oxide varistor transient suppression. Other means of suppression or the absence of suppression for performance reasons shall be Authority approved prior to use.

g. The number of suppression device types shall be kept to a minimum.

h. Equipment design and enclosures shall shield equipment from any effects resulting from the operation...
of an Authority handheld transceiver when said transceiver is within 18 inches of the enclosure.

i. Equipment design and enclosures shall shield equipment from any effects resulting from the operation of cellular telephones, including when said telephones are operated in the vicinity of the equipment and on the passenger platforms.

2. EMI Sources. Known EMI sources along the Authority ROW include but are not limited to the following major sources of interference that could affect operation of the System:

a. Medium and low voltage power circuits, including the Authority’s Traction Power AC source sub-transmission distribution system, operating at 60 Hz and carrying harmonics typical for the configuration and the loads served.

b. Direct-current traction power system:

1) Substation thyristor rectifier apparatus

2) Direct current power distribution to trains, via overhead power catenary circuits

3) On-board propulsion equipment, including solid-state chopper and motor circuits

4) Direct current arcing, catenary to pantograph

5) Temporary faults on the AC or DC power circuits

c. Local ground mat voltage rise or drop at any communications equipment room site, caused by patterns of DC traction power currents in running rail and earth return paths, or by temporary AC or DC circuit fault conditions.

d. Authority Train Control System, which comprises a variety of discrete digital and digitally coded signal sources and receivers at the Operations Control Center (OCC) Building, in Signal Houses, in wayside cables, in running rails, and in rail vehicles. Coded signal sources are in the DC to 20 KHz range.

e. The design shall provide surge arresters and other circuit protection devices required to protect equipment from lightning currents and voltages.

f. Authority, governmental, public, and private radio systems

g. Authority T-1 carrier terminals and copper cable circuits

h. Authority video multiplex terminals and coax cable circuits

i. Commercial 800 MHz cellular transmission facilities

3. To help avoid undesirable effects upon communications and control equipment or other installations along the ROW as caused by on-board LRT vehicle subsystems, electromagnetic emission limits have been specified and will not be exceeded. Meeting the emission limit requirements does not guarantee elimination of interference; it is the first level of defining the interface between the vehicles and their intended environment. Contractor shall work jointly with the vehicle supplier, wayside signal system supplier, and others designated by the Authority to ensure compatibility. Vehicle Emissions will be limited to the following:

a. Radiated Emissions Limits. Radiated emissions, as measured by the procedures in UMTA-MA-06-0153-85-11 will conform to the following limits:

1) From 0.01 MHz to 30 MHz, the maximum permissible interference limit will not exceed 20 dB above the limit of Figure 22 (RE05) MIL-STD-461E.

2) From 30 MHz to 88 MHz, the maximum permissible interference limit shall be 58 dB above 1 microvolt/meter/MHz bandwidth.

3) From 88 MHz to 1000 MHz, the maximum permissible interference limit will be 68 dB above 1 microvolt/meter/MHz bandwidth.
b. The limits in Paragraph 2.1.C.3.a will not be exceeded when measured at a distance of 100 feet from the track centerline (Reference: SAE Recommended Practice ARP 1393, 5/3/76).

c. Conductive Emissions Limits. Conductive emissions, as measured by the procedures from, UMTA-MA-06-0153-85-6, Method RT/CE02A, will have a current limit as follows:

1) From 0 Hz to 80 Hz: 10A max.
2) From 80 Hz to 90 Hz: 10 amperes decreasing log-linearly to 1 ampere max.
3) From 90 Hz to 120 Hz: 1A max.
4) From 120 Hz to 600 Hz: 10A max.
5) 600 Hz to 1500 Hz: 1A max.
6) 1500 Hz to 4 KHz: 0.02A max.
7) 4 KHz to 20 KHz: 0.03A max.
8) The limits above shall be met individually by each equipment apparatus as well as during the simultaneous operation of all equipment.

d. Inductive emissions, as measured by the procedures from "Inductive Interference in Rapid Transit Systems, Volume II: Suggested Test Procedures," UMTA-MA-06-0153-85-8, will be limited to a maximum of 20 millivolts, rms, rail-to-rail, at all frequencies between zero Hz to 1 KHz and a maximum of 10 millivolts from 1 KHz to 20 KHz. This condition shall be met by each individual equipment as well as the simultaneous operation of all equipment.

e. Conducted Disturbances. Contractor shall formulate a set of criteria governing both generation and tolerance of electrical disturbances on conductors between assemblies. The criteria shall distinguish the basic types of circuits present in the system and shall define a suitable comprehensive classification of disturbances, which may be present in each type of circuit. The criteria shall ensure that each connected assembly will be able to tolerate the disturbances introduced simultaneously by all of the other assemblies to which it could be connected. These criteria shall be a part of the EMC control plan.

f. Contractor shall formulate a set of criteria governing generation and tolerance of magnetically coupled disturbances on or between assemblies. The criteria shall identify the basic types of circuits present on the vehicle and shall define a suitable comprehensive classification of disturbances, which could be present in each type of circuit. The criteria shall ensure that each connected assembly will be able to tolerate the disturbances introduced simultaneously by all of the other assemblies to which it is magnetically coupled. These criteria shall be a part of the EMC control plan and shall be submitted for approval prior to issuing purchase specifications for any apparatus.

4. Emissions. Contractor shall design and implement the system such that its equipment:

a. Does not electrically interfere with the proper operation of the LRT vehicles or wayside equipment

b. Complies with 47 CFR Part 15

5. Overvoltage Protection

a. Overvoltage protection shall be provided for all outdoor Public Address (PA)/ Visual Message Board (VMB) equipment, and for new CIC’s.

D. Prohibited Materials and Methods

1. Extra-flexible, metallic or non-metallic, non-labeled conduit

2. Plastic conduit for interior electrical use, except that Polyvinyl Chloride (PVC) conduit may be used for power circuits below basement concrete floors and for ground wires in any location. The transition from PVC to steel shall be made below the floor.
3. Steel Conduit shall not be used outside unless in concrete. Use Galvanized Rigid Steel (GRS) conduit outside and wet locations above grade.

4. Aluminum wiring shall not be used.

5. Non-insulated stranded wiring shall not be used for grounding.

6. Use of Incompatible Materials:
   a. Aluminum fittings and boxes shall not be used with steel conduit.
   b. All materials in a raceway system shall be compatible.
   c. Dissimilar Metals. All dissimilar metals shall be properly insulated to prevent galvanic action.
   d. When bronze and aluminum components come into contact with dissimilar metals, surfaces shall be kept from direct contact by painting the dissimilar metal with a heavy coat of a proper primer or asphalt paint.
   e. When aluminum components come into contact with cement or lime mortar, exposed aluminum surfaces shall be painted with heavy bodied bituminous paint, water-white methacrylate lacquer, or zinc chromate.
   f. Fasteners. All exposed fasteners shall be stainless steel.

7. Multi-use Suspension Systems: Piggyback suspension systems for conduits and fixtures are prohibited. All suspensions shall be hung independently from structure, or, in limited cases, from trapeze suspension systems.

8. Use of wire ties to support conduit.

9. Use of splices to join communications or electrical wiring within ductbanks and raceways.

2.2 BASIC ELECTRICAL AND ELECTRONIC COMPONENTS

A. General. This section specifies the characteristics of basic electrical and electronic assemblies, which are custom designed and fabricated by the Contractor. Contractor shall not retain rights of royalty for future fabrication of these assemblies.

B. Communications Power Cable. Power cables, rated 600 volts and below, used in communications circuits shall be provided in accordance with these Specifications.

C. Electronic Components. For all Contractor custom designed electrical and electronic assemblies, all electrical and electronic components provided shall be:
   1. New and free of manufacturing defects
   2. Free of damage due to aging, storage, handling, or exposure
   3. Clearly and permanently labeled with rating, value, and type identification; coding is acceptable on components that are too small to label
   4. Derated according to conservative practice in the industry, or as proposed in relevant standards or guides, or according to the manufacturer's advice
   5. Commercially available as spare or replacement parts

D. Wiring and Printed Circuit Components
   1. Wiring Connections. Not more than 2 wires shall be connected to a single terminal
   2. Printed Circuit Cards
      a. Cards shall be constructed of epoxy glass material, NEMA Type FR-4, Grade G-10
      b. Cards shall be of sufficient thickness to permit easy insertion and removal without buckling or breaking.
      c. Cards shall be mechanically keyed to prevent incorrect interchange.
      d. Cards shall be equipped with a card puller.
      e. Large computer-type cards shall be equipped with a lever or cam-type locking device.
      f. Circuits shall be formed by etching.
      g. Conductor material shall be copper.
      h. Width and thickness of conductors shall be in accordance with IPC 2221B.
      i. Complete printed circuit card assemblies shall be conformal
coated in accordance with IPC-CM-770E.

j. Card contacts shall have gold plating of at least 0.00005-inch thickness.

k. Component mounting and lead solder connections shall be in accordance with IPC-CM-770E.

l. Component side shall be silk screened on the component side to identify all printed circuit parts. Silk-screened labels shall not be covered by installed printed circuit parts.

3. Printed Circuit Card Connectors. Printed circuit card connectors shall have the following features:

a. Unless otherwise Authority approved, contacts shall have gold plating of at least 0.00005-inch thickness.

b. Contacts shall be bifurcated.

c. Insulation resistance shall be 5,000 megohms minimum.

d. Insulation material shall be glass-filled diallyl phthalate per MIL-M-14F.

4. Printed Circuit Design. Printed card circuitry shall be designed in such a manner so that terminals assigned to a given power supply, common, or ground will be the same on all cards in each subsystem. Where practical, the remaining card circuitry shall be arranged in such a manner so that the terminals assigned to a given function will be the same on all cards in each subsystem.

a. Cards containing circuits, which affect safety, shall be designed such that removal of the card shall not create an unsafe condition, or cause a failure of another component.

b. Printed circuit cards shall be replaceable under operating (power on) conditions without adverse effect or damage to components either on the card or connected electrically to the card.

5. Printed Circuit Modifications. All modifications to manufactured printed circuit card assemblies shall be subject to Authority approval and shall be in accordance with all applicable IPC Standards and Guidelines.

6. Printed Circuit Identification. Each type of printed circuit card assembly shall be permanently and legibly marked with a unique number identifying that type of card assembly. Each card containing vital circuitry shall be permanently and legibly marked with a unique serial number and revision level.

7. Printed Circuit Card Cages. Printed circuit cards shall be installed vertically in card cage slots that are permanently mounted and enclosed inside a chassis or module.

E. Electronic Components

1. Resistors. Resistors provided as discrete components in electronic modules shall have a maximum tolerance within plus or minus 5 percent, or a narrower tolerance when prescribed by circuit design. Such resistors shall be rated at twice the maximum power that they will be subjected to in operation.

2. Capacitors. Capacitors provided as discrete components in electronic modules shall have a maximum tolerance of plus or minus 10 percent, or a narrower tolerance when prescribed by circuit design. Capacitors shall be rated for at least 1.5 times the maximum peak voltage that they will be subjected to in operation.

3. Inductors. Inductors provided in electronic modules shall have encapsulated windings and leads, and shall be rated to withstand at least twice the overall and internal winding peak voltages that they will be subjected to in operation.

4. Transformers. Power-level transformers provided in electronic modules shall have a minimum inter-winding breakdown voltage of 1,000 Vdc. Such transformers shall not emit audible noise in excess of 40 dB, referenced to 0.0002 dynes/cm² at a distance of 2 feet, while operating at rated voltage and load and performing their intended function.

5. Semiconductor Devices. All discrete semiconductor devices shall carry a Joint Electronic Device Engineering Council (JEDEC) number, or shall be available as standard products from more than one manufacturer. All semiconductor devices shall conform to the published specifications for such JEDEC number. All such semiconductor devices shall be the silicon type, unless the specific functions of certain circuits require another standard type.
a. Zener Diodes. Zener diodes provided for voltage regulation or reference levels shall be rated such that the diodes shall not be damaged if the entire load is removed abruptly, and shall have a zener voltage tolerance within plus or minus 5 percent.

b. Transient Protection. Zener diodes provided for transient protection shall be rated such that the diodes shall not be damaged in performing their functions within all actual conditions encountered in the operating system.

6. Integrated Circuit Packages. All digital integrated circuits shall be of the Transistor-Transistor Logic (TTL), Metal Oxide Semiconductor (MOS), or Complimentary Metal Oxide Semiconductor (CMOS) logic families. They shall be packaged in DIP or equivalent industry standard units, and identified with clear and permanent labels.

2.3 IDENTIFICATION

A. Labeling Components, Subassemblies, and Assemblies. All components, subassemblies, and assemblies shall require labels so that they shall be readily identified. Part reference designations shall be assigned in accordance with ANSI Standard Y32.16 and shall be marked on the product unless otherwise Authority approved. Reference designations for parts unique to an indicated location shall be preceded by the location control number.

B. Controls and Adjustments. Controls and adjustments shall be clearly identified as to function and shall be marked or indexed so that the control position or direction of rotation can be readily identified. Fixed guide marks on controls or adjustments shall be provided if the controls or adjustments require presetting for a standard maintenance operation.

C. Indexing. Mechanical assemblies subject to maintenance disassembly shall be indexed to ensure proper relative positioning of parts after reassembly.

D. Access Labeling. Labeling at accesses shall be provided and shall include, but not be limited to essential maintenance information, including but not limited to names of items inside; reference to schematic wiring diagrams and servicing procedures; and warning of hazardous or critical operations.

E. Equipment Cabinets. Each equipment cabinet shall have a unique I.D. located top center front and rear on exterior of cabinet frame, stenciled with black epoxy enamel. Lettering shall be in block letters 1/2 inch.

1. Each I.D. stenciled text shall consist of 2 lines; the first line to show cabinet number, and the second line to show specific name of the cabinet, as indicated. Cabinet name and number shall correspond with the cabinet terminology indicated on the Contract Drawings.

F. Junction and Pull Boxes. Each junction and pull box shall have a unique number stenciled on the cover with black epoxy enamel. Lettering height shall be 1 inch. Numbers shall identify the service of circuits within the box and the location of the box by civil stationing. Pull boxes shall be stenciled to show unique identification and civil stationing.

G. Relays. Relays shall be provided with nametags or engraved plastic "lamicord" engraving. Tags shall be of stamped or engraved metal plates. Information on tags or engraving shall include type, rating, part number, date and place of manufacture.

PART 3 - EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Install electrical materials, equipment, appurtenances, and accessories in locations as indicated, rigid and secure, plumb and level, and in alignment with related and adjoining Work to provide a complete and operable system. Do not weld electrical materials for attachment or support.

B. Provide anchor bolts and anchorage items as required, and field check to ensure proper alignment and location. Provide templates, layout drawings, and supervision at the job site to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

C. Install supporting members, fastenings, framing, hangers, bracing, brackets, straps, bolts, and angles as required to set and connect the work rigidly.

D. Control erection tolerance requirements so as to not impair the strength, safety, serviceability, or appearance of the installations. Determine exact locations of conduit. Route conduit parallel to building lines unless otherwise indicated.

E. The trade size, type, and general routing and location of conduits, raceways, and boxes shall be as indicated or specified.

F. Install exposed conduit so as to avoid conflicts with other Work. Install horizontal raceways close to the ceiling or ceiling beams, and above water or other piping wherever possible.
G. Install individual conductors and multiple-conductor sheathed cables in conduits, raceways, cable trays, ducts, and trenches as indicated to complete the wiring systems.

H. Install switches, receptacles, special purpose outlets, and cover plates complete in a neat manner in accordance with the NEC and local electrical codes. Plug unused openings in boxes, cabinets, and equipment.

I. Use of explosive fasteners is prohibited.

J. All electrical equipment, panels, telephone, and fire alarm panels shall be sealed against dust, whenever dusty conditions are present inside the rooms or outside, during the construction period.

3.2 CONDUIT AND FITTINGS

A. Provide as indicated and required in accordance with these Specifications.

3.3 EQUIPMENT, APPURTEANCES, AND INSTALLATION ACCESSORIES

A. Provide conduit hangers and inserts, pull cords, outlet boxes, junction and pull boxes, metal and plastic cable tray systems, and under floor duct work as indicated and required in accordance with these Specifications.

3.4 ELECTRICAL WIRING

A. Wiring Requirements

1. Provide wiring as indicated and required in accordance with the requirements of these Specifications.

2. Furnish wires and cables to the site in unbroken standard coils or reels to which shall be attached a tag bearing the manufacturer’s name, trade name of the wire, and the UL label for 600 V wire and cable.

3. Provide wiring complete as indicated. Provide ample slack wire for motor loops, service connections, and extensions. In outlet or junction boxes provided for installation of equipment by others, tape ends of wires and install blank covers.

4. Measure insulation resistance of the wiring system before connection to terminal blocks, motors, switchboards, motor control centers, transformers, panel boards, and control cabinets.

5. Do not bend cables during installation, either permanently or temporarily, to radii less than 10 times the outer diameters, except where conditions make the specified radius impracticable and shorter radii are permitted by the National Electrical Code and NEMA WC 7, Appendix N.

6. Secure and neatly bundle cables inside panel boards, control cabinets, switchboards, motor control centers, and pull boxes with nylon straps.

7. Identify wiring as specified in these Specifications.

B. Cable Supports: Install cable supports for vertical feeders in accordance with the National Electrical Code.

C. Splices and Terminations

1. Make wire and cable splices only in outlet, junction or pull boxes, or in equipment cabinets. Splices in conduit, trough, or raceway will not be permitted. Make splices by means of compression type connectors on stranded cables, and cover with tape to an insulation level equal to that of the cable.

2. For stranded copper wire, compression-type, insulated terminals in accordance with the wire and cable manufacturers’ recommendations shall be used. The terminals shall be installed only with tools and techniques recommended by the terminal manufacturer.

3. Solid wire shall be terminated by wire eyes. The use of compression-type terminals for solid wires is prohibited.

4. Wires and cables shall be terminated at terminal blocks. Compression-type insulated terminal connections to terminal blocks shall use a single washer on top of the terminal. Wire eyes require 2 washers for 1 eye, 3 washers for 2 eyes. Connections shall be completed with double nuts torqued to the rated value of the nut.

5. Use positive type connector installation tools as recommended by the manufacturer.

6. Mechanical hand tools, with dies for each conductor size as recommended by the manufacturer, may be used on conductor sizes through No. 6 AWG.

7. For conductor sizes larger than No. 6 AWG, use hydraulic tools with hexagonal or circumferential installing dies for each conductor size, as recommended by the manufacturer.

8. For inspection purposes, clearly mark die numbers on the installed connectors.
9. Before installation, apply anticorrosion electrical joint compound to conductors and terminal bolting pads.

10. Wire and cable shall be continuous from power source to equipment. Where splices are required, they shall be made only in approved fittings or junction boxes and shall be subject to Authority approval. Follow manufacturer's instructions in splicing wire and cable.

11. Fixture Wire: Make splices in lighting circuits with insulated crimp-type connectors.

12. Use approved manufacturer tools to strip off cable or wire insulation.

3.5 WIRING DEVICES

A. Locate switches 4 feet above finished floor and general-purpose duplex convenience receptacles 15 inches minimum above finished floor, except as otherwise indicated.

B. Attach receptacles rigidly to outlet boxes by means of 2 stainless steel screws.

C. For exterior and damp locations, surface or embedded, mount receptacles in watertight cast metal outlet boxes with threaded hubs or bosses and equipped with gasketed spring cover.

3.6 COMMUNICATIONS WIRING AND TERMINATION

A. All communications cable entering a facility from an outside environment shall be prevented from transmitting induced transient voltages harmful to the attached equipment through the use of gas discharge or Zener type protection blocks integral to Local or Main Distribution Frames (MDF). Cable shields and armor jackets shall be directly connected to signal ground at the Communications Facility. For cables running between Communications Facilities, the ground shall be applied at the facility closest to the OCC. In no case shall the cable shield be grounded at both ends. Protector blocks shall meet the requirements of these Specifications.

B. All voice frequency (VF) communications cabling connecting from end devices to Communication Transmission Subsystem (CTS) equipment shall terminate to the applicable terminal blocks in the facility's Local Distribution Frame (LDF) or MDF unless otherwise shown on the Contract Drawings. CTS VF channel equipment shall terminate to the LDF or MDF on 25 pair telephone style connectors. Connection from the equipment to the CTS shall be accomplished by installing cross-connecting wires from the associated equipment block to the CTS transmission equipment block. Cross Connects shall be twisted pair solid No. 22 AWG wire. LDF and MDF terminal blocks shall meet the requirements of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16850
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Telephone Subsystem to be designed, provided, installed, and tested under this contract. Scope of Work includes:

1. Local installation, wiring, turn-up, programming and testing of all new telephone instruments, enclosures and housings, and associated interconnect and station protection equipment from designated telephone locations to a field Communication Transmission Subsystem (CTS) interface, required for subsystem expansion to support communications to line sections defined under this contract.

2. The following types of telephone instruments and devices shall be furnished installed and, tested as a part of the Telephone Subsystem:
   a. Wayside telephones – environmentally hardened telephone instruments placed in typically non-public areas along the right-of-way such as on bridges, aerial track structures, or tunnel passages. Analog wayside telephones shall require a Gateway conversion to be compatible with the DART VoIP telephone system.
   b. Administrative telephones – wall or desk mounted telephone instruments located in wayside Communications Facilities, Signal Houses, Traction Power Substations (TPSS), station service buildings, elevator maintenance rooms, crew rooms, Operation Control Center (OCC), and other Authority facilities for internal administrative use. Administrative telephones shall be natively compatible with the DART VoIP telephone system.
   c. Passenger Emergency Call (PEC) units – telephone instruments located on station platforms, concourses, pedestrian walkways, areas of refuge and other public areas for patrons to communicate with local public service agencies (“911” services) during emergency situations or with the DART customer service department in non-emergency situations. PEC phones shall operate on a single CO or cellular phone line and have 2 buttons for calling 911 or DART Customer Service.
   d. Elevator Emergency telephones – telephone instruments integrated into each elevator cab panel for patrons to communicate with the Train Control Center (TCC) during an emergency situation. Elevator phones are hands free and only have one button for initiating a call. Elevator telephones shall be natively compatible with the DART VoIP telephone system.

B. Voice over Internet Protocol (VoIP) Telephone System:

1. The VoIP Telephone system shall utilize Ethernet networking over the CTS system. VoIP Telephone sets shall utilize Power over Ethernet (PoE).
   a. All components of the Telephone system shall be designed to be powered by either a battery backup, Uninterruptible AC Power Supply (UPS), or UPS and generator system during normal operation and for a minimum of 8 hours of temporary backup AC power in case of a failure of normal AC. Refer to facility power requirements and to Contract Drawings.
   b. Phones shall be fully compatible with DART’s existing VoIP Private Branch Exchange (PBX). Coordinate with DART for approved phone models. Non-approved models require samples and Authority pre-testing for system compatibility prior to approval.
   c. Gateway conversion equipment shall be fully compatible with DART’s existing Gateway equipment. Coordinate with DART for approved Gateway models. Non-approved models require samples and Authority pre-testing for system compatibility prior to approval.
   d. Contractor shall coordinate and receive approval from DART for compatible phone models.
   e. All desk-top components shall be installed in the transportation and administration facilities or as indicated in the contract drawings.
   f. DART will provide IP addresses and phone numbers for each phone to be installed.
7. DART IT will provide SIP server and DNS programming for connecting phones to Primary, or Secondary Virtual PBX.

8. DART Communications will provide phone monitoring via LAN Management Software.

9. Major components of the VoIP System shall include, but not be limited to, the following equipment:
   a. VoIP compatible external ringing device for TPSS facilities
   b. Noise cancellation headsets (wireless) meeting the noise cancellation characteristics identified in this specification and shall work with the new VoIP phones for all substations.

C. Existing System Description and Configuration

1. The existing telephone subsystem provides emergency and maintenance voice switched services to weatherproof, ruggedized telephone instruments installed at station platforms, pedestrian underpasses, aerial structures along the guideway, at tunnel cross passages, as well as standard telephone instruments at station elevators and fire alarm transmission equipment. Telephones are intended for use both internally by the Authority personnel and by Light Rail Transit System (LRT) patrons.
   a. The Authority utilizes AT&T's OPT-E-MAN Switched Ethernet service and NEC Univerge-3C virtual PBX servers. VoIP service for the existing analog phone systems are enabled via Gateway conversions.
   b. Existing wayside telephone instruments are served by one analog circuit and have a 12-digit dial pad. When the phone is off-hook, an extension is auto-dialed to the DART IT callpilot application which directs the calls to either Train Control or allows dialing of an authorized DART extension. Wayside telephones circuits utilize a Gateway conversion to be compatible with the DART VoIP telephone system.
   c. The existing administrative telephone subsystem provides administrative voice services to standard desk or wall mount telephones located in communications and signal houses, TPSS, crew rooms, and other locations over DART VoIP PBX extensions. Administrative analog telephones circuits utilize a Gateway conversion to be compatible with the DART VoIP telephone system.
   d. Existing Passenger Emergency Call (PEC) units are located on station platforms, concourses, pedestrian walkways, areas of refuge and other public areas for patrons to communicate with local public service agencies (“911” services) during emergency situations or with the DART customer service department in non-emergency situations. PEC phones operate on a single CO phone or cellular line and have 2 buttons for calling 911 or DART Customer Service.
   e. Existing Elevator Emergency telephones instruments are integrated into each elevator cab panel for patrons to communicate with the Train Control Center (TCC) during emergency situations. Elevator phones are hands free and only have one button for initiating a call. Analog elevator telephones circuits utilize a Gateway conversion for compatibility with DART’s VoIP telephone system.

1.2 REFERENCED STANDARDS

A. Americans with Disabilities Act (ADA)
   1. 28 CFR Part 36 – Nondiscrimination on the Basis of Disability by Public Accommodations and In Commercial Buildings (ADA Standards for Accessible Design)

B. American Society of Mechanical Engineering (ASME)
   1. ASME A17.1a-2002 - Safety Code for Elevators and Escalators

C. Federal Communications Commission (FCC)
   1. 47 CFR Part 68 – Connection of Terminal Equipment to the Telephone Network

D. American National Standards Institute (ANSI)

E. Building Industry Consulting Services International (BICSI)
F. International Organization for Standardization
   1. ISO 9001 – Quality Management Systems - Requirements

G. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)
   2. NFPA 72 - National Fire Alarm Code
   3. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

H. Telecommunications Industries Association (TIA)

I. Underwriters Laboratories (UL)
   1. UL1459 - UL Standard for Safety Telephone Equipment
   2. UL 60950 – UL Standard for Safety, Safety on Information Technology Equipment
   3. UL 50, Type 3R – Enclosures for Electrical Equipment

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements further listed herein.

B. Contractor shall submit for Authority approval the manufacturer and each product differing from those specified in these Specifications. Acceptability of the manufacturer shall be based on the manufacturer’s experience, equipment reliability, compliance with standards specified in this Section, and complete compatibility with the Authority’s current system.

C. Preliminary Design Review (PDR) Technical Requirements shall include the following information as part of the PDR submittal package for the Telephone Subsystem:

   1. Telephone subsystem block diagram, local and overall system description.
   2. Contractor shall submit complete material specification data sheets (MSDS), product samples, specification data sheets and product data including description and model number, shop drawings, catalog cuts, technical literature, software descriptions, and samples, as Authority requested for all equipment provided under this Contract including:
      a. All telephone instruments and accessories
      b. Equipment Enclosures and/or pedestals
      c. Protected Terminal Block (PTB) Assemblies and Protector Modules
      d. Installation Drawings
      e. Location Marker Detail
      f. Enclosure Identification Details including painting and lettering
      g. Operating Instructions and Details
      h. Mounting and installation details and schematics for telephones instruments, pedestals, and enclosures
      i. Complete end-to-end wiring diagrams for each instrument to be installed, including cross connect terminations details
      j. Complete list, in tabular format, of all telephones and jacks installed in the Contract. Each line item shall identify telephone number, IP address, type, e.g., wayside, PEC, elevator, and administrative telephone, and its location.

D. Contractor shall include the following information as part of the Final Design Review (FDR) Technical Requirements submittal package for the Telephone Subsystem:

   1. Update the PDR information including drawings, calculations and design information shall reflect a final design
   2. Electrical Drawings and Calculations
   3. Blue-light light power and control circuit end-to-end wiring details
   4. Telephone cable end-to-end wiring and termination details from each device through the station demarcation termination cabinet, and to the designated CTS equipment
   5. Protector terminal and all equipment grounds to station ground grid end-to-end wiring details
   6. Power cable voltage loss and telephone cable loop voltage loss calculations to confirm proper device operation at designed cable lengths
   7. Installation Work Plans
E. Contractor shall submit the following installation document for each site no later than 30 days prior to the scheduled installation activity. The installation plan shall include:

1. Drawings showing locations of each instrument and details of mounting including conduit details.
2. Installation Procedures including cutover and upgrade details.
3. Configuration and Provisioning Information
4. Network management system detail
5. Calculations or Certifications: UL certifications for all telephone instruments
6. As directed by the Authority, the Contractor shall provide product sample telephones for Authority approval.
7. In accordance with the format and requirements described in these Specifications the Contractor shall submit the following test plans and procedures to satisfy the Telephone Subsystem testing requirements:
   a. Test program plan: Contractor shall include all the required information for the Communications Facilities in the Test Program Plan as outlined in these Specifications.
   b. Contractor shall submit a complete Factory Test and Inspection Test Procedure to satisfy all the requirements outlined in Article 3.2 of this Section.
   c. Contractor shall submit a complete Field Test Procedure to satisfy all the requirements outlined in Article 3.2 of this Section.
   d. Contractor shall coordinate with the Authority for End-To-End system testing. This Contract shall be ultimately responsible for the following End-to-End testing activities for each new telephone instrument installed under this Contract.
   e. Contractor shall provide qualified staff to support the Authority’s System Integration Test (SIT) as described in Article 3.2 of this Section.
   f. Contractor shall submit Test Records and Results for review 1 week after the completion of each test in accordance with the format described in these Specifications.
8. As-Built Documentation
   a. Drawings
   b. Rail Operations Controller (ROC) operating instructions for call connection, disconnect, and use of programmable features for all telephone types.
   c. Operation and Maintenance (O&M) Manuals
9. Final Configuration and Provisioning Information: Contractor shall submit, within 30 days of installation, detailed information for each installed telephone instrument to allow system integration by the Authority.

1.4 QUALITY ASSURANCE
A. Applicable Standards and Codes. Contractor’s design and installation shall comply with all applicable Standards and Codes as listed herein. All equipment and designs shall comply with the latest version of standards as applicable in Article 1.2, Reference Standards.
B. Material and Workmanship Requirements
   1. All telephone instruments shall be registered under 47 CFR, Part 68, and shall comply with UL1459 (UL 60950).
   2. All equipment provided under this Section shall be UL listed.
   3. All telephone instruments shall be ADA compliant and shall be designed and installed in accordance with 28 CFR Part 36.
   4. All telephone instruments shall meet local codes and/or regulations for emergency operation as established by the authority having jurisdiction.
   5. All grounding shall be in accordance with local standards and these Specifications except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.
   6. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within 1 calendar year of the installation date shall not be used.
   7. All products specified herein shall be subject to Authority approval based on the
Contractor’s ability to demonstrate adherence to these Specifications and approval of the manufacturer’s quality process.

8. All new telephone instruments provided and installed under this contract shall be compatible with the DART VoIP PABX extensions delivered over the CTS or by standard Central Office (CO) lines furnished by local Telecommunications Service Providers.

9. All provided telephone equipment shall be new and unused.

C. Manufacturer Pre-Qualification Requirements

1. Manufacturers shall be ISO 9001 certified.

2. Programmable telephone units shall be compatible with a PC based management and maintenance monitoring and reporting package in accordance with Article 2.6 of this Section.

3. All manufacturers supplying product for this Contract shall be pre-qualified by the Authority based on the following criteria:
   a. Past performance and statistical reliability of products in a LRT or similar transit application.
   b. Demonstration Tests or Samples
   c. Certification of Design, Warranty, and Experience

D. Safety

1. Personnel installing any telephone equipment shall be required to follow the Authority safety rules and procedures while performing any field Work.

2. Follow any and all manufacturer recommended safety precautions and considerations during equipment or accessory installation.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. Subsystem

1. PEC units shall be individually fed by unique telephone lines from the demarcation termination cabinet and shall not be parallel wired, daisy chained or “party” lined on the same cable pair.

2. Wayside telephones shall not be parallel wired, daisy chained or “party” lined.

3. The same dial extension lines shall be shared by all telephones within a single signal house.

4. The same dial extension lines shall be shared by the telephones and headset systems within a single TPSS.

B. Telephone Identification. Each wayside and elevator telephone instrument shall be programmed to provide unique on demand information to authorized personnel at the TCC that identifies the telephone location and telephone type to indicate that assistance is required.

1. Contractor shall coordinate with the Authority to determine and program individual telephone identification information to be displayed on PBX station LCD display telephones in the TCC.

2. At a minimum, this identification shall be unique for each telephone and include the type of telephone instrument calling and its location.

C. Telephone instruments installed at station locations such as PEC, elevator, crew room telephones, service building and other administrative telephones shall be wired to station demarcation termination cabinet.

1. Typical station telephone instruments and demarcation termination cabinet details are shown in the Contract Drawings.

2. Demarcation Termination Cabinet terminal wiring assignments shall be in accordance with the Contract Drawings.

D. Contractor shall be responsible for completing each cable path by wiring from the telephone instrument, through the Demarcation Termination Cabinet, to a designated CTS or external Service Provider interface, described below.

E. All lines, except for PEC lines, shall be wired and connected to the CTS. VoIP phones shall be connected via CTS Ethernet switch. Analog phones shall be connected via VoIP gateway and then to the CTS Ethernet switch.

F. Gateway’s (convert analog phones to VoIP) are only to be utilized if required per approved design plans. Coordination with the Authority including product submittals and approvals shall be required for gateway equipment products and configurations to ensure reliability, full-functionality, and compatibility with the DART VoIP system.
G. Contractor shall wire and connect PEC lines from the demarcation termination cabinet to a service provider pedestal for cross connection to CO lines.

2.2 PASSENGER EMERGENCY CALL (PEC)

A. PEC units shall be installed on platforms, concourses, pedestrian underpasses or overpasses, walkways, fare vending areas, areas of refuge or other public areas in the vicinity of LRT stations in locations and quantities shown on the Contract Drawings.

B. PEC Instrument

1. The unit shall be an outdoor-rated (NEMA 3R or better), weatherproof, hands-free, stainless-steel faceplate, ADA compliant communications device.

2. The device shall operate from a single standard Central Office (CO) or cellular telephone line.

3. The unit shall have 1 button, red in color, labeled “EMERGENCY” that when activated, auto-dials a programmed and stored telephone number.
   a. The emergency call function shall be capable of storing a minimum of 2 successively dialed telephone numbers, each at least 10 digits in length.
   b. If the first programmed number does not answer or is busy, the unit shall automatically call the second programmed number after a user selectable number of rings (default should be programmed for 5 rings). The unit shall continue alternating calls between these 2 numbers until the call is answered or a user selectable amount of time has passed.
   c. Contractor shall coordinate with the Authority for telephone numbers to program into the memory locations.
   d. Activation of the emergency call function shall seize the line and preempt (disconnect) a non-emergency call in progress.
   4. The unit shall have 1 button, black in color, labeled “INFORMATION” accompanied by a standard 12 digit DTMF keypad, that when activated, auto-dials a programmed and stored telephone number and, after call connection, allows the ability to enter DTMF digits for navigation through interactive voice response (IVR) prompts.
      a. The information call function shall be capable of storing a minimum of 2 successively dialed telephone numbers, each at least 10 digits in length.
      b. Contractor shall coordinate with the Authority for telephone numbers to program into the memory locations.
      c. The call initiated in this manner shall disconnect either by pressing the “INFORMATION” button during an in-progress call or by automatically ending once the called party has hung up.

5. For emergency calls, there shall be no time-out disconnect, based on length of call, programmed for any PEC. Calls shall remain connected until disconnected by the distant end public safety operator.

6. The telephone shall be capable of and programmed for auto-answering and operation in a monitor mode, where authorized personnel may silently connect a call from any PBX station or external phone location to any field PEC and monitor activity immediately around the PEC.

7. Sound pressure level (SPL) within 3 feet in front of instrument should be a minimum of 3 dB above peak ambient station sound levels and conform to the NFPA 72 requirement of minimum intelligibility of 0.70 on the Common Intelligibility Scale (CIS) scale, corresponding to a Speech Transmission Index (STI) of 0.50. Concealed microphone sensitivity and speaker volume adjustment controls shall be provided for the Authority maintenance personnel to adjust the instrument to acceptable levels.

8. The telephone shall have an auxiliary output that enables peripheral equipment, such as a blue light, to be activated when only the emergency call button is pressed. The auxiliary outputs shall not activate when the information call button is activated. The auxiliary output shall be a solid-state relay that isolates the control voltage from the output contact.

9. Device Impedance. Off-hook impedance of 600 ohms or less.

10. Power Supply. Telephone line powered, requiring no battery back up or external power source.

11. Loop Current (at 48V supply): Minimum range of 24 to 80 mA.
12. Signaling. Capable of operating on standard CO phone lines or analog PBX extensions.

13. Ringer Equivalency (REN): 1.0A or less.


15. Environmental: Negative 4 degrees F to 140 degrees F and humidity of 0 percent to 95 percent non-condensing.

16. PEC units at areas of refuge shall be cellular based. Coordinate with DART for activation of the cellular account for the PEC.

C. Local and Remote Programming. The telephone shall be capable of local programming, through the use of a concealed, integrated, internal keypad or through the use of an externally attached programmer. The telephone shall be capable of remote programming by calling into the telephone over its connected telephone line using any standard touch-tone telephone set connected on the same network.

1. All programming shall be held in non-volatile memory and shall be saved in the event of disconnection from telephone line.

2. A password of at least 4 digits shall be required to enter the programming mode when dialing through the system to program in remote mode. Contractor shall program an identical but non-default password for each PEC and provide this password to the Authority.

D. Unit Enclosure, Identification, and Indication

1. The telephone instrument shall be installed in compliance with ADA guidelines as a self-contained unit within a freestanding, steel tower mount, manufactured by the same company as the telephone.

2. The tower shall be 100 inches tall, plus the height of the blue light assembly.

3. The word “ASSISTANCE” shall be emblazoned on all 4 sides of the tower in 3.25 inches highly reflective white lettering.

4. The color of the tower shall be Safety Blue.

5. The tower shall be mounted in locations indicated on Contract drawings with base plates and epoxy anchor bolts adequate to support the weight of the unit under wind loads described in the Contract Specifications. Base plates shall have an opening of no less than 3” diameter for all power and communications cabling required for operation.

6. The tower shall have at least 1 wiring access point or hand hole near the bottom of the unit, with a removable flush cover secured with tamper-resistant screws.

7. A blue light assembly shall be installed with each PEC telephone.

8. The telephone faceplate shall be illuminated by a 7-watt or less LED or compact fluorescent light for nighttime use.

9. The word “EMERGENCY” shall be incorporated on castings near the red button used to activate the emergency call function and the word “INFORMATION” shall be incorporated on castings near the black button and dial pad on the faceplate of the telephone.

a. Letters shall be raised no less than 3/32-inches, accompanied by Grade 2 Braille lettering, and otherwise comply fully with all requirements of the ADA.

b. Operating instructions shall be incorporated with or adjacent to the telephone.

10. An easily identifiable and labeled LED or other visual indication shall be provided on the telephone faceplate, which is activated by authorized personnel, to acknowledge to the hearing impaired that 2-way communications link has been established.

a. The visual indication shall be extinguished when the 2-way communications link is terminated.

b. The label for this indication shall not imply that any emergency response has been automatically dispatched or is otherwise underway. Such a prohibited example is, “Help is on the way”. Examples of permissible phrases include, “Call Received When Lit”, “Call Connected”, or “Light on Indicates Call Received”.

E. Power

1. PEC units at most locations shall be powered from adjacent station power source.
2. PEC units at places of refuge shall be solar powered with battery backup. Solar panels and battery shall be sized appropriately for the Dallas area and the orientation mounted so as to provide for continuous service. Panels and batteries shall be mounted so as to avoid vandalism.

2.3 WAYSIDE TELEPHONE INSTRUMENTS

A. Wayside telephone instruments shall be installed along LRT right-of-way in quantities and locations as shown on the Contract Drawings.

B. Telephone Instrument

1. The telephone instrument shall be a heavy duty, Dual Tone Multi-Frequency (DTMF) type telephone with standard 12-digit keypad.

2. Line Impedance. Off-hook line impedance shall be 600 ohms.

3. Talk Battery. The talk battery voltage shall be 24V to 48V (nominal) line.

4. Power Supply. Telephone line powered, requiring no battery back up or external power source.

5. Signaling. Signaling to the dial-up line switching equipment shall be via a DTMF push-button keypad. Loop start signaling (FXO/FXS) shall be utilized.

6. Hardware. The handset shall attach to the telephone base by a 19-inch, or greater, non-modular armored cord. The hookswitch shall be non-moveable, magnetic type. The weatherproof keypad shall provide the user with DTMF signaling capability to access specific Authority extensions.

7. Environmental. The wayside telephone instrument shall operate over the temperature range of negative 4 degrees F to 140 degrees F and humidity of 0 percent to 95 percent non-condensing.

C. Wayside Telephone Enclosure and Facilities

1. The phone housing shall be vandal resistant, weatherproof (NEMA 3R or better) and shall withstand corrosive environments. The enclosure shall have a spring closing door with a hasp and pin arrangement to securely latch the door. The enclosure shall be finished with brushed enamel paint, inside and out, in Pantone 116C “Authority Yellow Encoded Stock” color. All wayside telephones shall be permanently labeled with the Authority emblem.

2. An instruction and location marker plate shall be installed on the front cover of each enclosure.

3. The instruction marker shall include a list of all applicable dial extensions for various Authority divisions such as Transit Police and the OCC. Contractor shall coordinate with the Authority for a complete list of required extensions.

4. A blue light assembly shall be installed with each wayside telephone in accordance with Paragraph 2.8.B of this Section.

D. Junction Box: A junction box shall be installed beneath each wayside telephone enclosure. The enclosure shall be a NEMA-3R (or better) gasket protected enclosure with screw-on cover or Authority approved equal. Cover screws shall be tamper-resistant. The junction box enclosure shall be sized to house the wayside telephone terminal blocks.

2.4 ADMINISTRATIVE TELEPHONE INSTRUMENTS

A. Contractor shall provide and install single line, desk or wall-mounted, VoIP Authority compatible telephone instruments, lines, and outlets at communications facilities, TPSS, Signal Houses, crew rooms, aerial station facilities, and other locations as shown in the Contract Drawings.

B. General VoIP telephones

1. Telephones shall be compatible with the Authority’s existing VoIP PBX server and pre-approved by the Authority. Coordinate with the Authority for pre-approved models and requirements.

C. Wall-Mount Telephones

1. Wall-Mount Telephones shall be provided in Communications Facilities, station service facility vestibule areas, TPSS, crew rooms, elevator maintenance rooms,
2. The telephones shall contain a noise-canceling microphone. A wireless headset may be utilized to meet this requirement if approved by the Authority. The noise cancellation microphone and circuitry shall attenuate all background and ambient noise by more than 20 db referenced to the speaker’s voice level.

3. At substations, the telephone shall be installed with a loud ringing bell compatible with the VoIP phones. The loud ringer shall be a single gong type with volume control.

4. Telephones shall have a highly durable retractile handset cord with a minimum length of 25 feet. If a headset is provided this cord length requirement may be reduced with Authority approval.

D. Desk Top Telephones
1. Desktop type telephones shall be provided in crew rooms.

E. Electrical Parameters. Telephone sets provided shall meet or exceed the following specifications:
1. Power: Power over Ethernet (PoE). No external power required

F. Instrument Mounting
1. Location of telephone instruments and local distribution frame terminal block enclosures within rooms shall be as Authority approved.
2. Contractor shall install raceway from the stubbed up communication conduits to the local distribution frame (LDF) enclosure, and Electrical Metallic Tubing (EMT) conduit from the local distribution frame, CIC, or terminal block to each telephone instrument location. EMT conduit routing shall avoid other equipment and heat sources and shall be Authority approved. Pull strings shall be installed within the EMT.
3. Telephone jacks shall be installed at the Authority approved locations utilizing mounting screws. Adhesive mounts shall not be used.
4. Station wire shall be pulled through the EMT after installation of the EMT is complete. Contractor shall use adequate care to avoid damaging the station wire during installation.

2.5 ELEVATOR EMERGENCY TELEPHONE

A. An elevator emergency telephone shall be integrated into each elevator cab installed in stations or any other public area servicing LRT patrons to provide a means of emergency communications from a station patron, located inside the elevator, to the train control center.

B. Elevator Emergency Telephone Instrument
1. The elevator telephone instrument shall be a hands-free, ADA compliant emergency telephone.
2. Elevator telephones shall be compatible with the Authority’s existing VoIP PBX server and pre-approved by the Authority. Coordinate with the Authority for pre-approved models and requirements.
3. Call Operation and Functions
a. The telephone shall be capable of programming, storing, and dialing a minimum of two separate successively dialed telephone numbers, each at least 10 digits in length.
b. The telephone shall be capable of auto-answering and operating in a monitor mode, where authorized personnel may silently connect a call to any field telephone and monitor activity immediately around the telephone.
c. The telephone shall have a DTMF call disconnect function, enabling the control center operator to disconnect the call by pressing and sending a single touch tone key or a series of no more than three touch tone keys.
4. The telephone shall have only a single, 3/4 inch minimum sized button to initiate a call. The unit shall not have a 12-digit dial pad nor shall it use a corded handset in the car.
5. Sound levels at areas within the elevator cab shall be uniform and conform to the NFPA 72 requirement of minimum intelligibility of 0.70 on the Common Intelligibility Scale (CIS) scale, corresponding to a Speech Transmission Index (STI) of 0.50. Sound pressure level (SPL) within three feet in front of instrument should be a minimum of 3 dB above peak ambient station sound levels. Concealed microphone sensitivity and speaker volume adjustment controls shall be provided for DART maintenance.
personnel to adjust the instrument to acceptable levels.


7. Environmental. Minus 20 deg C to plus 60 deg C and humidity of 0 to 95 percent non-condensing.

C. Telephone Mounting, Identification, and Indication:

1. Telephone assembly shall be flush mounted into a recessed area in the elevator control panel, with brushed stainless faceplate finish or a finish to match the elevator panel. Alternatively, the unit may be mounted without faceplate behind an existing control panel that is integral to the elevator cab assembly, so long as the speaker and microphone cutout match, the elevator control panel labeling satisfies ADA standards, and specified features and functions of the telephone are made available. Mounting height shall be in accordance with ADA Standards for Accessible Design, 28 CFR Part 36, Section 4.10.14.

2. A readily identifiable location marker plate indicating station name, address, and telephone location (i.e. south elevator) shall be installed on or adjacent to the faceplate of each telephone.

3. The word “Help” shall be permanently incorporated and visible on the faceplate of the telephone or elevator control panel adjacent to the call button.

   a. Letters shall be raised no less than 3/32 inch, accompanied by Grade 2 Braille lettering, and otherwise comply fully with requirements of the ADA.
   
   b. Operating instructions shall be incorporated with or adjacent to the telephone and shall conform to ASME A17.1a-2002 Section 2.27.7.3.

4. The telephone instrument shall provide on demand information to authorized personnel at the Train Control Center that identifies the Station location, address, and elevator identification (i.e. north or south elevator) and that assistance is required.

5. An easily identifiable and labeled visual indication shall be provided on the same panel as the “Help” call button, which is activated by authorized personnel at the Train Control Center, to acknowledge that two-way communications link has been established.

   a. The visual indication shall be extinguished when the two-way communications link is terminated.
   
   b. The label for this indication shall not imply that any emergency response has been automatically dispatched or is otherwise underway. Such a prohibited example is, “Help is on the way”. Examples of permissible phrases include, “Call Received When Lit”, “Call Connected”, or “Received”.
   
   c. If a lamp is used as the visual indication, it shall be an LED device.

2.6 STATION PROTECTORS AND ENCLOSURES

A. Protected terminal block (PTB) assemblies (also referred to as ‘terminal blocks’), as manufactured by Marconi Communications, Circa Enterprises, Krone, or an Authority approved equal, shall be installed at each telephone instrument with positions sufficient to terminate all cable pairs plus at least 100 percent spare terminations at each telephone location. Station protectors shall be 3 element gas or solid-state type, designed to provide heavy duty transient and power fault protection for this telephone line application and shall meet the following minimum operating characteristics:

   1. Balanced operation
   
   2. DC Breakdown at greater than 350V at 2KV/sec
   
   3. DC Holdover Voltage of less than 150V, less than 200ms
   
   4. Surge Life of greater than 750 surges at 10A, 10x1000µsec

B. Individual terminals shall be sized to accept Outside Plant (OSP) and inside wire conductors.

C. An enclosure shall be installed beneath or adjacent to each telephone enclosure to house the PTBs. The enclosure shall be a NEMA 3R (or better) gasket protected enclosure with screw-on cover or Authority approved equal. Cover screws shall be tamper-resistant and non-corrosive. The enclosure shall be sized to house the telephone station protectors and all wiring. All cable cut outs shall be sized to accept all inbound and outbound cables.
2.7 PROGRAMMABLE TELEPHONE MANAGEMENT AND MAINTENANCE PACKAGE COMPATIBILITY FOR ANALOG TELEPHONES

A. Programmable telephone instruments shall be capable of operation with a single Windows based PC monitoring and reporting package, located at OCC.

B. The monitoring and reporting package shall connect to all instruments over the same telephone line used to connect normal emergency or information calls.

C. Maintenance or management calls to or from a telephone shall not interfere with or interrupt in progress emergency or information calls. If a management call is in progress and an emergency or information button is pushed, the emergency or information call shall disconnect the management call.

D. The telephone and the PC based monitoring package shall provide the following type of functions:

1. Detect and report telephone memory corruption, phone line interruption, microprocessor faults
2. Automatically poll for and report operational status (keep alive and/or health status) of network telephones
3. Automatically report and database any telephone fault condition
4. Provide call reports (with time, date, call length, telephone identification)
5. Generate reports of polling history, maintenance data, and call statistics

E. Contractor shall provide any hardware or software (including manufacturer options) required to provide this functionality to analog telephone instruments provided under this contract in accordance with manufacturers minimum requirements and recommended instructions.

2.8 BLUE LIGHT ASSEMBLY

A. PEC Telephone Blue Light:

1. A blue light fixture with vandal-resistant lens and a lamp and strobe, or combination of flashlamp or strobe shall be installed where specified.
2. Blue light shall be powered by 120V AC as shown in the Contract Drawings.
3. Conduits containing power lines shall be separate from those containing telephone signal wire along any run of ductbank, trough, conduit, or other system element. Signal and power cables shall be separated as much as possible within the stanchion containing the telephone instrument and light fixture. Power cable shall be sized adequately for cable distances and voltage drops and shall conform to the requirements of these specifications.
4. Lamp shall remain constantly on during on-hook situations and shall provide a high intensity strobe when an emergency telephone function goes off-hook.
5. Flash rate of strobe shall be a minimum of 60 and a maximum of 85 flashes per minute (FPM).
6. For telephone instruments with dual emergency and information purposes, the strobe shall only fire when the emergency button has been activated.
7. Strobe shall continue to flash until the call has been completed, when it shall automatically stop flashing and resume normal blue light operation.
8. Lamp shall be compact fluorescent, 13 watt or less, 800 lumens minimum, rated for 10,000 hours minimum. LED lamps of at least equivalent brightness are acceptable, but shall be rated for 50,000 hours minimum.
9. Lamp fixture shall be rated NEMA 3R or better.

B. Wayside Telephone Blue Light:

1. A blue light fixture with vandal-resistant lens and a lamp shall be installed where specified.
2. Blue light shall be powered by 120V AC as shown in the Contract Drawings.
3. Conduits containing power lines shall be separate from those containing telephone signal wire along any run of ductbank, trough, conduit, or other system element. Signal and power cables shall be separated as much as possible within the stanchion containing the telephone instrument and light fixture. Power cable shall be sized adequately for cable distances and voltage drops and shall conform to the requirements of these specifications.
4. Lamp shall remain constantly on at all times.
5. Lamp shall be compact fluorescent, 13 watt or less, 800 lumens minimum, rated for 10,000 hours minimum. LED lamps of at least equivalent brightness are acceptable, but shall be rated for 50,000 hours minimum.

6. Lamp fixture shall be rated NEMA 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. All new administrative, elevator, wayside telephone, and fire alarm device circuit shall be routed to and serviced by the Authority provided VoIP system.

2. Contractor is responsible for programming all PEC telephones in accordance with the Contract Specifications and Drawings.

3. PEC telephone lines shall be cross connected to Telecommunications Service Provider CO lines through the station demarcation termination cabinet to a Service Provider interface panel described later in this Section.

4. Contractor is responsible for programming PEC units to dial over the CO or cellular lines leased by the Authority.

5. The Contractor shall be responsible for the physical interface from the CTS system to each new or affected telephone.

6. Telephone instrument wiring and interconnection details shall be in accordance with these Specifications and Contract Drawings.

7. For elevator phones, the Contractor shall coordinate with the elevator equipment supplier for details in routing telecommunications cabling to the supplied telephone instrument and for telephone compartment dimensions.

8. Under no circumstances shall any emergency function auto-dialed telephone call be routed to voicemail or any other auto attendant answering system. These calls must be programmed to ring primary or secondary locations continuously until answered.

B. Factory Installation

1. Each wayside telephone instrument shall be factory assembled and wired.

2. Each assembly shall be tagged with its intended location.

3. PTBs shall be tagged with cable and color code designations.

C. Field Installation

1. Contractor shall provide, install, wire, and test telephone instruments. The devices shall be wired to a station demarcation termination cabinet, or as shown on Contract Drawings, then wired to designated CTS equipment in the Communications Facilities.

2. Telephone instruments shall be installed in locations, quantities, and configurations as shown on Contract Drawings.

3. Mounting height for all communication devices shall be in accordance with 28 CFR Part 26, Section 4.31.

4. Terminate all telephone cable pairs within each telephone instrument, terminal block, and junction box according to color code. Parallel or daisy chain wiring on the same cable pair, or piggy backing more than 1 pair on the same terminal posts between any telephone instruments shall not be permitted.

5. Telecommunications Service Provider Leased Line Interface to PEC Units

a. PEC units shall be connected to standard Central Office lines, leased by the Authority from SBC, Verizon, or some other local Service Provider, and connected at a Service Provider interface panel (pedestal) to be located adjacent to the demarcation termination cabinet.

b. The Service Provider interface panel shall be furnished by the Authority.

c. Contractor is responsible for installing the Service Provider interface panel in accordance with Contract Drawings and wiring from it to the demarcation termination cabinet to complete PEC circuit connectivity.

d. Contractor shall coordinate all work associated with this task through the Authority and local Service Provider.

6. All externally exposed mounting hardware, fixtures, buttons, ground connections, or
enclosures shall be tamper-proof and vandal-resistant.

7. Conduit from the cableways or pull boxes to and from the PTB enclosure and the telephone enclosure shall be 2-inch GRS conduit per these Specifications.

8. Grounding
   a. All equipment requiring grounding shall be grounded in accordance with manufacturer’s installation instructions and any local or NEC standards.
   b. Wayside telephones, enclosures, and protectors located on bridge or aerial structures shall be grounded to the structure utilizing No. 6 AWG stranded, insulated ground wire and Authority approved ground connection hardware.
   c. The telephone enclosure, junction box, and PTBs for each telephone instrument shall be connected to nearest ground grid.
   d. Telephone cable jacket shields shall be grounded to the PTB ground lug as shown in the Contract drawings.

3.2 TESTING AND INSPECTION

A. General: All testing and reporting shall be performed in accordance with Section 16801, “Basic Technical Requirements.”

B. Contractor shall perform the following inspections and tests on the Telephone Subsystem where applicable. Contractor shall provide written notice to the Authority not less than 10 days prior to each test and inspection so that the Authority may be present as desired.

   1. Factory Test and Inspection: Contractor shall perform or provide manufacturer’s certified testing results for all telephone instruments and interconnection equipment provided under this Contract. Include in this report any test measurement results:
      a. Verify power up
      b. Verify button and/or keypad operation
      c. Perform local programming
      d. Verify speaker and microphone operation
      e. Verify DTMF signaling
      f. Verify ringer operation

C. Field Test and Inspection

   1. The following field installation tests shall be performed from the communications facility CTS interface (i.e. LDF disconnect block) out to the individual telephone instruments using standard telephone line simulators and other equipment. Contractor shall include in this report the results of all test measurements. Contractor shall notify the Authority 21 days prior to testing so that a representative may be present during all telephone testing activities listed below:
      a. Cable pair continuity (DC loop resistance of each cable pair) between telephone instrument station protector terminal and Communications Facilities Local Distribution Frame.
      b. Speaker volume and microphone sensitivity level adjustments to ensure adequate functioning levels with no feedback.
      c. Off hook ringer impedance.
      d. Resistance to remote earth ground of no more than 25 ohms at each equipment, cable shield, and protector block ground connection.
      e. Continuity of each protector block module installed.

2. Functional Testing
   a. Verify successful operation of a test call through the primary connection to a local test unit / call simulator.
   b. Verify full-duplex 2-way communication once call is connected.
   c. Verify both standard ringing and call connection features upon incoming test call to the instrument.
   d. Verify disconnect function on calls initiated from the call simulator.

3. Verify continuous Blue Light voltage levels and operation at installed locations.

D. Contractor shall coordinate with the Authority for End-To-End system test. This Contract shall be ultimately responsible for the following End-to-End
TELEPHONE SUBSYSTEM - COMMUNICATIONS SYSTEM

testing activities for each new telephone instrument installed under this Contract:

1. VLAN provisioning to the CTS network.

2. Coordination with the Authority for VoIP PBX programming and phone functionality as required for a fully functioning system.

3. Connectivity from the phone to the CTS network VoIP VLAN

4. Verify off-hook dial tone, dialing, signaling, loop closure, and call connection of instruments during test calls placed to and from the control center, DART customer service department, or local jurisdiction having authority.

   a. Test calls shall be placed using the manual keypad or programmed auto-dial call buttons, depending on the type of telephone.

   b. The actual programmed auto-dial number(s) shall be used to test telephones with this capability.

   c. Coordinate proper procedures and advanced notice with the local jurisdiction having authority for all 911 test calls.

5. Verify all secondary number(s) programmed for auto-dial operation are functional in the event of primary line non-availability.

6. Verify full-duplex 2-way communication once call is connected.

7. Functionally verify audio performance of instrument during test call. Set transmission level points for specified audio levels.

8. Verify standard ringing or splash-tone upon incoming call to the instrument.

9. Verify silent monitoring function upon incoming call to the instrument.

10. Verify Blue Light strobe activation during PEC emergency and wayside test calls.

11. For the PEC information call function, verify auto-dial connection to, successful transmission of DTMF keypad tones, and proper IVR responses during a test call to the DART Customer Service Department.

12. Verify proper operation of all disconnect functions initiated by the control center and that calls cannot be disconnected by pressing the Emergency call button on the telephone.

13. Verify remote password protection and programming capability.


15. Verify, from the OCC, the on-demand identification of the calling instrument, including correct circuit identification and telephone location for all new telephones on TCC console phone displays upon an incoming call.

16. Verify polling connection, reporting, and full operation with Management and Maintenance application PC system and equipment.

E. Systems Integration Testing (SIT) shall be performed for each new telephone instrument installed in coordination with the Authority’s Systems Integration Consultant after all instrument and subsystem installation and provisioning is complete. Contractor shall provide qualified technical staff to support the Authority’s testing tasks.

   1. Contractor shall provide sufficient resources to correct system integration defects, found during this testing period, within 10 days after notification.

   2. Contractor shall demonstrate to the Authority that all defects found under the System Integration Testing were corrected and no new defects exist.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16851
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Public Address (PA) Subsystem. Work scope includes:

1. Contractor shall design, provide, install and test a PA subsystem in accordance with these specifications and in compliance with the American Disability Act (ADA).

2. The PA subsystem shall allow communications with patrons at Stations via the PA/VMB station controller equipment. The PA/VMB Controller will be provided and installed by the Contractor. The PA/VMB station controller will be communicating with OCC through CTS/Ethernet protocol. The PA subsystem shall allow adhoc and canned messages to be stored and initiated locally and from Operation Control Center (OCC).

B. Existing System Description and Configuration: The existing public address system provides voice messages to Authority patrons at the passenger stations in the North East and North Central lines of the Authority’s LRT system. Voice messages are initiated by the Authority personnel from the Train Control Center (TCC) or locally from PA/VMB input devices with local messages taking precedence over TCC messages. Voice messages can be issued in conjunction with VMB messages or separately.

C. New Work

1. Contractor shall extend the existing PA subsystem to the new stations of the Authority Extensions as shown in the Contract Drawings.

2. Contractor shall install PA equipment in the Station Communication Interface Cabinet (CIC) and/or Communications Facilities as shown in the Contract Drawings and described in these Specifications.

3. The PA subsystem shall allow adhoc and canned messages to be initiated from both the Local PA input device, and the PA/VMB Consoles located at OCC.

4. Contractor shall install all PA, (including Microphone, and cables) as shown in the Contract Drawings and described in these Specifications. Contractor shall wire from the speakers and ambient sensing microphones through the demarcation cabinet to the CIC or Communication Facilities as shown in the Contract Drawings.

5. Contractor shall perform sound studies to properly identify location and orientation of the speakers to satisfy the requirements and performance outlined herein.

6. Contractor shall provide a local PA input device for every Station. The input device shall be in accordance with these specifications and the Contract Drawings.

7. Contractor shall test a complete local PA subsystem as described in this Specification.

8. Contractor shall provide “Next Train” announcement at the stations. Contractor shall coordinate all work between the Signals and Communications work to ensure a seamless implementation of the “Next Train” announcement at the terminal stations.

D. Contractor shall perform all the required work and provisioning at OCC to provide remote access and control of the Station PA subsystem.

1.2 REFERENCED STANDARDS

A. American Disability Act (ADA)

1. 28 CFR Part 36 - Nondiscrimination on the Basis of Disability by Public Accommodations and In Commercial Buildings (ADA Standards for Accessible Design)

B. Underwriters Laboratories (UL)

C. International Electrotechnical Commission (IEC)

1. IEC 60268-16 - Objective Rating of Speech Intelligibility by Speech Transmission Index

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements listed in this Section.

1. Manufacturer Qualifications: Any manufacturer differing from those specified herein shall require a prequalification and Authority approval. Manufacturer acceptability shall be based on the manufacturer’s experience, qualifications, certifications such as ISO-9001, equipment reliability, compliance with standards specified herein, and full...
2. Contractor shall include the following information as part of the Preliminary Design Review (PDR) Technical Requirements for the PA subsystem submittal package:

a. Contractor shall submit an audio coverage analysis verifying the sound coverage, and sound levels of the Contractor’s design. Contractor shall use a standard software package such as “EASE” to perform this analysis. The software package used shall be the manufacturer’s latest version as of Notice to Proceed (NTP).

b. Public Address Block Diagram.

c. Proposed speaker locations at the stations.

d. Material Specification Data Sheets and Product Samples. Contractor shall submit complete product data including description, model number, shop drawings, catalog cuts, technical literature, software descriptions, and samples as requested by the Authority, for all equipment provided under this Contract. Including the followings:

   1) Speakers- Data sheet, samples and all required information on at least 3 speakers with housing, as well as proposed installation detail on each speaker for Authority approval. The Color of the Speaker Housing, grill and backbox shall be Benjamin Moore 1600 with Satin finish.

   e. Proposed instruction as well as the label material to be used for the Local PA announcement instructions (to be installed by the microphone, as describe in this Section).

   f. Identification and specification of all external interfaces to other systems, subsystems provided under this Contract, and to any other Contracts.

   g. Descriptions of modifications required (if any) to the existing equipment to interface with new equipment.

   h. Complete wiring diagrams for all field equipment provided and installed under this contract.

   i. Complete terminal cabling and interconnection diagrams.

   j. Proposed rack layouts and elevations for new field nodes, including assembly drawings, installation drawings, and part lists.

3. Contractor shall include the following information as part of the Final Design Review (FDR) Technical Requirements submittal Package for the PA subsystem:

a. Updated PDR information for drawings, calculations and design information shall reflect a final design.

b. Shelf layout and inventory within equipment chassis.

c. Final wiring details.

d. Final speaker mounting details.

4. Contractor shall submit the following Installation Work Plans and Detailed Documentation for each site no later than 60 days prior to scheduled installation activities. The installation plan shall include:

a. Block and signal level diagram.

b. Wiring diagrams of rack equipment, and to demarcation cabinet and Supervisory Control And Data Acquisition (SCADA) interface. Include power and communications wiring.

c. Equipment layout in plan and elevation views

d. Conduit installation specific to PA.

e. System Configuration and switch setting Data. Contractor shall submit as part of the Installation Work Plan all configuration settings of equipment to be installed.

5. Calculations and Certifications

a. Calculation as listed in the PDR and FDR.

b. Certifications: Copy of the following certifications shall be included:
1) ISO certification for all proposed manufacturers.

6. Product Samples
   a. At least 3 different complete speaker units with housings shall be provided for the Authority to choose and approve. The Color of the housing, backbox, and the grill shall be Benjamin Moore 1600 with Satin Finish, or as directed by the Authority.
   b. Label with instruction printed for operating the local PA microphone shall be submitted for the Authority's approval.

7. Contractor shall submit the following PA Test Plan and Procedures:
   a. Test Program Plan: Contractor shall include all the required information for the PA Subsystem in the Test Program Plan as outlined in these Specifications.
   b. Factory and Inspection Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article 3.2 of this Section.
   c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in Article 3.2 of this Section. This includes a station sound coverage test to satisfy the requirements of these Specifications.
   d. End-To-End Acceptance Test: Contractor shall submit a complete Local End-To-End Public Address Test procedure to satisfy all the required functionality and requirements outlined in Article 3.2 of this Section.
   e. System Integration Test: Contractor shall provide qualified staff to support the PA subsystem integration test as described in Article 3.2 of this Section. System Integration Testing (SIT) will be directed by the Authority.

8. Contractor shall submit all the Test Records for review 14 days after the completion of each test in accordance with these Specifications.

9. As-Built Documentation
   a. Drawings.
   b. Operation and Maintenance Manuals.
   c. Specifications.
   d. Final configuration settings.
   e. Any software source code.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes. Contractor’s design and installation shall comply with all applicable Standards and Codes as listed herein. All PA equipment shall comply with the latest version of the following standards as applicable:
   1. Equipment and installation shall conform to all applicable National Electrical Code, and local regulations.
   2. All equipment shall be UL listed.
   3. Station PA design shall be in compliance with local noise ordinances.
   4. IEC 60268-16

B. Material and Workmanship Requirements
   1. All equipment provided under this Section shall be UL listed.
   2. All grounding shall be in accordance with local standards, and Specifications required by this contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.
   3. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within 1 calendar year of the installation date shall not be allowed.
   4. All products specified herein shall be subject to Authority approval that will be based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.

C. Manufacturer Pre-Qualification Requirements: All equipment provided and installed under this Contract shall be new and compatible with existing equipment installed at the OCC in order to perform the intended use set forth by the Authority.
PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. PA system shall receive and process messages from the OCC Communications Controller. Audio shall be directed to the correct PA speakers by way of the local Station PA/VMB Controller at the station CIC or a Communications Facilities via Ethernet. The PA equipment shall also provide for local generation of audio messages to PA speakers. Contractor shall demonstrate that the proposed PA subsystem equipment listed herein are the same, compatible or better than the existing one, to allow a seamless end-to-end PA subsystem implementation from operational central control to the station.

1. PA Coverage
   a. PA subsystem shall provide intelligible output coverage with nominal Sound Pressure Levels at a level 6 dB to 12 dB over normal train, equipment, and public (ambient) noise during peak travel times.
   b. On station platforms, the coverage shall be a uniform level (within plus or minus 3 dB) at 5 feet above floor level. The coverage area meeting this uniformity requirement shall not be less than 90 percent of the platform area.
   c. On mezzanines, the coverage shall be a uniform level (within plus or minus 3 dB) at 5 feet above floor level. Exact coverage areas are delineated in the Contract Drawings. Audio messages shall be directed simultaneously at platform and mezzanine levels of aerial stations.

2. PA Intelligibility Standards
   a. PA subsystem shall provide a Speech Transmission Index (STI) of 0.8 measured from the input of the station PA equipment to the speaker output covering the station platforms and mezzanine.

3. PA Functions
   a. OCC Public Address Messages. PA messages received from the OCC shall be addressable to a single station.
   b. Local PA messages. Local ad-hoc PA messages shall be generated from a microphone at the station’s CIC, Communications or other Facilities. Local PA messages shall be broadcast to all zones within the station.
   c. “Next Train” announcement. The PA/VMB subsystems shall be capable of automatically generating the “Next Train” announcement at the terminal stations. The Next Train logic signal will be created and made available as dry contacts by Signals System at the station CIC or Communications Facility.
   d. PA /VMB message priorities. The priority of the messages will be as described below.

1) Highest Priority - PA / VMB initiated from a Station Fire Alarm Control Panel (FACP).
2) Second Priority – PA / VMB initiated from a local input device at the station.
3) Third Priority – PA / VMB announcement initiated from the OCC.
4) Fourth Priority – Prerecorded messages.
5) Lowest Priority – “Next Train” message announcement at the terminal stations.
   e. PA Summary Alarm – The following PA subsystem alarms shall be combined into a single PA Summary Alarm using a normally closed contact for reporting to the OCC via the local Remote Terminal Unit:

f. PA Acoustic Feedback. Contractor’s design shall prevent acoustic feedback from local PA announcements.
g. PA Power Amplifier Redundancy. The failure of any one PA power amplifier shall not result in the loss of PA coverage in any station area.

h. PA Sound Level. The sound level shall be automatically adjusted upward through the use of a sensing microphone or microphones located centrally at the station to compensate for increases in ambient sound levels.

1) Compensation shall not exceed 15 dB above ambient sound levels.

2) Maximum sound level shall not exceed 105 dBA.

i. PA Zoning. Platforms shall have coverage for 4 zones. Two zones are required, a Northbound Zone, and a Southbound Zone. Third zone shall be for Mezzanine, and the forth is reserved for future applications such as the station parking lot.

1) PA Chime shall initiate from the PA/VMB Controller.

B. Public Address Equipment General Requirements

1. Unless superseded by specific equipment requirements below, the PA electronic equipment shall have the following general specifications:

a. Solid state design

b. Latest manufacturer’s model

c. Balanced outputs

d. Rack-mountable

e. Frequency response: 30 to 20 kHz within plus or minus 1 dB

f. THD: Less than 1 percent over the frequency range at full rated output.

g. Hum and Noise: Less than 80 dB at rated output.

1. Audio Processor performance criteria include:

a. Audio:

1) Phantom Voltage: 24V DC

2) Input Gain Range: plus 20 dB to negative 12 dB

3) Digital Sampling: 24 bit, 48 kHz

4) Input Impedance: 20 kohms balance, 10 kohms unbalanced

5) Dynamic Range: greater than 100 dB (A-weighted, 20 Hz to 20 kHz)

6) Frequency Response: within plus or minus 0.5 dB, 20 Hz to 20 kHz

7) Common Mode Rejection: 50 dB at 60 Hz

8) Crosstalk: greater than 80 dB at 10 kHz

9) Total Harmonic Distortion: less than 0.05 percent

10) Maximum Input Level: plus 32 dBu line, or plus 7dBu mic

11) Output Impedance: 100 ohms balanced, 50 ohms unbalanced

12) Control Port:

a) Power Supply: plus 5V DC and plus10V DC at 1A

b) Outputs: logic low and logic high

c) Inputs: logic low and logic high, 0 to 10V analog

2.3 AUDIO POWER AMPLIFIERS

A. The audio processor shall be compatible or better than the current audio processor a Crown IQ-USM 810. The audio processor shall provide mixing, filtering, busy and processor faults, and sound level controls.

Audio power amplifiers shall be Power Amplifier Crown CTs Series 600 amplifiers or Authority approved equal to allow a seamless end-to-end PA subsystem implementation from operational central control to the station. Contractor shall provide amplifiers in the size and quantity to provide a power capacity 50 percent greater than...
the power output required at nominal sound pressure levels.

1. The amplifier performance criteria include:
   a. Frequency Response: 20 Hz to 10 kHz
   b. Signal to Noise Ratio: less than 105 dB A-weighted
   c. Total Harmonic Distortion: less than 0.1 percent at full rated power
   d. Inter-modulation Distortion: less than 0.1 percent, 60 Hz and 7 kHz at full power
   e. Crosstalk: greater than 80 dB, 20 Hz to 1 kHz
   f. Voltage Gain: 70V operation, 1.4V sensitivity
   g. Common Mode Rejection: 50 dB, 20 Hz to 1 kHz
   h. AC Line Voltage: 120V AC
   i. Front Panel Indicators: Bridge Mode, Ready, Signal, Clip, Thermal, Fault, Data, Power
   j. Protection: thermal, fault, filters, over- and under voltage, circuit breaker, inrush limiting

2.4 DIGITAL SIGNAL PROCESSOR (DSP) - FAULT MONITOR

A. Fault monitor shall be compatible or better than the current DSP Crown IQ P.I.P.-USP2 DSP and Load Supervision module. The module shall provide continuous supervision of the amplifier and loudspeaker lines. The fault monitor failure outputs shall be wired and integrated into the PA Summary Alarm as described in Paragraph 2.1A.3.e of this Specification.

B. Fault monitor Performance Criteria shall include:
   1. Amplifier output monitor.
   2. Ethernet plug.
   3. 24-bit conversation and 32 bit DSP processing.
   4. 64 assignable filters with multiple filter types.
   5. Two-second available delay.
   6. Input compressor and output limiters.

2.5 SPEECH PROCESSOR

A. A speech processor shall be required to enhance speech intelligibility in loud noise-floor environments. Speech processors shall be installed at stations where ambient noise levels (with no trains idled at the station) exceed 70 dB over any operating time.

B. Speech processor shall be compatible or better than the current equipment a Communications Company SP-1.

1. Speech processor performance criteria shall include:
   a. Type: adjustable peak clipping of a lower sideband sing at suppressed carrier frequency
   b. Frequency Responses:
      1) Select On: 6 dB/octave pre-emphasis up to peak from 1500 Hz to 3100 Hz, 18 dB rolloff above 3400 kHz
      2) Select Off: Flat Response
   c. Output: 0 to 10V into 600 ohms
   d. Input: line and microphone
   e. Frequency Shift: 7 Hz shift for control of acoustic feedback
   f. Remote Select: contact closure to ground, or floating control to 24 V DC
   g. Front Panel Controls:
      1) Line level
      2) Microphone level
      3) Clipping level
      4) Output level
      5) Local/Remote switch
PUBLIC ADDRESS SUBSYSTEM - COMMUNICATIONS SYSTEM

6) 7 Hz switch
7) Power on/off

h. Rear Panel Controls:
1) Microphone pad
2) Line In/out ground switch

i. Displays:
1) Clipping bar graph: negative 3 dB to 24 dB
2) Output bar graph: negative 9 dB to +18 dB

2. Speech processor shall be considered as part of the PA subsystem in meeting the intelligibility requirements.

2.6 SPEAKERS
A. The speakers shall conform to the following:
1. Sensitivity 2.83 V at 1 m.: 90 dB (anechoic), 93 dB (half space).
2. Rated impedance: 8 ohms
3. Rated power: 50 watts (average)
4. Wattage tap selections: 30, 15, 7.5, 3.75 watts
5. Frequency response: 80 Hz to 22 kHz

2.7 PA CABLES
A. PA cables shall conform to the requirements of these Specifications and the Contract Drawings.

2.8 SENSING MICROPHONES
A. Sensing microphones shall be compatible or better than the current microphone Crown PZM11LLWR.
1. Microphone performance criteria include:
   a. Frequency Response: 80 Hz to 10 kHz
   b. Polar Pattern: hemispherical
   c. Impedance: 75 ohms
   d. Sensitivity: 1.4V/ Pa

2.9 STATION PA/VMB CONTROLLER
A. Station PA/VMB Controllers are common equipment to the PA and the VMB subsystem described in these Specifications. PA equipment including public address audio line selection/pre-amplification shall interface to a single Station PA/VMB Controller at the Station CIC or Communications Facility as shown in the Contract Drawings.

B. Station PA/VMB Controller will be provided and installed by the contractor and shall be fully compatible with the existing system located at the OCC. The controller shall be equipped with all required modules to satisfy all requirements for PA/VMB communications from the local PA/VMB input device. The PA/VMB Controller shall perform the following PA functions:
1. Provide multiple audio outputs to support PA zoning as described in this Section.
2. Accept multiple local audio input sources. Provide priority selection of audio sources.
3. Provide 10/100 BASE T Ethernet interface to support network communications and connection to SONET backbone.
4. Provide fiber optic network interface card where Ethernet link exceeds 100 meters.
5. Store multiple PA and VMB messages locally and remotely for automatic selection.
6. Report equipment fault via contact closures as a summary alarm connected to the local RTU and transmitted to OCC for alarm indication.
7. Provide 4 PA zones per station.
8. Provide an interface for local input device.

2.10 LOCAL PA INPUT DEVICE
A. Local PA announcements shall be initiated from a hardwired push-to-talk microphone located in the CIC, Communications Facility or an aerial station FACP, and as shown in the Contract Drawings.

B. Operational instruction for local announcement shall be provided at the microphone or as directed by the Authority.

C. Color of the microphone for local announcement shall be red.
PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Contractor shall meet the requirements of this subsection in meeting the installation requirements.

B. Factory Installation: Contractor shall mount and wire PA equipment in a rack prior to shipment to the site for final installation.

C. Field Installation

1. PA speakers shall be installed and wired by the Contractor. Cables from the speakers shall be wired to the Demarcation Cabinet as shown in the Contract Drawings.

2. PA amplifiers and other equipment shall be installed as shown in the Contract Drawings. All PA cable entering the location of the station’s PA/VMB Station Controller shall be wired through protected terminal blocks at that location. Power shall be derived from the Uninterruptible Power Supply (UPS) as shown in the Contract Drawings.

3. The Local PA Input Device shall be installed as shown in the Contract Drawings.

4. Contractor shall ensure the housings, backboxes, and the grills of all speaker assemblies shall be painted Benjamin Moore 1600 with Satin Finish in accordance with Section 09970 “Coatings for Steel”, or as directed by the Authority.

3.2 TESTING

A. General: Contractor shall meet the requirements of this subsection in meeting the testing requirements. The testing of the working PA subsystem shall be the responsibility of the Contractor and other contracts organized as:

1. Contractor shall prepare test plans, test and inspection procedures and checklists, conducting the test and/or inspection until acceptable results are achieved, and preparing and submitting test and/or inspection reports.

B. Factory Testing and Installation Inspection

1. Contractor shall perform factory tests of the racked and wired PA equipment. Minimum testing requirements shall be:

   a. Power on test. Measure input current under no load.

   b. Power under load. Measure input current under expected average and peak load.

   c. Functional test of system faults.

   d. Microphone and line level input to output test under load.

   e. Frequency response test under load.

2. Installation Inspection: Contractor shall perform an Installation Inspection on installed PA equipment. Inspection shall be done using the Installation Drawings and an Installation Inspection Checklist. All non-conforming checklist items shall be noted.

C. Field Test

1. Contractor shall perform field tests consisting of the following:

   a. Functional tests of equipment for line and microphone inputs at nominal Sound Pressure Level.

   b. Functional test of detecting and reporting PA equipment indications.

   c. Functional test of priority select between Local and OCC messages.

   d. Functional test of the “Next Train” message announcement and visual indication at each Terminal station.

   e. Functional test of feedback for locally generated PA messages.

   f. Functional test of pre-recorded message operation.

   g. Correct phasing of all speakers.

   h. Functional and sound level test of the chime.

   i. Functional testing of ambient sound level sensing and PA sound level compensation mechanism.

   j. Audio coverage test: Under canopies, at 5 feet above the platform level, test frequencies at 250 Hz, 1 kHz, 3 kHz, Sound Pressure Level (dBA scale). Confirm coverage requirements. Measurements made every 5 feet
along platform edge and extending 5 feet beyond the canopy limits.

k. Audio coverage test: On mezzanines, at 5 feet above the mezzanine level, test frequencies at 250 Hz, 1 kHz, 3 kHz, Sound Pressure Level (dBA scale). Confirm coverage requirements. Measurements made every 100 square feet as shown in the Contract Drawings.

l. Contractor shall perform an intelligibility test using the STI method as described in IEC 60628-16 and at specific locations as identified above.

D. System End-To-End Acceptance Test

1. Contractor shall provide a local End-To-End test procedure to test a complete local PA Subsystem at every station to show the proper functionality at the field.

2. Contractor shall perform End-To-End testing of the field PA/VMB equipment to the servers at OCC.

E. Systems Integration Test: Contractor shall provide technical support to the Authority in performing System Integration Tests. This test shall include a complete PA/VMB test including the field and OCC elements.

F. Contractor shall submit test reports, including items specific to technical requirements, above. In addition, the Contractor shall record in tabular form all test configuration settings of the PA equipment. The Test records and results shall be submitted 14 days after each test.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16852
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the detailed technical requirements for the Visual Message Board (VMB) Subsystem to be designed, provided, installed, and tested under this Contract. Work scope includes:

1. Contractor shall design, provide, install and test a VMB subsystem to complement the Station Public Address (PA) subsystem and comply with American Disability Act (ADA) requirements. The PA/VMB equipment at the stations shall be coordinated and be compatible with the PA/VMB equipment at the OCC.

2. The Public Address/Visual Message Board (PA/VMB) subsystems shall allow communications with patrons at Stations via the PA/VMB station controller equipment. The PA/VMB station controller (provided by DART for installation by the Contractor) shall communicate with the OCC via SONET/Ethernet protocol. The PA/VMB subsystem shall allow live and canned messages to be initiated from both the Local PA/VMB input device, and the PA/VMB Console(s) located at Operation Control Center (OCC).

B. Existing System Description and Configuration:
The existing VMB subsystem provides text messages to the Authority patrons at the existing stations in the North East and North Central Light Rail Transit (LRT) system. Text messages are initiated by the Authority personnel from the Train Control Center (TCC) or locally from a PA/VMB Message Panel with local messages taking precedence over TCC messages. Text messages can be issued in conjunction with public address messages or separately. The existing visual message signs are manufactured by Daktronics, Inc (Galaxy, X-1001-16x96-4.2-Tri-color), Daktronics, Inc. (Galaxy AF-6200-16x96-RG-DF) and Luminator (510999-002 and 510999-001).

C. New Work.

1. Contractor shall provide a VMB subsystem to the new stations in accordance with Technical Specifications and the Contract Drawings.

2. Contractor shall install VMB equipment in the Station Communication Interface Cabinets (CIC) and/or Communications Facilities as shown in the Contract Drawings and described in these Specifications.

3. Contractor shall install station VMB wiring as shown in the Contract Drawings. Contractor shall wire from the Sign through the demarcation cabinet to the CIC or Communications Facilities as shown in the Contract Drawings.

4. Stanchions for supporting the VMBs shall be designed, provided and installed by the Contractor. Contractor shall mount the VMBs on these stanchions and complete the final connections for power and communications.

5. Contractor shall provide “Next Train” message announcement (simultaneous audio and text message) at Terminal stations. Contractor shall coordinate all work between the Signals and Communications work to ensure a seamless implementation of the “Next Train” announcement (PA and VMB) at each terminal station.

6. Contractor shall perform tests as described in these Specifications.

7. Contractor shall test a complete local VMB subsystem as described in this Specification including all the work and provisioning required at OCC to provide remote access and control from the OCC, and System Integration test. Contractor shall provide coordination and qualified technical staff to support design and implementation of a seamless and complete PA and VMB subsystem.

8. Contractor shall take the lead, with support from the Authority in troubleshooting of the PA VMB system, when the station equipment does not function or communicate properly with the remote equipment at OCC.

9. Provide and install a KVM (keyboard, video, mouse) style input device with each PA/VMB Controller for local control and configuration.

1.2 REFERENCED STANDARDS

A. Americans with Disabilities Act (ADA)

1. 28 CFR Part 36 – Nondiscrimination on the Basis of Disability by Public Accommodations and In Commercial Buildings (ADA Standards for Accessible Design)
B. International Organization for Standardization
   1. ISO 9001 – Quality Management Systems - Requirements

C. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)

D. Underwriters Laboratories (UL)
   1. UL 48 - Standard for Safety Electric Signs

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements further listed in this Section.

1. Manufacturer Qualifications:

   a. Any manufacturer differing from those specified herein shall require a prequalification and Authority approval.

   b. Manufacturer acceptability shall be based on the manufacturer's experience, qualifications, and certifications, i.e., ISO-9001, equipment reliability, and compliance with standards specified herein, and full compatibility with the Authority's existing system.

2. Preliminary Design Review (PDR) Technical Requirements

   a. Contractor shall include the following information as part of the PDR submittal package for the VMB subsystem:

      1) Visual Message Board Subsystem Block Diagram
      2) Electrical diagrams, calculations and power requirements.
      3) Demonstration of sign display characteristics including graphics and compatibility with the existing VMB controller software (Venus 1500 v1.83 from Daktronics).

   4) Contractor shall provide data sheet, samples and all required information on the signs to include the housing and installation details for Authority approval.

   5) System compliance documentation for ADA requirements.

   6) Material Specification Data Sheets and Product Samples. Contractor shall submit complete product data including description and model number, shop drawings, catalog cuts, technical literature, software descriptions, and samples (as requested by the Authority), for all equipment provided under this Contract.

   7) Identification and specification of all external interfaces to other systems, subsystems provided under this Contract, and to any other Contracts.

   8) Descriptions of modifications required (if any) to the existing equipment to interface with new equipment.

   9) Complete Wiring diagrams, terminal cabling, and interconnecting diagrams for all field equipment provided and installed under this Contract.

   10) Proposed rack layouts and elevations for new field systems, including assembly drawings, installation drawings, and part lists.

   11) Proposed VMB stanchion layout and elevation.

3. Final Design Review (FDR) Technical Requirements: Contractor shall include the following information as part of the
FDR submittal package for the VMB subsystem:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

b. Shelf layout and inventory within equipment chassis

c. Final wiring details, including alarm points

d. Final VMB mounting details including stanchion structural design details.

4. Installation Work Drawings and Detailed Documentation: Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The Installation Work Drawings shall include:

a. Drawings and Diagrams. Contractor shall submit installation drawings and diagrams for each station installation. Specific drawings and diagrams shall include:

1) Block diagram

2) Wiring diagrams of rack equipment showing Supervisory Control And Data Acquisition (SCADA) interface, including power and signal wiring.

3) Equipment layout in drawings and side views

4) Conduit installation specific to VMBs

b. System Configuration and switch setting data. Contractor shall submit as part of the Installation Work Drawings all configuration settings of equipment to be installed.

c. Procedures. Contractor shall submit installation procedures as part of the Installation Work Drawings for each station.

5. Calculations and Certifications

a. Calculation as listed in the PDR and FDR.

b. Certifications: Copy of the following certifications shall be included:

1) ISO certification for all proposed manufacturers.

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority. This may include the proposed visual message signs.

7. Test Procedures, and Results

a. Test Procedures shall be submitted in accordance these Specifications, and specifically Section 16801, Basic Technical Requirements – Communications System”, and as outlined herein:

1) Test program drawings: Contractor shall include all the required information for the VMB subsystem in the Test Program drawings as outlined in these Specifications.

2) Factory and Inspection Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article 3.2 of this Specification.

3) Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in Article 3.2 of this Specification.

4) End-To-End Acceptance Test: Contractor shall submit a complete Local End-to-End Public Address and Visual Message Board Test procedure to satisfy all the required functionality and requirements outlined in Article 3.2 of this Specification.

b. System Integration Test (SIT): Contractor shall provide qualified staff to support the VMB SIT as described in Article 3.2 of this Specification. SIT will be directed
8. Test Records: Contractor shall submit the Test Records for review 14 days after the completion of each test, in accordance with these Specifications.

9. As-Built Documentation
   a. Drawings, conduit and cable schedule
   b. Operation and Maintenance Manuals
   c. Specifications
   d. Final configuration settings

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes: Contractor’s material, design installation and testing shall comply with all applicable Standards and Codes as listed herein. All VMB equipment shall comply with the latest version of the standards as applicable in Article 1.2 of these Specifications.

B. Material and Workmanship Requirements.
   1. VMB shall meet ADA requirements for message display at stations. Contractor shall submit documentation showing compliance with ADA requirements.
   2. All equipment provided under this Section shall be UL listed.
   3. All grounding shall be in accordance with local standards, and specifications required by this Contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.
   4. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within 1 calendar year of the installation date shall not be used.
   5. All specified material shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.
   C. Manufacturer Pre-Qualification Requirements: All new equipment provided and installed under this contract shall be compatible with the existing VMB System equipment installed in the field and central locations in order to perform the intended use set forth by the Authority.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. VMB system shall receive and process messages from OCC. Messages shall be directed to the correct VMB display by way of the local PA/VMB Station Controller at the station CIC or Communications Facilities. The VMB equipment shall provide for local generation of messages to be displayed and broadcast at the station’s VMB equipment.
   1. VMB Coverage. The VMBs shall be placed on the platform so that patrons can see the displayed message from all positions along the platform edge. VMBs on mezzanines in aerial stations shall be located as shown in the Contract Drawings.
   2. VMB Zones. VMBs shall be individually addressable and capable of sending messages to minimum of 4 zones.
      a. Two Zones for station platforms. One zone is for the north bound platform side, and the second is for the south bound platform side. In the case of a station side platform, each is a zone. In the case of a station center platform, each side of the platform is a zone.
      b. Third VMB zone shall be the mezzanine area.
      c. The fourth Zone shall be for other applications such as parking lot or underpass.
      d. Messages directed to any of the platform zones shall be displayed on mezzanine VMBs.

2.2 STATION PA/VMB CONTROLLER

A. The Station PA/VMB Controller is common equipment to both PA and VMB subsystems, described in detail in these Specifications.

B. The station PA/VMB Controller will be provided by the Authority for installation by the Contractor. The controller will be equipped with all required modules and software applications to satisfy all requirements for PA/VMB communications from local VMB input device for the existing signs (Daktronics, Galaxy Model No. X-1001-16X96-4.2-Tri-Color). The PA/VMB Controller will perform the following functions:
1. Provide multiple audio and data outputs to support PA and VMB zoning.

2. Accept multiple local audio input sources. Provide priority selection of audio sources.

3. Provide 10/100 BASE T Ethernet interface to support network communications and connection to the CTS network.

4. Provide fiber optic network interface card where Ethernet link exceeds 100 meters.

5. Store multiple local PA and VMB messages for automatic selection.

6. Report equipment fault via contact closures connected to the local RTU.

7. Provide an interface for local input device.

8. Modification to controller interfaces may be required for connection to new VMB signs. Contractor is responsible for required modifications.

2.3 VISUAL MESSAGE BOARD

A. The VMB is used to display visual messages at the stations. The VMB shall be the Daktronics, Inc Galaxy Model No. AF-6400-48x240-6-RGB-DF or Authority approved equivalent and be compatible with the existing sign control software. Visual messages shall be initiated from the OCC, and from a Local PA/ VMB Input Device.

1. OCC Visual Messages: Visual messages received from the OCC shall be addressed to one or both platform zones in a station. Messages shall appear only in the zone addressed.

2. Local Visual Messages: Local VMB messages shall take priority over OCC initiated messages and shall appear in all zones within the station.

3. Location: Contractor shall provide VMB signs at Station at locations and in quantities shown on Contract Drawings.

4. VMB Display: The VMB shall be capable of displaying text or graphic images on a large bright screen of high intensity red and green light emitting diodes (LED). The display shall have the following characteristics and be compatible with the current system:

   a. Variable character heights: Minimum of 2 lines of text, minimum 21 character per line when the character height is 4 inch

   b. Automatic Intensity Control

   c. Minimum of 16M colors. Viewing angle shall be plus or minus 70 degrees from center axis

   d. Multiple Fonts

   e. Multiple display effects; flash, scroll, roll, graphics.

   f. Graphic Capability

       1) Address individual pixels to form an image.

       2) Utilize bitmapped (bmp) files to create graphic frames on the display face

5. VMB Addressing: Each VMB shall be individually addressable from OCC for sending information, configuring memory, and for investigating the contents of memory. VMBS shall be addressable as groups, such as, station, extension, or platform zone.

6. VMB Intensity: The VMB shall automatically lower its intensity in concert with ambient light conditions. The peak intensity settings during daylight hours and night hours shall be subject to the Authority approval.

7. VMB Strobe: Each VMB shall include a strobe light capable of signaling deaf patrons when a visual message is being broadcast.

8. VMBS shall be equipped with sunshades.

9. VMB LED Characteristics shall conform to the following:

   a. VMB Display Characteristics: The overall luminous intensity shall be a minimum of 5000 nits

   b. LED Size: 6.6 mm maximum.

   c. Pixel: Each pixel shall include 1 surface mounted LED controlled to enable a minimum of 16M colors
10. VMB Physical and Electrical Characteristics shall conform to the following:

a. Below Ground Enclosure: NEMA 4X (NEMA 4X rating shall be preserved even after installation, including all mounting hardware and cable conduits)

b. Above Ground Enclosure: NEMA 3R (NEMA 3R rating shall be preserved even after installation, including all mounting hardware and cable conduits.

c. Enclosure Size: 18 inches high by 70 inches wide by 14 inches Deep (without sunshade) maximum

d. Display Window: Shatterproof, vandal resistant, ultra-violet resistant, condensation prevention.

e. Metal Components: Corrosion resistant

f. Maintenance Access: Access doors on each side of double sided sign

g. Input Power: 120V AC UPS circuit

11. VMB strobe shall conform to the following:

a. Mounted on VMB

b. Strobe Rate: 1 per second

c. Vandal resistant and weatherproof

2.6 VMB CABLES

A. VMB cables shall conform to the requirements of Section 16841, “Communications Cable – Communications System”, and these Specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Contractor shall meet the requirements of this subsection in meeting the installation requirements.

B. Field Installation

1. OCC Installation: The required wiring, provisioning and cross-connects at the OCC Equipment Room will be performed by the Contractor. Coordinate with the Authority for access and as-built conditions.

2. VMB Installation

a. VMB stanchions and foundations shall be installed as designed by the Contractor and approved by the Authority.

b. Color of VMB housing shall match stanchion color, Benjamin Moore 1600, and be subject to the Authority approval.

B. Color of sunshade shall match the housing color. Outside color of sunshade can be a lighter shade to reduce direct heat gain. Color shall be subject to the Authority approval.

3. VMB communication equipment shall be installed as shown in the Contract Drawings. All communication cable to/from the CIC or Communications Facilities shall be wired through protected terminal blocks and proper grounding.

4. Power shall be derived from UPS as shown in the Contract Drawings.

5. A pullout tray shall be provided at the PA/VMB cabinet to support a laptop PC or other maintenance equipment, for troubleshooting and testing purposes. Power and communication jacks shall be allocated for the laptop. This will allow include summation of the PA/VMB Controller trouble, loss of communications with VMB, and the VMB trouble signals.

2.4 LOCAL VMB INPUT DEVICE

A. Local adhoc VMB messages shall be able to be initiated from a local pull out drawer style keyboard, mouse, and a LCD display panel, installed in the rack at the Station CIC or Communications Facilities. See Contract drawings for more details.

B. A pullout tray shall be provided at cabinet to support additional user / maintenance devices.

2.5 VMB SUMMARY ALARM

A. The VMB summary alarm shall be available to OCC via dry contacts provided to the Communications Central Contractor at the interface panel (to be transmitted to OCC via the RTU). The summary alarm shall be designed and provided as 1 single dry contact alarm to
adjacent and convenient connection from laptop to the pullout tray side.

3.2 TESTING

A. Contractor shall perform the following inspections and tests on the VMBs. The Authority shall be given at least 21 days written notification prior to each test and inspection so that the Authority may be present as desired.

1. Factory Test and Inspection:
   a. Contractor shall inspect the VMB at the Factory for conformance to Specification manufacturing standard requirements.
   b. Contractor shall perform factory tests of the racked and wired VMB equipment. Minimum testing requirements shall be:
      1) Power on test. Measure input current under no load.
      2) Power under load. Measure input current under expected average and peak load.
      3) Functional test of system faults.
      4) Conformance to light output and viewing angle requirements.
      5) Contractor shall submit test reports, including items specific to technical requirements, above. In addition, the Contractor shall record in tabular form all test configuration settings of the VMB equipment.

2. Installation Inspection
   a. Contractor shall perform an Installation Inspection on installed VMB equipment. Inspection shall be done using the Installation Drawings and an Installation Inspection Checklist. All non-conforming checklist items shall be noted.
   b. Contractor shall submit Installation Inspection reports, including items specific to technical requirements, above.

3. Field Equipment Tests
   a. Contractor shall perform the following field equipment functional tests:
      1) Functional test of all message features.
      2) Functional test of strobe feature.
      3) Equipment failure supervision interface.
      4) Display of locally generated messages and OCC initiated messages.
      5) Demonstration of graphics capability.
      6) Functional test of single and multiple zone operation.
      7) Strobe operation and timing
   b. Contractor shall submit the reports within 14 days after completion of each Field Test. Contractor shall also submit Installation Inspection reports, including items specific to technical requirements, above.

4. System End-to-End Acceptance Test
   a. Contractor shall provide a local end-to-end test procedure to test a complete Visual Message signs at every station to show the proper functionality and performance at the field.
   b. Contractor shall provide a local end-to-end test procedure to test complete “Next Train” functionality at each Terminal station. This includes the audio and visual announcement; priority of the announcement, and the testing of the Signals System Next Train Logic. This will ensure the interface and implementation of this function in the field are in accordance with the requirements outlined in these specifications.
   c. Contractor shall perform End-To-End testing of the field PA/VMB equipment to the OCC server.
d. Contractor shall submit the end-to-end test reports within 14 days after completion of each test.

5. Systems Integration Test

a. Contractor shall provide technical support to the Authority's System Integration Consultant in performing SITs. This test shall include a complete PA and VMB subsystems functional test including the field and OCC elements.

b. Contractor shall submit the test records for any work done under SIT within 14 days after completion of each test.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16853
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Fire Alarm Subsystem to be designed, provided, installed, and tested under this Contract. Scope of Work includes:

1. Providing, installing and testing all fire alarm and associated equipment in Communication Facilities and any other facilities referencing this section and as shown in the Contract Drawings.

2. Providing a fire suppression system in facilities (communications, signal houses, traction power substations) where required by code. The fire suppression system shall be in accordance with the latest applicable codes, including:
   a. Requirements of local Jurisdictional Authority
   b. NFPA
   c. UL Listings

B. The new Fire Alarm Subsystem work shall include a Fire Alarm Control Panel with IP communications and an IP compatible DACR. Requires redundant new DACR units at the OCC, new DACR software and GUI. This functionally eliminates the use of a DACT and 2 analog phone lines per reporting facility that were previously provided as part of DART legacy fire alarm system. The Fire Alarm Subsystem is subject to approval by the City of Dallas.

C. Fire alarm control panels, sensors, annunciators and associated equipment shall be common to all new facilities including communications rooms, stations, signal houses, substations, and other Authority facilities referencing this Specification Section.

1.2 REFERENCED STANDARDS

A. American Society for Quality (ASQ):
   1. ASQ Z1.11 - Quality Assurance Standard

B. Institute of Electrical and Electronics Engineers (IEEE):
   2. IEEE C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits

C. International Organization for Standardizations
   1. ISO 9000 - Quality Management Systems - Fundamentals and Vocabulary
   2. ISO 9001 - Quality Management Systems - Requirements

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electric Code (hereinafter referred to as NEC)
   2. NFPA 72 - National Fire Alarm Code

E. Underwriters Laboratories, Inc. (UL):
   1. UL 268 - Standard for Safety Smoke Detectors for Fire Protective Signaling Systems

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements further listed in this Section.

1. Manufacturer Qualifications:
   a. Fire Safety Professional Engineer: Qualifications, with verification of experience and license number, of a Licensed Fire Safety Professional Engineer in the State of Texas, with at least 4 years of current experience in the design of fire protection and detection systems shall be provided to the Authority for approval prior to commencement of design.
   b. Equipment Installer
      1) Documentation demonstrating that the fire alarm system installers have been regularly engaged in the installation of fire detection and suppression and alarm systems meeting NFPA standards for a minimum of 3 years immediately preceding commencement of this contract shall be provided as part of the Installation Work Plan.
      2) Documentation shall include proof of satisfactory performance on at least 3 projects similar to that
required by these specifications, including the names and telephone numbers of using agency points of contact for each of these projects.

3) Documentation shall indicate the type of each system installed and include a written certificate that each system has performed satisfactorily in the manner specified for a period of not less than 12 months following completion.

4) Listing of the installer under "Protective Signaling Services - Local, Auxiliary, Remote Station Proprietary (UUJS)" or under "Protective Signaling Services - Central Station (UUFFX)" of the UL Fire Protection Equipment Directory will be accepted as equivalent proof of compliance with the foregoing experience requirements.


a. Contractor shall include the following information as part of the PDR submittal package for the Fire Alarm Subsystem:

1) Battery calculations shall be provided for supervisory and alarm power requirements.

2) Ampere-hour requirements for each Fire Alarm Panel and all sensor components and the battery recharging periods shall be included.

3) Battery calculations shall substantiate both NFPA 72 and specification requirements.

4) A complete list of Fire Alarm Subsystem equipment (including manufacturer's descriptive and technical literature and catalog cut sheets) including the IP communicator, sensor equipment, alarm annunciation devices and Fire Alarm panel.

5) Drawings showing the plan and elevation for typical configurations of Communications Facility, Communications Rooms, and Signal House.

6) Certified copies of current approvals or listings issued by UL, FM or other nationally recognized testing laboratory, showing Fire Alarm Subsystem equipment compliance with specified NFPA standards.

b. Contractor shall include the following as part of the PDR for the fire suppression system:

1) Completed layouts drawings to include isometric details of agent storage containers, mounting details, proposed pipe runs and sizes, and symbol legend.

2) Electrical layout drawings shall show the location of all devices and include point-to-point conduit runs and a description of the method(s) used for detector mounting.

3) Qualifications of fire suppression system installers.

4) Qualifications of fire suppression system training instructors.

3. Final Design Review (FDR) Technical Requirements. Contractor shall include the following information as part of the FDR submittal package for the Fire Alarm Subsystem:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

b. Detail drawings for Communications Facilities containing Fire Alarm systems.

c. Drawings shall be signed by the Texas Licensed Fire Safety Professional Engineer (as required on a per-system basis) and
approved, signed, and sealed by the authority having jurisdiction.

d. Drawings shall consist of the following:

1) Schematics.
2) Wiring diagrams.
3) Complete subsystem interconnection diagrams.
4) Fire Alarm Panel layout.
5) Other details required to verify that the system conforms to industry standards and requirements.

e. Spare Parts Data:

1) Spare parts data for each different item of material and equipment specified, shall be provided. Data shall include a complete list of spare parts and supplies with the current unit prices and source of supply, along with a list of any parts which the manufacturer recommends be replaced periodically.

4. Installation Work Plans. Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The Installation Work plan shall include:

a. Drawings and Diagrams to include:

1) Equipment layout in Drawings and elevation views. This includes details of adding the new IP based DACR units into the existing OCC display.
2) System block diagram.
3) Wiring diagrams showing detail connection of all system components including power and control wiring.
4) Conduit installation details.

5. Calculations or Certifications

a. Calculations as listed in the PDR and FDR.

b. Certifications: Copy of the following certifications shall be included:

1) ISO certification for all proposed manufacturers.

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.

7. Test Plan and Procedures: In accordance with the format and requirements described in these Specifications, as a minimum, the Contractor shall submit the following drawings and procedures to satisfy the Fire Alarm Subsystem testing requirements:

a. Test program plan: Contractor shall include all the required information for the Fire Alarm Subsystem in the Test Program Plan as outlined in these Specifications.

b. Factory and Inspection Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article 3.2 of this Section.

c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in Article 3.2 of this Section.

d. System Acceptance Test: Contractor shall submit a complete system acceptance test procedure to satisfy all the requirements outlined in Article 3.2 of this Section.

e. System Integration Test (SiT): Contractor shall provide qualified technical staff to support this test as described in Article 3.2 of this Section. SiT will be directed by the Authority.

8. Test Records: Contractor shall submit the Test Records and Results for review 14 days after the completion of each test, in accordance with the format described in these Specifications.

9. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the Fire Alarm Subsystem.
1.4 QUALITY ASSURANCE

A. Manufacturer Pre-Qualification Requirements

1. The Authority shall approve the manufacturer Pre-Qualification Requirements.

2. Contractor shall provide all data required by the Authority for its evaluation.

3. Contractor shall make the arrangements for any required demonstrations and tests as required to ensure specification compliance or properly installed Fire Alarm Subsystem equipment.

4. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of digital alarm communicator systems and shall be items that have been in satisfactory use for at least 2 years prior to bid opening.

5. Equipment shall be supported by a service organization that can provide service within 24 hours.

6. Qualifications shall be based on the following criteria:
   a. Past Performance and Experience
   b. Fire alarm equipment manufacturers shall demonstrate previous successful experience in supplying, testing and installation of fire alarm systems and components specified herein.

C. Provide a list containing of 3 recently completed projects of similar type and size with contact names and telephone numbers for each.

D. Manufacturer Quality Assurance/Quality Control Program

1. Manufacturers of fire alarm subsystem, in accordance with the requirements of these specifications, is required to have in place or implement, an effective Quality Assurance/Quality Control program adhering to the requirements of ISO 9001 to ensure purchase control performance.

2. Manufacturers shall be ISO 9001 registered and contractor is to submit ISO 9001 Certification Number.

3. Contractor shall monitor the manufacturers to assure that the approved Quality Assurance/Quality Control Program is being closely adhered to and that the equipment is being manufactured in accordance with these Specifications.

E. Warranty: Manufacturer shall warrant that the design, material, and workmanship incorporated in each equipment item shall be of the highest grade and consistent with the established, and generally accepted, standards for transit applications; and that each such item and every part and component thereof shall comply with these Specifications.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. Fire Alarm Subsystem shall be a complete, supervised system consisting of fire alarm control panel with digital transmitter connected to communications facility fire alarm panels and communicate with existing new Authority digital receiver system at the Train Control Center (TCC).

B. Fire alarm control panel shall also control the fire suppression system, including interlock with HVAC and ventilation of the facility.

C. Fire Alarm Subsystem equipment shall be compatible with, and capable of interfacing to the new reporting system to be implemented by the Contractor at the OCC.

D. System shall be activated into the alarm mode when a fire alarm condition is detected. The system shall remain in the alarm mode until the alarm is acknowledged and reset by the operator.

E. New Work shall also include providing cabling and communications interface to signal house, station and TPSS fire alarm system.

F. Contractor shall verify that existing reporting systems are maintained with the equipment added to the fire alarm cabinet in the OCC. Contractor shall take the lead, with support from DART, in troubleshooting of the Fire Alarm subsystem when the station equipment do not function or communicate properly with the remote equipment at OCC.

2.2 CONTRACTOR FURNISHED MATERIALS

A. Work consists of providing heat and smoke detector sensors, connected to the fire alarm panel and interfacing this equipment to the new Fire Alarm Reporting Subsystem.

B. Detectors Zoning Arrangement: Detectors shall be arranged in 2 zones within the Communications Facility.

C. Detector Wiring: Fully supervised Class-A circuits shall be utilized for:
1. Power to all sensors from the control panel power supply.

2. Activation of alarm indication from sensor to control panel.

D. The following alarm conditions shall be wired to the local Remote Terminal Unit (RTU) and FACP IP communicators at each location to be monitored:

1. Fire Alarm: One or more zones at a specific location has active fire signal.

2. Fire System Trouble: A fault has been sensed within the fire detection system includes low battery or failed detector.

3. Fire Supervisory Alarm: An alarm condition using a normally-closed contact (failed-safe) derived from:
   a. Activation of any fire supervisory circuit, and
   b. Activation of a Knox box intrusion alarm.

4. Two spare indications for future use.

E. An active alarm, trouble, or supervisory condition in any structure that reports to the system shall automatically initiate the following functions:

1. System shall:
   a. Receive the alarm indication from the FACP.
   b. Transmit the abnormal condition information via IP connection to the OCC fire alarm reporting unit.

2. Alarm Annunciation Circuits

   1. Audio and visual alarm annunciators shall be arranged on separate Class-A circuits, supervised by the control panel.
   
   2. Indication of alarms from control panel to RTU and FACP shall utilize supervised circuits and as shown in the Contract Drawings.

F. Supervisory Functions: Communications between the fire alarm reporting unit and each remote fire alarm control panel shall be monitored and failures alarmed and reported.

2.3 FIRE ALARM CONTROL PANEL SPECIFICATIONS

A. Primary Functions

1. Monitor heat and smoke detectors for activation and failure.

2. Control activation of audio and visual alarm indicators.

3. Supervise wiring, perform self-tests (including a battery life test) and provide indication of any abnormal system events.

4. Provide Fire Alarm, Fire System Trouble, Fire Supervisory Alarm, Knox Box Alarm and Spare indication outputs to the RTU and the fire alarm reporting system.

5. Provide 2 normally open contacts, close upon detection of fire alarm, for shutting down of facility air conditioning unit and closing air dampers.

6. Provide a normally-closed contact to close upon sensing any supervisory and trouble alarm conditions.

7. Provide remote testing and monitoring of serial port.

I. Control Unit

1. The control unit shall utilize the multiple zone detection design methodology to determine the fire/no fire condition.

2. Control unit logic shall be self-checking to ensure that the required fire/no fire decision is made.

3. Control unit shall supervise all input and output modules to verify system integrity.

4. Control unit shall monitor AC power and the status of the standby battery.

J. Input/Output Modules

1. Input Circuits.
FIRE ALARM SUBSYSTEM - COMMUNICATIONS SYSTEM

2. Manual pull stations and sensors shall be supervised for activation and power.
3. Independent modules shall be used for separate zones.

K. Output Circuits
1. Output circuits shall supervise from 19 VDC to 24 VDC output to audio and visual devices.
2. Independent modules shall be used for audio and visual devices.

L. Relay Modules
1. Relays shall be assigned as follows:
   a. Fire Alarm.
   b. Fire System Trouble.
   c. Fire Supervisory Alarm.
   d. Knox Box Alarm
   e. Interlocks to shutdown air conditioning unit and close air dampers.
   f. Two spares.
   g. Two contacts on each of the alarm and trouble relays shall be provided.
   h. Relay contacts shall be Form-C.

M. Supplemental Relay Modules
1. Four independent single-pole, double-throw, non-supervised relays shall be provided per module.
2. Relays shall be individually assigned.
3. Relays shall be activated on any alarm level or trouble condition.
4. One manual disable switch shall be associated with each relay.
5. Relay contacts shall be Form-C.

O. Power
1. Primary power shall be 120 VAC, 57 Hz to 63 Hz, from the Main AC Power Distribution panel.
2. Battery backup for 48 hours shall be provided, housed within the control panel enclosure, via the use of dedicated sealed lead-calcium batteries.
3. In the event of loss of 120 VAC power, the control panel shall automatically switch to battery operation. The switchover shall be accomplished with no interruption of protective service, and without adversely affecting the battery-powered capabilities.
4. Upon restoration of 120 VAC power, transfer back to the normal AC power supply shall be automatic and the battery shall be recharged.
5. Battery charger shall be capable of restoring the batteries from full discharge to full charge within 48 hours.
6. Converter/battery charger shall be installed within the panel enclosure.
7. Power supply transient voltage surge suppression shall be provided.
8. Power supply shall power the panel and all sensors and output devices.

2.4 DIGITAL ALARM COMMUNICATOR TRANSMITTER
A. The traditional DACT functionality shall be provided using IP-based communications via the Ethernet network to the DART OCC. The fire alarm control panel and fire alarm reporting unit shall be UL listed and NFPA approved for this application.
2.5 FIRE ALARM REPORTING UNIT

A. Fire Alarm Reporting unit shall include redundant servers, graphical display and KVM. Required equipment shall be integrated into the existing OCC DACR display cabinet as indicated on the drawings.

B. Reporting Unit shall include all software necessary for monitoring, indicating, and reporting alarms and status messages.

C. Contractor shall configure the system for all alarm and status reporting for the new facilities equipped under this contract. Graphical layout shall be Authority approved.

2.6 ALARM BELL

A. Alarm bells shall be fabricated from a high quality die casting with a baked red enamel finish.

B. Power consumption shall be 0.030 ampere at 24 VDC.

C. Typical output shall be 84 dBA at 24 VDC.

D. Typical output shall not be less than 15 dBA above ambient noise level.

E. Alarm bells shall mount to a standard 4 inch square outlet box.

2.7 ALARM HORN

A. Alarm horns shall be fabricated from a high quality die casting with a baked red finish.

B. Power consumption shall be 0.035 ampere at 24 VDC.

C. Typical output shall be 97 dBA at 24 VDC.

D. Alarm horns shall mount on a standard 4 inch square outlet box.

2.8 ALARM STROBE LIGHT

A. Each alarm strobe light shall be a high intensity flashing light, utilizing a Xenon flash tube sealed in silicone and housed in a polycarbonate (Lexan™) lens.

B. Translucent lens shall be attached to a fire alarm gloss red back plate.

C. Power consumption shall be 0.033 ampere at 24 VDC.

D. Strobe shall flash at a rate and duty cycle compliant with ADA requirements current at time of procurement.

E. Lens shall have "Fire" imprinted on 2 sides.

2.9 STROBE HORN

A. Strobe horn shall be a high intensity flashing, ADA Compliant, light with 97 dBA horn output.

B. Typical output shall be equal or greater than 15 dB above ambient noise level.

C. Strobe horn shall be housed in a fire alarm, gloss red, die cast enclosure.

D. Light source shall be sealed in silicone and protected by a polycarbonate (Lexan™) lens.

E. Strobe lens shall be white translucent with the word "FIRE" imprinted upon it in red.

F. Power shall be 0.068 ampere at 24 VDC.

2.10 FIXED-TEMPERATURE HEAT DETECTOR

A. Thermal detectors shall activate at 135 degrees F nominal temperature setting with exception of TPSS facilities which shall activate at 194 degrees F.

B. Detectors shall be hermetically sealed.

C. Detectors shall be shock and corrosion resistant.

D. Detectors shall automatically reset upon returning to normal temperature.

2.11 IONIZATION SMOKE DETECTOR

A. Ionization type smoke detectors shall have relay contact outputs rated for 24 VDC, 1.0A minimum.

B. Sensitivity shall be adjustable.

C. A red alarm indication LED shall be provided on the enclosure.

D. Power shall be 18.8 VDC to 27.7 VDC with current draw as follows:

1. Normal: 40 microampere at 24 VDC
2. Alarm: 85 milliamperc at 24 VDC
3. The detector shall mount on a 4-inch octagonal outlet box utilizing tamper-resistant screws.
4. Operating temperature shall be 32 to 120 degrees F.

2.12 MANUAL FIRE ALARM PULL STATION

A. Manual fire alarm pull station shall be installed within Communications Facilities, at locations as specified herein and as shown on Contract Drawings.
FIRE ALARM SUBSYSTEM - COMMUNICATIONS SYSTEM

B. Manual stations shall be double action type, providing for 2 separate and distinct actions to activate an alarm.

C. Enclosure shall be constructed of high impact polycarbonate (LexanTM) or metal, red enclosure with raised white lettering and a smooth high gloss finish.

D. A common key shall be provided to reset the station.

2.13 FIRE EXTINGUISHER

A. Fire extinguisher shall use Carbon Dioxide (CO₂), intended for Class B and Class C fire hazards.

B. Fire extinguishers shall be portable, wall-mount type with UL rating 10B and 10C.

C. Fire extinguisher containers shall be heavy-duty, seamless, aluminum alloy cylinders, painted red, with instructions label permanently affixed.

D. Discharge mechanism shall have a locking pin to prevent accidental discharge.

E. Fire extinguisher shall have a flexible hose and horn for aiming at the fire.

F. Fire extinguisher shall meet or exceed the following specifications:
   1. CO₂ capacity: 15 pounds.
   2. Weight: 40 pounds maximum.
   3. Range: 3 feet to 8 feet
   4. Discharge time: 12 seconds.

G. Fire extinguisher shall be currently inspected, certified, and tagged and shall be properly maintained in accordance with manufacturer's recommended guidance and local Fire Department regulations, until such time when the Authority grants Final Acceptance.

2.14 FIRE SUPPRESSION SYSTEM

A. Contractor shall design, provide, install and test a complete Fire Suppression System for systems facilities, when required and/or as identified in the Contract Documents.

B. Fire Suppression and Alarming System shall be designed as an integrated, comprehensive system. The systems shall be signed and sealed by a Fire Protection Engineer licensed in State of Texas.

C. Proposed system and products shall meet the following:
   1. EPA SNAP approved products;
   2. Shall be effective at suppressing fire; while it is suitable for energized equipment, and it would not damage critical electronics and vital mechanical devices.
   3. Proposed product shall be similar to products listed below or equivalent:
      a. INERGEN, manufactured by Ansul
      b. FM-200, manufactured by Great Lakes Chemical Company

D. System shall automatically be initiated upon a "Fire Alarm" signal. Detectors shall be Cross-Zoned detection requiring 2 detectors to be in alarm before release. This will ensure a false alarm would not initiate the release of the fire suppression agent. A pre-release warning shall be provided. A fire alarm shall close/seal the room ventilation and also shut down the HVAC system.

E. Manufacturer of the suppression system hardware and detection components shall be ISO 9000 registered. The name of the manufacturer shall appear on all major components. All devices, components and equipment shall be the products of the same manufacturer. All devices, components and equipment shall be new, standard products of the manufacturer’s latest design and suitable to perform the functions intended. All devices and equipment shall be UL listed and/or FM approved.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed as shown in the Contract Drawings, and in accordance with the manufacturer’s recommendations.

B. Interconnections, services, and adjustments required for a complete and operational system shall be provided.

C. Equipment primary power shall be extended from the main 120 VAC breaker panel.

D. Backup battery power shall be integral to each system panel.

E. Fire Alarm Reporting Unit: New fire alarm reporting unit shall be integrated into the new IP DACR servers and GUI software at the OCC. Contractor shall verify functionality of the FACP’s IP communications prior to and after implementation of the new equipment.
F. Wiring

1. System wiring shall be installed in electric metallic tubing.

2. Conductors for the alarm system shall be installed in conduits, junction boxes, or outlet boxes separate from lighting and power systems conduit.

3. Conduit shall be 1/2-inch minimum. No more than one conductor shall be installed under any screw terminal.

4. Circuit conductors entering or leaving any mounting box, outlet box enclosure or cabinet shall be connected to screw terminals with each terminal marked in accordance with the wiring diagram.

5. Connections and splices shall be made using screw terminal blocks. Wire nut type connectors shall not be used.

6. Wiring within control equipment shall be readily accessible without removing component parts.

G. Over-voltage and Surge Protection

1. Cables and conductors, which serve as communications links, shall have surge protection circuits installed at each end.

2. Fuses shall not be used for surge protection.

H. Delivery and Storage: Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variation, dirt and dust, and any other contaminants.

I. Keys for Lockable Fire Enclosures

1. A master set of keys for locking FACP enclosures shall be consolidated and delivered to the Authority prior to project closeout.

2. Keys for similar equipment enclosures, where practical, shall be keyed identically so that 1 key operates the same enclosure at multiple locations.

3. Master set shall include keys to open any of the enclosures installed under this contract.

4. One set of keys shall also be left in each enclosure at each location.

3.2 TESTING AND INSPECTION

A. Contractor shall perform the following inspection and test on the Fire Alarm Subsystem at each equipment installed location. The Authority shall be given at least 10 days written notice prior to each scheduled test so that the Authority may be present.

1. Factory Testing and Inspection: No factory test and inspection of fire alarm subsystem equipment is required.

2. Field Inspection. Field inspection of fire alarm equipment, including remote reporting, at each facility shall verify the following:

   a. Conformance to standards, methods, quality, specification requirement and approved drawings.

   b. Proper routing and termination of wire and cable.

   c. Secured cable and wire connections.

   d. Proper grounding of all equipment.

   e. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.

3. Field Test

   a. Tests shall be performed in the presence of the Authority and under the supervision of the fire alarm system manufacturer's qualified representative.

   b. Contractor shall perform the following field tests:

      1) Contractor shall provide all instruments and personnel required for the tests.

      2) Upon installation completion, the Contractor shall subject the system to a complete functional and operational performance test. As a minimum, the tests shall include:

         a) Test all inputs, outputs, and functions of the Fire Alarm Control Panel and the remote reporting capability to the fire alarm reporting unit at the OCC.
b) Verify correct DACR functionality for existing units, after the work is complete.

c) Verify operation of the heat detectors.

d) Verify sensitivity of smoke detectors.

e) Measure audible alarms output level from specific locations.

3) When all corrections have been made, the system shall be re-tested to assure that it is functional.

4. System Acceptance Test

a. Testing shall be in accordance with NFPA 72. The recommended tests in NFPA 72 shall be considered mandatory and shall verify that any design or installation deficiencies have been corrected.

b. Contractor shall coordinate with the Authority for development of Acceptance Testing procedures, and to fulfill the requirements of the local Fire Marshall, for compliance to local Fire Department regulations. An inspector from the local jurisdictional fire department shall also witness tests in order to provide a certificate of approval for the system upon test completion.

c. Tests shall include the following:

1) Tests shall indicate that there are no grounded, shorted, or open circuits.

2) Tests of each IP communicator to each IP DACR, including transmission of alarm signals at each location.

3) Tests of normal and emergency power supplies, including batteries.

4) Tests shall include verification of complete system operation at extreme end of the required emergency power duration, and verification of recharging time.

5) Each Fire suppression systems functions shall individually and locally be tested, in accordance with an approved test procedure. All functions, including system and equipment interlocks, shall be tested to prove they are ready for final acceptance of the complete Fire System including end-to-end and remote monitoring of the Fire System.

5. Systems Integration Test: Contractor shall provide qualified technical staff to support this test as directed by Authority’s System Integration Consultant.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System”

END OF SECTION 16854
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the detailed technical requirements for the Intrusion Alarm Subsystem to be designed, provided, installed, and tested under this Contract. Scope of Work includes:

1. Providing, installing and testing all new intrusion alarm equipment in new Communications Facilities, and Communications Interface Cabinets (CIC), as specified and as shown on Contract Drawings.

2. The Intrusion Alarm Subsystem shall detect and monitor alarm conditions and shall provide the required sensor equipment, local alarm annunciations and the corresponding Supervisory Control And Data Acquisition (SCADA) remote outputs.

3. The intrusion alarm equipment shall be compatible with, and capable of interfacing to the Authority’s existing SCADA system.

4. New Work shall also include providing cabling and interfacing Traction Power Substations (TPSS) intrusion alarm systems, Ticket Vending Machines (TVM), and Signal Houses intrusion alarm systems as shown in the Contract Drawings.

B. Existing System Description and Configuration: The existing Intrusion Alarm Subsystem utilizes Intrusion Alarm Control Panels, Liquid Crystal Display (LCD) keypads, and doorframe-mounted magnetic switches at Communication Houses, with magnetic door switches installed at CIC’s, Proximity switches at each door, with toggle switches and indicator lamps.

1.2 REFERENCED STANDARDS

A. American Society of Quality (ASQ)

1. ASQ Z1.11 - Quality Assurance Standards - Guidelines for the Application of ANSI/ISO/ASQC Q9001 or Q9002 to Education and Training Institutions- ANSI/ASQC Z1.11

B. The Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specification and the specific technical requirements further listed herein.

1. Manufacturer Qualifications: Any new equipment differing from those specified in the technical specifications shall require a prequalification and approval of the proposed manufacturer. Acceptability of the manufacturer shall be based on the manufacturer’s experience, equipment reliability, compliance with standards specified in this section, and complete compatibility with the Authority’s existing system.

2. Preliminary Design Review (PDR) Technical Requirements: Contractor shall include the following information as part of the PDR submittal package for the Intrusion Alarm subsystem:

a. Battery calculations shall be provided for supervisory and alarm power requirements.

b. Ampere-hour requirements for each Intrusion Alarm Control Panel and all sensor components, and the battery recharging periods shall be included.

c. Battery calculations shall substantiate specification requirements.

d. A complete list of Intrusion Alarm Subsystem equipment (including manufacturer’s descriptive and technical literature and catalog cut sheets) including sensor equipment, alarm annunciation devices and Intrusion Alarm Control panel.

e. Preliminary wiring diagrams for all field Intrusion Alarm equipment provided and installed under this contract.

f. Drawings showing the plan and elevation for typical Communications House configurations, Communications Rooms, CIC’s, Signal Houses and TPSS’s.
3. Final Design Review (FDR) Technical Requirements: Contractor shall include the following information as part of the FDR submittal package for the Intrusion Alarm Subsystem:

   a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

   b. Battery calculations shall be provided for supervisory and alarm power requirements.

   c. Ampere-hour requirements for each Intrusion Alarm Control Panel and all sensor components, and the battery recharging periods shall be included.

   d. Battery calculations shall substantiate specification requirements.

   e. A complete list of Intrusion Alarm Subsystem equipment (including manufacturer’s descriptive and technical literature and catalog cut sheets) including sensor equipment, alarm annunciation devices and Intrusion Alarm Control panel.

   f. Detail drawings for Communications Facilities containing Intrusion Alarm systems. The drawings shall consist of the following:

      1) Schematics
      2) Wiring diagrams
      3) Complete subsystem inter-connection diagrams Intrusion Alarm Control Panel layout

   g. Other details, as required to verify that the system conforms to industry standards and requirements

4. Installation Work Plans: Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The Installation Work plan shall include:

   a. Drawings and Diagrams to include:

      1) Equipment layout in plan and elevation views.

   2) System block diagram.

   3) Wiring diagrams showing detail connection of all system components including power and control wiring.

   4) Conduit installation details.

5. Calculations or Certifications

   a. Calculations as listed in the PDR and FDR.

   b. Certifications: Copy of the following certifications shall be included:

      1) ISO certification for all proposed manufacturer

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.

7. Test Plan and Procedures

   a. Test procedures shall be submitted for all the required tests as described in Article 3.2 of this Section. As a minimum:

      1) Test program shall include all the required tests for this subsystem

      2) Factory Test Procedure

      3) Field Test Procedure

      4) Integration Test Procedure

   b. Test Records: Contractor shall submit the Test Records and Results for review 7 days after the completion of each test, in accordance with these Specifications.

8. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the Intrusion Alarm Subsystem.

1.4 QUALITY ASSURANCE

A. Contractor’s design and installation shall comply with all applicable Standards and Codes as listed herein.

B. Material and Workmanship Requirements

   1. All equipment provided under this Section shall be UL listed.
2. All grounding shall be in accordance with local standards, and specifications required by this contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

3. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within 1 calendar year of the installation date shall not be used.

4. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.

C. Manufacturer Pre-Qualification Requirements: All new equipment provided and installed under this contract shall be compatible with existing Intrusion Alarm Subsystem equipment installed in field and central locations in order to perform the intended use set forth by the Authority.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. System Description

1. The system equipment shall consist of magnetic door switches, proximity sensors (Signals), audible annunciation devices and intrusion alarm control panels, to be interfaced to the existing SCADA system.

2. The system shall be activated into the alarm mode when an abnormal condition occurs in any of the intrusion alarm sensors, after a pre-determined time delay.

3. The system shall remain in the alarm mode until the alarm is acknowledged and reset by the operator.

4. The following points shall be transmitted via the local Remote Terminal Unit (RTU) (provided by Others) system, for each location:
   a. Communications House intrusion alarm.
   b. Communications Room intrusion alarm.
   c. CIC intrusion alarms.
   d. TVM intrusion alarms.
   e. Station equipment room intrusion alarm, as required.

B. Detectors Arrangement: Detectors shall be installed on Communication House and Room doors, CIC doors, Signal and Instrument houses’ doors (proximity sensors), and Station equipment room doors.

C. Detectors Wiring: Fully supervised Class-A circuits shall be utilized for activation of alarm indication from sensor (switches) to control panel.

D. Alarm Functions: The following alarm function shall be wired to the local RTU at each location to be monitored:

1. Alarm: One or more indicators at a specific location have active intrusion alarm signals.

2. An active alarm in any structure that reports to the system shall automatically initiate the following functions:
   a. The Intrusion Alarm Control Panel shall receive the alarm indication input from the Communications House and Room door magnetic switch, and provide an alarm indication to the Train Control Center (TCC) via the local RTU and shall initiate a local alarm bell.
   b. The Intrusion Alarm Control Panel shall receive the alarm indication input from the CIC doors’ magnetic switches, and provide an alarm indication (“Cabinet Open”) to the TCC via the local RTU.

E. Electrical Power

1. Intrusion Alarm equipment shall receive primary power from the Main AC Power Distribution panel.

2. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and shall not prevent transmission nor cause false transmission of an alarm.

3. The Intrusion Alarm Control Panel shall be installed with an individual battery backup system, for 48 hours of battery-power operation.

F. Alarm Annunciation Circuits

1. Audio alarm annunciation devices shall be arranged on separate Class-A circuits, supervised by the control panel.
2. Indication of alarm from control panel to RTU shall utilize supervised (normally closed) circuits.

2.2 INTRUSION ALARM CONTROL UNIT

A. Functions: The intrusion alarm control unit shall perform the following functions:

1. Monitor normally closed contacts of magnetic switch assembly.
2. Control local audio alarm annunciation activation.
3. Allow deactivation when valid 4 to 4-digit security code is entered via the control keypad within 30 seconds of opening the door.
4. Allow reactivation when valid security code is entered.
5. Provide intrusion alarm indication to RTU via dry contact closure.
6. Provide for selecting the local security code. A key shall be required to set the code.

B. Operation

1. There shall be a 30 second nominal entry/exit time period.
2. A low-level alert tone shall be activated when the magnetic switch is activated.
3. If the alarm is deactivated by correct entry of a 4-digit security code within 30 second entry period, low-level alert tone shall be deactivated; otherwise an alarm condition shall be detected.
4. Alarm detection shall cause an output to the RTU and activation of local high-level audio alarms.
5. The alarm shall be armed by correct entry of the 4-digit code. There shall then be a 30 second period for exiting without activating an alarm.
6. If an incorrect or incomplete code is entered, it shall be cleared after 3 seconds. The operator could then re-enter the code.

C. Enclosure

1. The intrusion alarm control unit shall be housed in a NEMA-12 enclosure with locking cover.

2. Front panel Light Emitting Diode (LED) indications shall be provided for power on and battery status.

2.3 INTRUSION ALARM KEYPAD

A. Characteristics

1. The keypad shall be integrated with the alarm control unit or shall be a separate wall-mounted unit.
2. Keys shall be labeled 0 through 9, *, and #.
3. The keypad shall be resistant to entry of dirt and moisture.
4. The keypad shall provide tactile feedback of operation; membrane keypads shall not be acceptable.
5. The keypad shall be powered from the alarm control panel.
6. The keypad shall have LED indications of status: ready, armed, alert.

2.4 INTRUSION ALARM MAGNETIC SWITCH

A. Specifications

1. The magnetic switch shall consist of flush mounted magnet and switch assemblies, each housed in thermoplastic.
2. The switch assembly shall activate when the magnet is more than 1/4-inch removed.
3. The switch contacts shall activate within 10 ms and shall be rated for 24V DC at 500 ma.
4. Normally open and normally closed contacts shall be provided.
5. The magnetic switch provided shall be capable of a minimum of 100,000 operations over a minimum period of 10 years without failure.

2.5 ALARM BELL

A. Specifications

1. Alarm bells shall be fabricated from a high quality die casting with a baked red enamel finish.
2. Power consumption shall be 0.030 ampere at 24 VDC.
3. Typical output shall be 84 dBA at 24 VDC.
4. Typical output shall not be less than 15 dBA above ambient noise level.

5. Alarm bells shall mount to a standard 4 inch square outlet box.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Equipment shall be installed as shown in the Contract Drawings, and in accordance with the manufacturers’ recommendations.

2. Required interconnections, services, and adjustments for a complete and operational system shall be provided.

3. Electrical work shall be in accordance with NEC.

B. Power: Equipment primary power shall be extended from the Main AC Power Distribution panel.

C. Wiring

1. System wiring shall be installed in electric metallic tubing. The conductors for the alarm system shall be installed in conduits, junction boxes, or outlet boxes separate from lighting and power systems conduit.

2. Conduit shall be 1/2-inch minimum in accordance with NEC. No more than 1 conductor shall be installed under any screw terminal.

3. Circuit conductors entering or leaving any mounting box, outlet box enclosure or cabinet shall be connected to screw terminals with each terminal marked in accordance with the wiring diagram.

4. Connections and splices shall be made using screw terminal blocks. Wire nut type connectors shall not be used in the system.

5. Wiring within control equipment shall be readily accessible without removing component parts.

D. Over-voltage and Surge Protection

1. Cables and conductors, which serve as communications links, shall have surge protection circuits installed at each end.

2. Fuses shall not be used for surge protection.

E. Delivery and Storage: Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variation, dirt and dust, and any other contaminants.

F. Keys for Alarm Panels

1. A master set of keys for locking Intrusion Alarm Control Panels shall be consolidated and delivered to the Authority prior to project closeout.

2. Keys for similar equipment enclosures, where practical, shall be keyed identically so that 1 key operates the same enclosure at multiple locations.

3. The master set shall include keys to open any of the enclosures installed under this Contract.

4. One set of keys shall also be left in each enclosure at each location.

3.2 TESTING AND INSPECTION

A. Contractor shall perform the following inspection and test on the Intrusion Alarm Subsystem at each equipment installed location. The Authority shall be given at least 10 days written notice prior to each scheduled test so that the Authority may be present as desired.

1. Factory Testing and Inspection:

   a. Factory testing and inspection of intrusion alarm subsystem for Communications Houses shall include the following:

      1) Each Intrusion alarm control panel shall be powered-up and tested after the factory wiring is complete.

      2) Verify magnetic switch and alarm operation.

      3) Verify intrusion alarm keypad operation.

   b. Factory testing and inspection of intrusion alarm subsystem for communication room will not be required since equipment shall be field installed.

2. Field Inspection

   a. Field Inspection of intrusion alarm equipment at each communications house/room and CIC shall verify the following:
1) Conformance to standards, methods, quality, specification requirement and approved drawings.

2) Proper routing and termination of wire and cable.

3) Secured cable and wire connections.

4) Proper grounding of all equipment.

5) Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.

3. Field Testing

   a. The tests shall be performed in the presence of the Authority under the supervision of the intrusion alarm system manufacturer’s qualified representative.

   b. Contractor shall perform the following:

      1) Provide all instruments and personnel required for the tests.

      2) Upon completion of the installation, the Contractor shall subject the system to a complete functional and operational performance test. As a minimum, the tests shall include:

         a) Verify operation of the keypad panel.

         b) Verify operation of the magnetic switches.

         c) Measure audible alarms output level from specified locations.

         d) Test all inputs, outputs, and functions of the Intrusion Alarm Control Panel.

      3) When all corrections have been made, the system shall be re-tested to assure that it is functional.

4. System Acceptance Test

   a. The tests shall include the following:

      1) Tests to indicate there are no grounded, shorted, or open circuits.

      2) Tests of each input to the Intrusion Alarm Control Panel, including transmission of alarm signals across local RTU at each location.

      3) Tests of normal and emergency power supplies, including batteries.

5. End-To-End and Systems Integration Test

   a. Contractor shall provide qualified technical staff and perform End-To-End testing (for SCADA and alarming at TCC).

   b. Contractor shall take the lead, with support from the Authority in troubleshooting of the Intrusion subsystem when the station equipment do not function or indicate properly at OCC.

   c. Contractor shall provide qualified technical staff and resources to support the Authority’s System Integration Testing.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

   A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

   A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16855
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Closed Circuit Television (CCTV) Subsystem to be designed, provided, installed, and tested under this Contract. Scope of Work for the Project includes:

1. Providing, installing and testing all new CCTV equipment in new Passenger Stations, as specified and as shown on Contract Drawings.

B. Providing, installing and testing modifications to DART’s existing CCTV monitoring, control and network storage system located at the OCC and NWROF facilities, including all licenses necessary for the new CCTV equipment. New CCTV equipment shall utilize the new Project network and the existing DART SONET network for communications to the OCC and NWROF. The system expansion shall incorporate IP fixed Network Video Recorders (NVRs), Physical Security Integration Management (PSIM) software client, network switches, codecs, and any other hardware or software required to transmit/receive video over an IP network for a complete and functional system.

1. All modifications to the existing network shall be included in the scope herein.

C. Existing System Description and Configuration: The existing CCTV Subsystem utilizes IP cameras, Network Video Servers (NVR’s), Archive Servers, viewing workstations, and associated software. DART currently uses the Cisco Video Surveillance Operations Manager (VSOM) system 7.0 as the Primary security application. Contractor shall verify the version being utilized at the time of required work. All equipment shall be integrated with this system.

D. Contractor shall fully integrate all of the new cameras and video streams into the existing PSIM system and will require geospatially placing icons onto new and existing system maps. The icons shall allow access to the camera’s controls and video streams. The functionality shall match that of the existing integrated cameras. All camera device monitoring shall be activated and tested; this shall include but not be limited to; status, loss of video, faults, failures, alarms, and all tampering related events/alarms.

1. The existing CCTV Subsystem utilizes IP cameras, Network Video Servers (NVR’s), Archive Servers, viewing workstations, and associated software. DART uses Cisco Physical Security Operations Manager as the Primary security application. All equipment shall be compatible with this system and integrated into the existing system.

E. Contractor shall configure all CCTV cameras for be set up to single stream images with or H.264 compression. This stream shall have at least HD resolution (1920 x 1080) at 30 fps for NVR recording. The camera shall also be capable of providing a second stream with at least D1 resolution (720 x 480 NTSC) or 4CIF at 30 fps, provided that frame rate of the primary stream is reduced to 15 fps. Before CCTV camera set-up, the Contractor shall verify all camera settings with the Engineer or an AUTHORITY representative.

F. CCTV system is currently in use by DART personnel and is considered a critical system for DART Operations and security. All coordination for system improvements must be coordinated in advance as to not impact operations. This may require the Contractor to perform, installation, testing, upgrades or system outages at off-peak times.

G. For the purpose of Configuration Management, the Contractor must inform the AUTHORITY of the length of time the contractor will be making any system modifications. The dates and length of downtime of the system must be submitted in writing on the Contractor’s letterhead to the Communications Department and the AUTHORITY project manager, and must be approved by those groups. Contractor shall verify all camera settings being utilized at the time of required work. All equipment shall be integrated with this system.

H. Contractor shall provide all configuration/setup/programming of new and existing video system components identified in this specification section for a complete working system. Device configuration settings shall be submitted to the Engineer and the AUTHORITY for approval prior to installation.

I. Contractor shall perform visual adjustments of each camera on installation to account for lighting conditions, desired field-of-view, distance to primary targets, and environmental conditions. Contractor shall also perform a final camera tuning and field of view adjustment to all cameras installed under this project 30 days after the video system has been installed; cameras have been positioned, and have been recorded.
1.2 REFERENCE STANDARDS

A. Contractor’s design and installation shall comply with the latest editions of all applicable Standards and Codes included herein. Work shall meet or exceed the standards and procedures specified.

1. American Public Transportation Association (APTA)
   a. The CCTV system shall conform to the Technical Recommended Practices for the Selection of Cameras, Digital Recording Systems, Digital High Speed Networks and Train Lines for Use in New Transit Related CCTV Systems, as per the latest version of the referenced APTA publication.
      1) APTA IT-RP-001-08

2. American Society of Quality (ASQ):
   a. ASQ Z1.11 - Quality Assurance Standards - Guidelines for the Application of ANSI/ISO/ASQC Q9001 or Q9002 to Education and Training Institutions-ANSI/ASQC Z1.11

3. The Institute of Electrical and Electronics Engineers (IEEE)
   a. IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

4. National Fire Protection Association (NFPA)
   a. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specification and the specific technical requirements further listed herein.

1. Manufacturer Qualifications:
   a. Any new equipment differing from those specified in the technical specifications shall require a prequalification and approval of the proposed manufacturer. Acceptability of the manufacturer shall be based on the manufacturer’s experience, equipment reliability, compliance with standards specified in this section, and complete compatibility with the Authority’s existing system.
   b. Prior to approval of the CCTV system hardware and software components, the Contractor shall submit the proposed equipment vendors qualifications and a written statement from the vendors acknowledging that the hardware and software to be supplied shall meet all functionality as required within this specification.

   a. Contractor shall include the following information as part of the PDR submittal package for the CCTV subsystem:
      1) Battery calculations shall be provided for CCTV power requirements.
      2) Complete list of CCTV Subsystem equipment (including manufacturer’s descriptive and technical literature and catalog cut sheets) including Cameras, enclosures, storage devices, Ethernet switches, software licenses
      3) Preliminary wiring diagrams for all field CCTV equipment provided and installed under this contract.
      4) Drawings showing the plan and elevation for each station equipped or retrofitted.
      5) Preliminary drawings showing the modifications necessary at OCC and NWROF.
      6) Submit the following to the Engineer for approval: Network diagram of complete system, illustrating proposed configuration and interconnections. The Network diagram shall
include detailed network architecture of all related IP devices, IP schema, device bandwidth, configuration and routing requirements.


a. Contractor shall include the following information as part of the FDR submittal package for the CCTV Subsystem:

b. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

c. Battery calculations shall be provided for CCTV equipment.

d. Complete list of CCTV Subsystem equipment (including manufacturer's descriptive and technical literature and catalog cut sheets) including Cameras, enclosures, storage devices, Ethernet switches, software licenses.

e. Detail drawings for Stations containing CCTV systems. The drawings shall consist of the following:

1) Wiring diagrams for stations and control centers

2) Complete subsystem interconnection diagrams

3) CCTV coverage plans, indicating lens to be used for each camera, expected field of view (discounting obstructions) and proposed focal point.

f. Other details, as required to verify that the system conforms to industry standards and requirements

g. FDR should include site specific plans showing details of the following:

1) Camera enclosure location and mounting details.

2) Cable and conduit details.

3) Light intensity ranges throughout the surveillance areas (determined by actual field tests).

4) Camera field-of-view. This shall include indication of any obstruction or potential obstructions due to trees or foliage.

5) Submit schematic and wiring diagrams complete with terminal numbers.

6) Submit NVR storage recording calculations, in days and hours, based on motion sensing configuration. Define camera image motion zones and activity levels.

7) Submit procedures for programming and troubleshooting.

8) Submit full interconnect diagram for overall system, including interface connections to existing equipment.

9) Submit configuration plan for camera/NVR access levels

4. Installation Work Plans: Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The Installation Work plan shall include:

a. Drawings and Diagrams to include:

1) Equipment layout in plan and elevation views, including all conduit and cable

2) System block diagram.

3) Wiring diagrams showing detail connection of all system components including Ethernet, power and control wiring.

4) Conduit installation details.
5. Calculations or Certifications
   a. Calculations as listed in the PDR and FDR.
   b. Certifications: Copy of the following certifications shall be included:
      1) ISO certification for all proposed manufacturers.

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.

7. Test Plan and Procedures:
   a. Test procedures shall be submitted for all the required tests as described in paragraph 3.2 of this Section. As a minimum:
      1) Test program shall include all the required tests for this subsystem
      2) Factory Test Procedure
      3) Field Test Procedure
      4) Integration Test Procedure
   b. Test Records: Contractor shall submit the Test Records and Results for review 7 days after the completion of each test, in accordance with these Specifications.

8. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the Intrusion Alarm Subsystem

1.4 QUALITY ASSURANCE

A. Contractor's design and installation shall comply with all applicable Standards and Codes as listed herein.

B. Material and Workmanship Requirements
   1. All equipment provided under this Section shall be UL listed.
   2. All grounding shall be in accordance with local standards, and specifications required by this contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

3. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within 1 calendar year of the installation date shall not be used.

4. All products specified herein shall be subject to the Authority approval based on the Contractor's ability to demonstrate adherence to the specified requirement and approval of the manufacturer's quality process.

C. Manufacturer Pre-Qualification Requirements: All new equipment provided and installed under this contract shall be compatible with existing CCTV Subsystem equipment installed in central locations in order to perform the intended use set forth by the Authority.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. System Description
   1. System equipment shall consist of IP cameras, cabling, Power over Ethernet (PoE) switches, storage devices, and video management software.
   2. The system shall provide for video surveillance of substantially all of the station platform and parking areas with fixed cameras.
      a. 90 percent coverage of station platform entrances, platform areas and walkways shall be provided.
      b. 100 percent coverage of Passenger Emergency Call Units and Ticket Vending Machines shall be provided.
   3. The intent of this system is to provide optimized video images of sufficient quality to facilitate the identification of individuals and objects to facilitate crime prevention, revenue protection, anti-terrorism, and promote general situational awareness in and around station areas.
   4. System installation, including physical security of equipment and configuration of all system components shall allow DART Police or other authorized Authority personnel to maintain chain-of-custody integrity of any recorded video evidence such that the video may be admissible in a court of law for prosecutorial purposes.
   5. Any CCTV camera, NVR, and video encoder installed under this contract must
be an open device and the manufacturer must provide an SDK to other device and software manufacturers to allow the integration of the device.

6. All CCTV cameras, NVRs, and video encoders installed under this contract shall be integrated and fully functional with the DART PSIM software and the integration shall be approved by PSIM vendor. If the Contractor wishes to use a CCTV camera that meets the specifications and is not currently integrated into the PSIM software, then they must have the camera integrated and the integration approved by PSIM at no additional cost to the contract and without any contract time extension.

B. Camera Arrangement

1. Cameras shall be installed on station platforms and within parking areas. Station canopies and lighting poles shall be used to support cameras to the greatest extent possible.

2. Cabling distances from the station communications room to the cameras shall be limited to 300 feet for copper cable in all instances. Where the distance to a camera exceeds this 300 foot limit, a cabinet with Ethernet switch shall be provided to aggregate the IP video and transmit it to the station communications room via local fiber cable.

C. Electrical Power: CCTV equipment shall receive primary power from the communications Uninterruptible Power Supply (UPS).

2.2 CCTV CAMERAS

A. Existing Cameras.

1. CIVS-IPC-6000P, with CIVS-IPCA-VCM31-8 housing

2. CIVS-IPC-3535

3. CIVS-IPC-7070

B. New Cameras: New cameras shall meet the minimum specifications of the existing cameras and also be compatible with the existing camera system. Additionally the following are minimum requirements for new cameras:

1. Minimum scene illumination (for 30 IRE video) shall be:
   a. Color (Day): 0.65 lux at F1.0
   b. B&W (Night): 0.12 lux at F1.0, 0 lux preferred with illuminator active for new cameras

2. Fixed IP Camera shall output multiple video streams using different codecs simultaneously.

3. Fixed IP Camera shall be capable of streaming both H.264 and MJPEG, minimum.

4. Fixed IP Camera shall be ONVIF conformant.

5. Fixed IP Camera shall support on-camera analytics and shall come standard with intelligent motion detection which allows the camera to alarm on motion and to ignore unimportant sources of motion such as moving trees or waves.

6. Camera equipment and layout shall allow image clarity sufficient to be capable of identifying persons in areas defined as having CCTV Coverage.

7. Fixed IP Camera shall stream 30 FPS at 1920 x1080 with H.264 encoding.

8. Electrical:
   a. RJ-45 connector for 100Base-TX Ethernet
   b. Input voltage: PoE (IEEE 802.3af) Class 0, 12.95 watts at camera; maximum

9. Camera shall be fully operational to the Operating Temperature listed elsewhere in this specification on IEEE 802.3af PoE.

10. Imaging System
   a. Iris: Automatic iris control
   b. Imaging Sensor: 1/4 inch minimum
   c. Image Resolution: 1080p (1920 x 1080, 30 fps), minimum

1) Varifocal Lens: 3.3 mm to 8.3 mm, minimum F1.6, maximum

11. Provide LED status indicators on each camera to report power, hardware and communications failures.

12. Provide a minimum of 1 alarm in and 1 alarm out port capable of initiating specific actions when an alarm is detected.
13. Cameras shall have backlight compensation to overcome severe backlighting situations. The image brightness shall be set to automatically compensate for adverse lighting conditions.

14. Signal to noise ratio shall be greater than 48 dB.

15. Minimum Illumination (No Image Enhancement, AGC On):
   a. Color: 0.5 lux for 50 IRE
   b. Black & White: 0.06 lux for 50 IRE

16. Fixed IP Camera Angle Adjustment:
   a. Panning Range: 350 degrees
   b. Tilting Range: 20 degrees to 80 degrees, minimum

17. Fixed IP Camera assembly shall meet or exceed the following environmental requirements:
   a. Operating Temperature: Negative 13 degrees F to 122 degrees F (using PoE)
   b. Environmental Rating: IP66

18. Networking Requirements:
   a. Fixed IP Camera shall include Unicast and Multicast streaming.
   b. Fixed IP Camera shall support the following protocols: TCP/IP, UDP/IP, IPv4, IPv6, HTTP, HTTPS, (Unicast, Multicast IGMP) UPnP, DNS, DHCP, RTP, and NTP

19. Camera Lenses
   a. Lenses shall be integral to each camera.

20. Camera Enclosures: Contractor shall provide an enclosure and mounting hardware as necessary to install each camera to the supporting structure.

21. General Construction
   a. Impact resistant housing, IK10, minimum
   b. Smoked, vandal-resistant polycarbonate dome

   c. Vandal resistant CCTV Camera assembly. Contractor shall provide an enclosure and mounting hardware as necessary to the supporting structure.

22. Coordinate approved camera types with the Authority to determine if camera enclosures require painting. Typical camera housings shall be painted to match the color of the Authority’s facilities.

23. Enclosures shall meet NEMA 3R standards or better.

24. Camera Mounting Kit
   a. A camera mounting kit for each specific enclosure and mounting surface or support shall be provided. The kit shall be designed to support the load of the camera and enclosure along with the wind load. All parts shall be protected from corrosion.
   b. For pole mount cameras, the camera mounting kit shall be provided for placing a standard wall-mount unit on camera-equipped poles.
   c. Camera mounting kits and assemblies mounted on poles shall be painted to match the approved pole color. Camera mounting kits and assemblies mounted on columns or other structures shall be painted to match architecture color schemes and are subject to Authority approval.

2.3 NETWORK VIDEO SERVER

A. Characteristics

1. All cameras implemented as part of this contract shall utilize the existing DART Video Management System, New Network Video Servers NVS shall be provided at the Camp Wisdom and UNT Stations. Any additional licenses to place these servers and associated cameras on the DART system shall be provided.

2. Video storage shall be provided at each location for 30 days storage at full frame rate and resolution for all connected cameras. Video storage shall be certified by Cisco, the CCTV system manufacturer, as compatible and appropriate for video storage.
3. If the Contractor wishes to use a CCTV camera that meets the specifications and is not currently integrated into the NVR or DART PSIM, than they must have the camera integrated at no additional cost to the contract and without any contract time extension.

2.4 LOCAL AREA NETWORK EQUIPMENT

A. CCTV Field Ethernet Switches shall meet or exceed the following criteria:

1. Shall be rack or din rail mounted
2. Shall support Jumbo Frames up to 9,018 byte frame size.
4. Shall be 1 rack unit in height.
5. Rack Mount Ethernet Switch ports shall include the following.
   a. Minimum (24) auto-sensing and auto-negotiating 10/100/1000 ports
   b. 1 RS-232C DB-9 console port
   c. 4 open 10/100/1000 SFP Ports (for use with 1000LX GBIC transceivers)
6. Ethernet Switch shall meet the following performance requirements:
   a. Latency: <6 µs
   b. Throughput: up to 38 million pps
   c. MAC address table size: 12,000 entries
   d. 32 Gbps switching fabric
7. Ethernet Switch shall meet the following environmental requirements:
   a. Operating temperature: 32 degrees F to 113 degrees F
   b. Operating relative humidity: 10 percent to 85 percent non-condensing
8. Ethernet Switch shall meet the following electrical requirements:
   a. Voltage: 100-240VAC
   b. Frequency: 50-60Hz
9. Ethernet Switch shall meet the following safety requirements:
   a. UL Listed (UL60950), cUL, CE, Emissions meet FCC Part 15, Class A.
10. Ethernet Switch shall meet the following device management standards:
    a. RFC 1591 DNS (client)
    b. HTML and telnet management
11. Ethernet Switch shall meet the following network management standards:
    a. RFC 2819 Four groups of RMON: 1 (statistics), 2 (history), 3 (alarm) and 9 (events)
    b. SNMPv1/v2c/v3
12. Ethernet Switch shall use the following IP Multicast Standards:
    a. IGMPv1, IGMPv2, IGMPv3
13. Ethernet Switch shall be in compliance with the following security features:
    a. IEEE 802.1X Port Based Network Access Control
    b. RFC 1492 TACACS+
    c. Secure Sockets Layer (SSL)
    d. SSHv1/SSHv2 Secure Shell
14. Ethernet Switch shall meet the following protocols and industry standards:
    a. IEEE 802.1D MAC Bridges
    b. IEEE 802.1p Priority
    c. IEEE 802.1Q VLANs
    d. IEEE 802.1s Multiple Spanning Trees
    e. IEEE 802.1w Rapid Reconfiguration of Spanning Tree
    f. IEEE 802.3x Flow Control
    g. RFC 854 TELNET
    h. RFC 951 BOOTP
    i. RFC 2030 Simple Network Time Protocol (SNTP) v4
j. RFC 2131 DHCP

B. Environmentally hardened Ethernet switches shall be utilized to aggregate IP streams from cameras and to provide for optical uplinks so as not to exceed 300 foot distance typical for copper cable Ethernet circuits.

1. All hardened Rack Mount PoE Ethernet Switches shall meet or exceed the following criteria:

a. Shall mount in a 19 inch equipment rack.

b. Shall support Power over Ethernet (POE) on all copper ports.

c. Rack Mount Ethernet Switch ports shall include the following.

1) Minimum (24) auto-sensing 10/100 POE ports

2) 1 RS-232C DB-9 console port

3) 2 open 10/100/1000 SFP Ports (for use with 1000LX GBIC transceivers)

d. POE Switch shall meet the following performance requirements:

1) Latency: 6 µs

2) Throughput: up to 11.9 million pps

3) MAC address table size: 4,000 entries

e. POE Switch shall meet the following environmental requirements:

1) Operating temperature: -40 degrees F to 185 degrees F (-40 degrees C to 85 degrees C)

2) Operating relative humidity: 5 percent to 95 percent non-condensing

f. POE Switch shall meet the following electrical requirements:

1) Voltage: 48 VDC

g. POE Switch shall meet the following safety requirements:

1) UL Listed (UL60950), UL, CE, Emissions meet FCC Part 15, Class A.

2) IEC 61850 EMC and Operating Conditions Class C for Power Substations

3) IEEE 1613 Class 2 Environmental Standard for Electric Power Substations

4) NEBS L3 and ETSI compliant

5) NEMA TS-2 and TEES for traffic control equipment Standards and Protocols

h. POE Switch shall meet the following device management standards:

1) RFC 1591 DNS (client)

2) HTML and telnet management

i. POE Switch shall meet the following network management standards:

1) RFC 2819 Four groups of RMON: 1 (statistics), 2 (history), 3 (alarm) and 9 (events)

2) SNMPv1/v2/v3

j. Poe Switch shall use the following IP Multicast Standards:

1) IGMPv1, IGMPv2, IGMPv3

k. POE Switch shall be in compliance with the following security features:

1) IEEE 802.1X Port Based Network Access Control

2) RFC 1492 TACACS+

3) Secure Sockets Layer (SSL)

4) SSHv1/SSHv2 Secure Shell
I. POE Switch shall meet the following protocols and industry standards:

1) IEEE 802.1D MAC Bridges
2) IEEE 802.1p Priority
3) IEEE 802.1Q VLANs
4) IEEE 802.1w Rapid Reconfiguration of Spanning Tree
5) IEEE 802.3af Power over Ethernet
6) IEEE 802.3x Flow Control
7) RFC 854 TELNET
8) RFC 951 BOOTP
9) RFC 2030 Simple Network Time Protocol (SNTP) v4
10) RFC 2131 DHCP

C. Ethernet switches shall be compatible with the DART network as defined in Section 16877 including the existing DART SONET system. All Ethernet switches shall be managed.

2.5 OUTDOOR EQUIPMENT CABINETS

A. CCTV Remote Field Cabinet Specifications

1. Outdoor equipment cabinets shall be provided as necessary to house Ethernet switches for aggregation and fiber uplink, as described above. Cabinets shall be sized to accommodate the Ethernet switches, fiber distribution panels and cabling.

2. Cabinets shall be NEMA-4X. Cabinets shall mount to the station platform, canopy, light pole or a concrete pedestal (provided by the contractor) as appropriate to the installed location and per architect and Authority acceptance.

3. Cabinets shall be fabricated from 12-gauge stainless steel.

4. All cables within the cabinet shall be organized and routed in conduit of flex tube for cable protection.

5. Cable entrances shall be sealed with duct sealant that provides moisture and fire barrier.

6. Steel plates shall be provided as backing to the lockset or hasp. Contractor shall provide locks for each cabinet, keyed as directed by DART.

7. Grounding

a. Cabinet shall be equipped with a copper grounding bus bar. The bus bar shall be located in the bottom of the cabinet and shall be mounted on insulators that isolate the bus bar from the cabinet.

b. Bus bar shall be bonded to a No. 4 AWG insulated stranded copper conductor that shall be connected to the station ground grid or a ground rod for cabinets not located within the station area.

c. Cabinet enclosure shall be equipped with a 3/8 inch high tensile strength bronze stud which shall be connected to the bus bar via a No. 6 AWG conductor.

d. All electronic equipment chassis grounds shall be grounded using No. 10 AWG insulated stranded copper conductors, connected to the ground bus.

2.6 INDOOR EQUIPMENT CABINETS

A. CCTV Cabinet Specifications: Where indoor cabinets are used at passenger stations, CCTV equipment shall be mounted with other communications equipment in cabinets as per Section 16837.

2.7 WIRE AND CABLE

A. Specifications

1. Cameras shall utilize Category 6e Shielded twisted pair cable as per Section 16841.

2. Fiber optic uplinks shall utilize multimode fiber optic cable as per Section 16845. Fiber distribution panels shall be provided as per contract Drawings and Section 16845.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Equipment shall be installed as shown in the Contract Drawings, and in accordance
with the manufacturers’ recommendations.

2. Required interconnections, services, and adjustments for a complete and operational system shall be provided.

3. Electrical work shall be in accordance with NEC.

B. Power: Equipment primary power shall be extended from the UPS AC Power Distribution panel.

C. Wiring

1. System wiring outside of the communications room shall be installed in conduit. The conductors for the CCTV system shall be installed in conduits, junction boxes, or outlet boxes separate from lighting and power systems conduit.

2. Conduit shall be 1/2-inch minimum in accordance with NEC.

3. Wiring within equipment shall be readily accessible without removing component parts.

D. Over-voltage and Surge Protection

1. Cables and conductors, which serve as communications links, shall have surge protection circuits installed at the equipment room or cabinet end.

2. Fuses shall not be used for surge protection.

E. Delivery and Storage: Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variation, dirt and dust, and any other contaminants.

3.2 TESTING AND INSPECTION

A. Contractor shall perform the following inspection and test on the CCTV Subsystem at each equipment installed location. The Authority shall be given at least 10 days written notice prior to each scheduled test so that the Authority may be present as desired.

1. Field Inspection: Field Inspection of CCTV equipment at each station shall verify the following:

   a. Conformance to standards, methods, quality, specification requirement and approved drawings.

   b. Proper routing and termination of wire and cable.

   c. Secured cable and wire connections.

   d. Proper grounding of all equipment.

   e. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.

   f. Correct mounting position and orientation of each camera.

2. Field Testing

   a. Tests shall be performed in the presence of the Authority under the supervision of the CCTV system manufacturer’s qualified representative.

   b. Contractor shall perform the following:

      1) Provide all instruments and personnel required for the tests.

      2) CAT5e and CAT6 cable shall be tested after termination to ensure that the cable was not damaged during pulling and that it was properly terminated. The Engineer reserves the right to attend or send a representative to any cable testing that is performed.

      3) An Ethernet bandwidth test shall also be performed on each CAT5e and CAT6 cable with commercial off the shelf handheld Ethernet bandwidth testers that perform RFC 2544 compliant tests at 1 Gigabit. The Ethernet bandwidth tester shall also be capable of saving test reports to internal or removable storage for printing a PDF of each report. Each cable report shall be submitted. The test setup shall use 1 tester on each end of the cable and shall test bi-directionally. Upon
completion of the installation, the Contractor shall subject the system to a complete functional and operational performance test. As a minimum, the tests shall include:

a) Verify operation of each camera, including video.

b) Verify field of view for each camera provides expected coverage.

c) Verify and adjust focus of each camera, based on observation of video at the DART control center.

d) Verify that video from each camera is recorded. Verify that resolution and frame rate are correct.

e) Verify that alarms tag video correctly.

3. End-To-End and Systems Integration Test: Contractor shall provide qualified technical staff to support the End-To-End test for CCTV, performed by others.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16856
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the detailed technical requirements for adding a new line section to the DART OCC.

1. All work shall be accomplished by personnel approved by the manufacturer of the existing DART system.

2. Work includes provision of all hardware and software (including licenses and modifications) to provide a fully functioning, stable system with all of the functionality that currently exists.

3. Work includes modification to the existing overview display and workstation graphics to depict the new line section and facilities. A preliminary concept of the display modifications is shown on the drawings.

4. All functionality that exists on the existing system shall be provided for the new line section. This shall include:
   a. Controller Log-in to territory
   b. Interlocking monitoring and control
   c. Substation monitoring and control
   d. Passenger station equipment monitoring and control
   e. Train tracking
   f. Dark territory train counts for existing line sections adjacent to the new line section
   g. Interface with PA/VMB functionality for automated train arrival announcements
   h. Interface with CCTV server for streaming video, camera controls and monitoring
   i. Interface with VBS for vehicle reporting
   j. Alarm and status management
   k. Alarm and status reporting

1.2 REFERENCED STANDARDS

A. Contractor’s design and installation shall comply with the latest editions of all applicable Standards and Codes included herein. Work shall meet or exceed the standards and procedures specified

1. American Society of Quality (ASQ)
   a. ASQ Z1.11 - Quality Assurance Standards - Guidelines for the Application of ANSI/ISO/ASQC Q9001 or Q9002 to Education and Training Institutions - ANSI/ASQC Z1.11

2. The Institute of Electrical and Electronics Engineers (IEEE)
   a. IEEE C62.41 - IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

3. National Fire Protection Association (NFPA)
   a. NFPA 70 - National Electrical Code (hereinafter referred to as NEC)

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specification and the specific technical requirements further listed herein.

1. Personnel Qualifications: All personnel that will work on hardware or software are subject to AUTHORITY approval. Provide resumes of all proposed personnel.

2. Manufacturer Qualifications: Any new equipment or software differing from those specified in the technical specifications shall require a prequalification and approval of the proposed manufacturer. Acceptability of the manufacturer shall be based on the manufacturer’s experience, equipment reliability, compliance with standards specified in this section, and complete compatibility with the Authority’s existing system.

3. Preliminary Design Review (PDR) Technical Requirements. Contractor shall include the following information as part of the PDR submittal package:
a. Battery calculations shall be provided for modified CCS power requirements.

b. A complete list of CCS modified or new Subsystem equipment (including manufacturer's descriptive and technical literature and catalog cut sheets) including Cameras, enclosures, storage devices, Ethernet switches, software licenses.

c. Preliminary wiring diagrams for all field CCS equipment provided and installed under this contract.

d. Drawings showing the plan and elevation for each station equipped or retrofitted.

e. Preliminary drawings showing the modifications necessary at OCC and NWROF.

f. A software requirements specification and preliminary software design description for the modifications shall be provided. This shall give a description of the software modules, databases, XML, and other elements that will require change. It will also identify and necessary re-structuring or changes to database dimensions.

4. Final Design Review (FDR) Technical Requirements. Contractor shall include the following information as part of the FDR submittal package for the CCS Subsystem:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

b. Battery calculations.

c. A complete list of CCS Subsystem modified or new equipment (including manufacturer's descriptive and technical literature and catalog cut sheets) including Cameras, enclosures, storage devices, Ethernet switches, software licenses.

d. Detail drawings for CCS systems. The drawings shall consist of the following:

1) Wiring diagrams

2) Complete subsystem inter-connection diagrams

e. Other details, as required to verify that the system conforms to industry standards and requirements

f. An updated software requirements specification and final software design description for the modifications shall be provided. This shall give a description of the software modules, databases, XML, and other elements that will require change. It will also identify and necessary re-structuring or changes to database dimensions.

5. Installation Work Plans. Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The Installation Work plan shall include:

a. Drawings and Diagrams to include:

1) Equipment layout in plan and elevation views, including all conduit and cable

2) System block diagram.

3) Wiring diagrams showing detail connection of all system components including Ethernet, power and control wiring.

4) Conduit installation details.

6. Calculations or Certifications

a. Calculations as listed in the PDR and FDR.

b. Certifications: Copy of the following certifications shall be included:

1) ISO certification for all proposed manufacturers.

7. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.
8. Software Implementation and Cutover Plan
   a. Implementation and cutover of the software to support the new line section without disruption to the Authority’s operations is imperative. All software must be fully tested off-line before it is implemented on the DART system. This is to include regression testing to verify that there is no loss of functionality. This is to also include stress testing of the software to validate that stability of the software has not been compromised by the addition of the new line section.
   b. Contractor shall submit a complete plan for implementing and cutting over the software. This plan shall include necessary hold and validation points to verify suitability prior to placing any upgrades into service. The plan shall also include a description of the software testing and validation procedures that shall be used.
   c. Contractor shall provide a release plan that will indicate which changes will be provided in each release and the general format of the release notes to be provided with each release. Release notes shall include a section describing how the release will be installed as well as a procedure for backing out the release if necessary.

9. Test Plan and Procedures
   a. Test procedures shall be submitted for all the required tests as described in paragraph 3.2 of this Section. As a minimum:
      1) Test program shall include all the required tests for this subsystem
      2) Factory Test Procedure
      3) Field Test Procedure
      4) Integration Test Procedure
   b. Test Records: Contractor shall submit the Test Records and Results for review 7 days after the completion of each test, in accordance with these Specifications.

10. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the Control Center hardware and software.

1.4 QUALITY ASSURANCE
   A. Contractor’s design and installation shall comply with all applicable Standards and Codes as listed herein.
   B. Material and Workmanship Requirements
      1. All equipment provided under this Section shall be UL listed.
      2. All grounding shall be in accordance with local standards, and specifications required by this contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.
      3. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within one calendar year of the installation date shall not be used.
      4. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.
   C. Manufacturer Pre-Qualification Requirements: All new equipment provided and installed under this contract shall be compatible with existing CCS Subsystem equipment installed in central locations in order to perform the intended use set forth by the Authority.
   D. Personnel Requirements All software work shall be performed under the supervision of personnel certified to work on the existing GE software. Personnel are subject to AUTHORITY approval.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS
   A. System Description: The existing system provides for complete monitoring and control of all DART lines. Complete documentation regarding system functionality can be made available to the Contractor upon request from the Authority.
   B. Integration of New Line Sections
      1. All new Project controls and indications shall be fully integrated into the existing system and shall function in a manner
similar to existing controls and indications of the same type. Any new software licenses or upgrades necessary to support this integration shall be provided.

2. The drawings show a typical layout for modifying displays to accommodate the new line section in a geographically representative manner. All displays shall be subject to Authority approval.

3. All reporting capabilities of the system shall be provided for the new line section, with reports containing data for both existing and new locations, in appropriate context. This shall include ad-hoc queries.

4. Alarm and status display shall show new line section information in the correct context and order, similar to existing lines.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Any new equipment required shall be installed as shown in the Contract Drawings, and in accordance with the manufacturers' recommendations.

2. Required interconnections, services, and adjustments for a complete and operational system shall be provided.

3. Electrical work shall be in accordance with NEC.

B. Power: Equipment primary power shall be extended from the UPS AC Power Distribution panel.

C. Wiring

1. System wiring outside of the communications room shall be installed in conduit. The conductors for the CCS system shall be installed in conduits, junction boxes, or outlet boxes separate from lighting and power systems conduit.

2. Conduit shall be 1/2-inch minimum in accordance with NEC.

3. Wiring within equipment shall be readily accessible without removing component parts.

D. Over-voltage and Surge Protection

1. Cables and conductors, which serve as communications links, shall have surge protection circuits installed at the equipment room or cabinet end.

2. Fuses shall not be used for surge protection.

E. Delivery and Storage: Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variation, dirt and dust, and any other contaminants.

F. Software Modifications

1. Software modifications shall be executed in accordance with the approved implementation and cutover plan. It is anticipated that all software revisions will be developed and tested in an offline environment that resembles the installed environment at DART. The live DART system shall not be used for development.

2. Contractor shall work with the Authority and specifically the Authority's OCC personnel to schedule any software releases. All software releases shall be installed during non-revenue hours. Contractor shall provide on-site personnel to support the release. These personnel shall remain at DART during the morning rush hour or until the Authority indicates that they are satisfied with the installation.

3.2 TESTING AND INSPECTION

A. Contractor shall perform the following inspection and test on the CCS Subsystem at each equipment installed location. The Authority shall be given at least 10 days written notice prior to each scheduled test so that the Authority may be present as desired.

1. Factory Testing: Factory testing of CCS software shall be required, to verify complete functionality of the system for new line section and to validate that no unintended problems were introduced to existing functionality.

2. Field Testing

a. The tests shall be performed in the presence of the Authority under the supervision of the CCS system manufacturer's qualified representative.
b. Contractor shall perform the following:

1) Provide all instruments and personnel required for the tests.

2) Upon completion of the installation, the Contractor shall subject the system to a complete functional and operational performance test. As a minimum, the tests shall include:

- Logging in and assuming control of the new line section
- Setting routes (all methods)
- Displaying correct track circuit occupancies and signal aspects
- Capability to exercise all substation controls
- Correct display of all substation indications
- Correct display of all passenger station status indications
- Correct display of counts of trains in existing adjacent dark territories
- Correct generation of train arrival announcements
- Correct operation of status and alarm windows
- Correct generation of reports
- Correct generation of query results
- Correct graphical display and nomenclature

3. End-To-End and Systems Integration Test:

a. Contractor shall provide qualified technical staff to perform the End-To-End test for CCS. The Authority will use the system for a period up to thirty days and report any anomalies to the Contractor. The Contractor shall correct anomalies and re-validate the system.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for providing Supervisory Control and Data Acquisition (SCADA) Remote Terminal Units (RTU’s) to provide for controls and indications of wayside devices from the DART OCC.

1. All work shall be accomplished by personnel approved by the manufacturer of the existing DART system.

2. Work includes provision of all hardware and software (including licenses and modifications) to provide a fully functioning, stable system with all of the functionality that currently exists.

3. RTU’s shall be provided for monitoring and control of Traction Power Substations, Signal Houses, and Communications Facilities and their systems.

1.2 REFERENCED STANDARDS

A. Contractor’s design and installation shall comply with the latest editions of all applicable Standards and Codes included herein. Work shall meet or exceed the standards and procedures specified.

1. American National Standards Institute (ANSI)

2. American Railway Engineering and Maintenance of Way Association (AREMA)

3. American Society of Quality (ASQ)


5. The Institute of Electrical and Electronics Engineers (IEEE)

6. National Fire Protection Association (NFPA)

7. National Electrical Manufacturer’s Association (NEMA)

8. National Electrical Code (NEC)


10. Underwriters Laboratories, Inc. (UL)

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specification and the specific technical requirements further listed herein.

B. Any new equipment differing from those specified in the technical specifications shall require a prequalification and approval of the proposed manufacturer. Acceptability of the manufacturer shall be based on the manufacturer’s experience, equipment reliability, compliance with standards specified in this section, and complete compatibility with the Authority’s existing system.

C. Preliminary Design Review (PDR) Technical Requirements. Contractor shall include the following information as part of the PDR submittal package for the Intrusion Alarm subsystem:

1. Battery or UPS calculations shall be provided for RTU power requirements.

2. A complete list of RTU Subsystem equipment (including manufacturer’s descriptive and technical literature and catalog cut sheets) including enclosures, storage devices, Ethernet switches, software licenses.

3. Preliminary wiring diagrams for all field RTU equipment provided and installed under this contract.

4. Drawings showing the plan and elevation for each station equipped or retrofitted.

5. Preliminary drawings showing the modifications necessary at OCC and NWROF.

6. A SCADA points list for each location including at a minimum the type (input/output) and the output relay contact states (normally open or normally closed).


1. Contractor shall include the following information as part of the FDR submittal package for the RTU Subsystem:

   a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

   b. Battery calculations shall be provided for RTU equipment.
c. A complete list of RTU Subsystem equipment (including manufacturer's descriptive and technical literature and catalog cut sheets) including enclosures, storage devices, Ethernet switches, software licenses.

2. Detail drawings for RTU systems. The drawings shall consist of the following:
   a. Wiring diagrams.
   b. Complete subsystem inter-connection diagrams.

3. Other details, as required to verify that the system conforms to industry standards and requirements.

E. Installation Work Plans. Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activities. The Installation Work plan shall include:

1. Drawings and Diagrams to include:
   a. Equipment layout in plan and elevation views, including all conduit and cable.
   b. System block diagram.
   c. Wiring diagrams showing detail connection of all system components including Ethernet, power and control wiring.
   d. Conduit installation details.

F. Calculations or Certifications

1. Calculations as listed in the PDR and FDR.

2. Certifications: Copy of the following certifications shall be included:
   a. ISO certification for all proposed manufacturers.

G. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.

H. Test Plan and Procedures

1. Test procedures shall be submitted for all the required tests as described in Article 3.2 of this Section. As a minimum:
   a. Test program shall include all the required tests for SCADA subsystem

b. Factory Test Procedure

c. Field Test Procedure

d. Integration Test Procedure

2. Test Records: Contractor shall submit the Test Records and Results for review 7 days after the completion of each test, in accordance with these Specifications.

I. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the SCADA Subsystem.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes: Contractor's design and installation shall comply with all applicable Standards and Codes as listed herein.

B. Material and Workmanship Requirements

1. All equipment provided under this Section shall be UL listed.

2. All grounding shall be in accordance with local standards, and specifications required by this contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

3. Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within one calendar year of the installation date shall not be used.

4. All products specified herein shall be subject to the Authority approval based on the Contractor's ability to demonstrate adherence to the specified requirement and approval of the manufacturer's quality process.

C. Manufacturer Pre-Qualification Requirements: All new equipment provided and installed under this contract shall be compatible with existing RTU Subsystem equipment installed in central locations in order to perform the intended use set forth by the Authority.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. System Description

1. SCADA RTU Equipment – DART's SCADA system is currently fully operational. The new RTU's for this contract shall be fully integrated into the existing system. The Contractor is
advised to become fully familiar with the existing hardware, software and operations of the SCADA system used by DART and design the new system to be fully compatible with it. To achieve this, the Contractor should visit DART’s facilities and study relevant technical information before designing the new RTU’s.

2. The SCADA RTU Equipment shall be capable of communications with DART’s Central Control System (CCS) and have the functionality as indicated in Section 16866. Communications between the RTU and the office shall be based on the DF1 protocol as implemented for existing DART facilities.

   a. If RTU functionality is implemented via interface with a traction power or signal PLC, the work shall include protocol conversion to use the DF1 protocol.

3. The SCADA RTU Equipment shall be compatible with the existing Allen-Bradley product DART approved equal. Typical SCADA RTU components are shown on the Contract Drawings. SCADA panels include:

   a. PLC Chassis with power supply, CPU, and input/output modules.
   b. SCADA power supply.
   c. Terminal blocks.
   d. Any interposing relays necessary.

4. PLC programming shall utilize the modules and structure typical for existing PLC’s utilized on the DART SCADA system.

2.2 SCADA POINTS

A. The required SCADA Points are indicated in these Specifications, on the Contract Drawings and as shown in the typical SCADA points list in this Section’s appendix. The SCADA points shall support similar monitoring and control capabilities as are in place for existing DART locations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

   1. Equipment shall be installed as shown in the Contract Drawings, and in accordance with the manufacturers’ recommendations.

   2. Required interconnections, services, and adjustments for a complete and operational system shall be provided.

   3. Electrical work shall be in accordance with NFPA 70.

B. Power:

   1. Equipment primary power shall be extended from the UPS AC Power Distribution panel or a battery backup.

   2. When the AC supply is interrupted, the UPS or battery backup system shall supply the RTU with the required power for a minimum of 8 hours.

C. Wiring

   1. System wiring outside of the communications room shall be installed in conduit. The conductors for the RTU system shall be installed in conduits, junction boxes, or outlet boxes separate from lighting and power systems conduit.

   2. Conduit shall be 1/2-inch minimum in accordance with NFPA 70.

   3. Wiring within equipment shall be readily accessible without removing component parts.

D. Over-voltage and Surge Protection

   1. Cables and conductors, which serve as communications links, shall have surge protection circuits installed at the equipment room or cabinet end.

   2. Fuses shall not be used for surge protection.

E. Delivery and Storage: Equipment delivered and placed in storage shall be protected from the weather, humidity and temperature variation, dirt and dust, and any other contaminants.

3.2 TESTING AND INSPECTION

A. General: All testing and reporting shall be performed in accordance with Section 16801, “Basic Technical Requirements - Communications System.”

B. Contractor shall perform the following inspections and tests on the RTU Subsystem where applicable. Contractor shall provide written notice to the Authority not less than 10 days prior to each test and inspection so that the Authority may be present as desired.
1. Factory Test and Inspection:
   a. Factory testing and inspection of RTU system shall be required.
   b. Inspections shall verify proper wiring and workmanship of SCADA panels.
   c. Testing shall verify proper programming of the PLC’s, including alignment of the SCADA points list.

2. Field Inspection: Field Inspection of RTU equipment at each station shall verify the following:
   a. Conformance to standards, methods, quality, specification requirement and approved drawings.
   b. Proper routing and termination of wire and cable.
   c. Secured cable and wire connections.
   d. Proper grounding of all equipment.
   e. Correct and complete labeling and tagging of wire, cable, terminal, connectors and equipment.
   f. Correct mounting position and orientation of each camera.

3. Field Testing
   a. The tests shall be performed in the presence of the Authority under the supervision of the RTU system manufacturer’s qualified representative.
   b. Contractor shall perform the following:
      1) Provide all instruments and personnel required for the tests.
      2) Locally verify all input output points using a laptop configured to allow for toggling of points and indication monitoring.
      3) Upon completion of the installation, the Contractor shall subject the system to a complete functional and operational performance test. As a minimum, the tests shall include:
         a) End-To-End Test: Contractor shall provide qualified technical staff for the End-To-End test for SCADA, to the OCC, including proper indications, controls and status monitoring.
         b) Systems Integration Test: Contractor shall provide qualified technical staff to support the Authority’s System Integration Test for SCADA, to the OCC, including proper indications, controls and status monitoring.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT
   A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”
### 16868 APPENDIX – TYPICAL SCADA I/O LIST

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<th>Point Name</th>
<th>Input (I) or Output (O)</th>
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<td><strong>Communications</strong></td>
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<tr>
<td>UPS Loss of AC Power</td>
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<tr>
<td>UPS Trouble Alarm</td>
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<tr>
<td>PA/VMB Summary Alarm</td>
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<td>PA Amplifier 2 Alarm</td>
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## Traction Power

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PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Fare Collection Local Area Network (LAN) to be designed, provided, installed and tested under this Contract. Work scope includes:

1. Technical and administrative requirements for interfaces between Communications and Central Control System (CCS) and the Fare Collection discipline, and the detailed technical requirements for the Fare Collection LAN to be designed, provided, installed, and tested.

B. Existing System Description and Configuration

1. Multiple Ticket Vending Machines (TVM) at each station are connected into a LAN to consolidate data at the Communications Interface Cabinet (CIC) or Communications Room via a 10/100 Mbps multi-port switch and forward the information to Ethernet ports on the Communication Transmission Subsystem (CTS) equipment.

2. Ethernet ports at all CTS equipment are provisioned at 100 Mbps for a separate Fare Collection Virtual Local Area Network (VLAN) to segregate this traffic from all others on the network.

3. The Fare Collection VLAN will have existing connectivity to the Authority LAN and subsequently to a Fare Collection Data Storage Computer (DSC) located at Authority Headquarters via the CTS. This connectivity shall allow data to be exchanged between individual Station TVMs and the Data Storage Computers.

C. Responsibilities

1. DART will provide the Fare Collection Equipment, completely programmed.

2. Contractor shall install the equipment at the designated locations at the stations.

3. Contractor shall connect power and the data network equipment, as described in this section.

4. Contractor shall support DART in testing the end-to-end communications capabilities.

1.2 REFERENCED STANDARDS

A. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 802 – Local and Metropolitan Area Network Standards

B. International Organization for Standard (ISO)

1. ISO 9001 – Quality Management Standards

C. National Fire Protection Association (NFPA)

1. NFPA 70 – National Electric Code

D. Underwriters Laboratories, Inc. (UL)

1. UL 444 – Communications Cables

2. UL 1863 – Communications-Circuit Accessories

1.3 SUBMITTALS

A. Submittal format and content shall comply with the requirements of these Specifications and the specific technical requirements further listed in this Section.

1. Preliminary Design Review (PDR) Technical Requirements

a. Complete product data including description and model number, shop drawings, catalog cuts and technical literature for the following equipment and material:

1) Data switch

2) SC Duplex Single Mode Fiber Optic Jumper Cables

3) Media conversion equipment

4) Category 5e Ethernet Patch Cables

b. Fare Collection LAN block diagram and overall system description.

c. Interface description between the Fare Collection LAN and other Communications subsystems and contracts required to complete the transfer of Fare Collection data from TVMs to DSC.
d. Proposed revision of Data switch operating software with descriptive documentation, including, but not limited to:

1) Release Notes
2) Product Bulletins
3) Applicable Field Notices

e. Equipment operating instructions or details.
f. Mounting and installation details, rack layouts.
g. Complete End-to-End wiring diagrams.
h. Outside Plant (OSP) cable routing, pair, and fiber strand usage diagrams.
i. Intra and Inter rack wiring.
j. Patches.
k. Power and grounding

2. Final Design Review (FDR) Technical Requirements. Contractor shall include the following information as part of the FDR submittal package for the Fare Collection LAN:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.
b. Fiber optic link loss budgets for all fiber optic spans between CICs and Communications facilities, sufficient to show that all proposed spans meet published link loss budgets.

c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in paragraph 3.2 of this Section.

d. End-to-End Acceptance Test: There is no requirement for an End-to-End Test performed on the Fare Collection LAN.

e. System Integration Test: Contractor shall provide qualified staff to support the Fare Collection LAN integration test as described in paragraph 3.2 of this Section. The Authority will direct the System Integration Test.

3. Installation Work Plans. Contractor shall submit the following installation document for each site no later than 60 days prior to the schedule installation activities. The Installation Work plan shall include:

a. Drawings showing plan and elevation details of equipment including conduit interface and all mounting hardware.
b. Cable and wire requirements.
c. Grounding details.

4. Calculations or Certifications: Fiber span loss calculations (as required in the Design Review Sections) to validate switch distances.

5. Test Plan and Procedures. Test Plan and Procedures shall be submitted in accordance with these Specifications and as outlined herein:

a. Test Program Plan: Contractor shall include all the required information for the Fare Collection LAN in the Test Program Plan as outlined in these Specifications.
b. Factory Test and Inspection Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in paragraph 3.2 of this Section.
c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in paragraph 3.2 of this Section.

d. End-to-End Acceptance Test: There is no requirement for an End-to-End Test performed on the Fare Collection LAN.

e. System Integration Test: Contractor shall provide qualified staff to support the Fare Collection LAN integration test as described in paragraph 3.2 of this Section. The Authority will direct the System Integration Test.

6. Test Records: Contractor shall submit the Test Records for review 14 days after the completion of each test in accordance with these Specifications.

7. As-Built Documentation

a. Submit as-built drawings and complete equipment data with operating instructions.
b. Accompanying each interface drawings package, submit a written interface specification that details the functional, electrical and mechanical interface properties.
c. Submit default or as-built Configuration and Provisioning Information for each programmable piece of equipment to allow system integration by follow-on contractors and consultants, including:
FARE COLLECTION LOCAL AREA NETWORK - COMMUNICATIONS SYSTEM

1) Programming passwords.
2) Programmable feature settings.
3) Board level switch/strap settings.
4) Node addressing information.
d. Submit card layout or slot configurations (component equipment inventory).
e. Submit any other configuration or provisioning which deviates from manufacturer's default state.

1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes: Contractor’s design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein. All equipment and methods shall comply with the latest version of standards as applicable in paragraph 1.2 of this Section.

B. Material and Workmanship Requirements

1. All equipment provided under this Section shall be UL listed.
2. All products specified herein shall be subject to Authority approval based on the Contractor’s ability to demonstrate adherence to these Specifications and Authority approval of the manufacturer’s quality process.
3. All products shall be compatible with existing LAN and CTS elements in order to perform the intended use set forth by the Authority.
4. Discontinued or end-of-life product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end-of-service within one calendar year of the installation date shall not be used.

PART 2 - PRODUCTS

2.1 FARE COLLECTION LAN DATA SWITCH AND OTHER MATERIALS

A. The Fare Collection LAN shall utilize TCP/IP as the transport and network layer service protocol. Physical Ethernet interface settings shall be set to 100 Mbps, Full Duplex.

B. Fare Collection LAN data transmission equipment, media conversion, and interconnection equipment at each station or Communications Facility shall include:

1. Data switch and LAN equipment shall be commercial off-the-shelf equipment (COTS).
2. The Data Switch shall support the following protocols and operating characteristics:
   a. IEEE 802.3 (10BaseT)
   b. IEEE 802.3u (100BaseTX, FX)
   c. IEEE 802.3x (flow control)
   d. IEEE 802.1q (VLAN)
   e. IEEE 802.1w (Rapid Spanning Tree)
   f. SNMP v1, v2c
   g. Input power: 120 VAC 60Hz nom.
   h. Power consumption < 25 W
   i. Network management via both Telnet (VT100) and Command Line Interface (CLI)
3. At each Station CIC or Communications Facility serving ticket vending machines the Contractor shall provide sufficient full duplex 100Base-FX MM fiber ports to terminate all TVM’s. This shall be accomplished using one or more multi-port, multifunction Data Switches.
4. Data Switches shall not exceed the allocated rack space requirements shown in the Contract Drawings for each location. The Data Switch shall be either rack mounted or mounted to a Contractor provided shelf in the space indicated on the Contract Drawings. If a shelf is used for mounting the data switch, it shall be mounted on sliding rails and all cords and cables will be mounted with service loops and slack to support extending the shelf without interference.
5. Data Switch shall perform media conversion between all of its Ethernet port types. All fiber ports shall be full duplex (i.e. two fibers per port – one transmit, one receive) Each Data Switch shall provide as a minimum the following Ethernet data port quantities and types:
<table>
<thead>
<tr>
<th>QTY</th>
<th>TYPE</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>10/100Base TX</td>
<td>RJ45</td>
</tr>
<tr>
<td>2</td>
<td>100Base-FX SM</td>
<td>SC</td>
</tr>
<tr>
<td>4</td>
<td>100 Base-FX MM</td>
<td>SC</td>
</tr>
</tbody>
</table>

6. Data Switch shall be capable of local management and shall be remotely manageable by a telnet connection and a single SNMP based manager application.

7. Media conversion for Fare Collection equipment as described in these Specifications and as shown on Contract Drawings.

8. Fiber distribution panels and accessories as described in these Specifications and as shown on Contract Drawings.

9. At stations with a CIC, fiber optic cable from the CIC to a designated Communications Facility.

10. Cable and termination equipment to support transmission of TVM intrusion alarms through a station demarcation panel to the nearest Communications Facility, as described in these Specifications and as shown on Contract Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment shall be installed as shown in the Contract Drawings, and in accordance with the manufacturer’s recommendations.

B. Contractor shall install data transmission equipment, media conversion, and interconnection equipment at each station CIC, and Communication Facility as applicable.

C. Contractor shall coordinate all Work described in this Section with the Authority.

D. Contractor shall coordinate details of all interface requirements with the Authority.

E. Contractor shall program the Data Switch VLAN configuration as necessary to isolate TVM data ports from PA/VMB and other data sources that may also connect to the switch.

F. Cable and Wiring

   1. Contractor shall provide TVM intrusion alarm cable from each TVM routing through underground conduits to intermediate interconnection equipment to an RTU located in the nearest communications facility, to monitor and alarm any intrusion event over the SCS.

2. Contractor shall coordinate all civil work and installation of all facilities and equipment cables with the Authority.

G. TVM quantities and locations shall be in accordance with Contract Drawings.

3.2 TESTING AND INSPECTION

A. Contractor shall perform the following inspection and test on the Fare Collection LAN at each installed location. The Authority shall be given at least 10 days written notice prior to each scheduled test so that the Authority may be present as desired.

1. Factory Test and Inspection

   a. Factory Testing shall be conducted on individual equipment or assembled subsystems after all mounting, installation, wiring and other activities to support turn-up are complete.

   b. Diagnostic testing shall be performed for all equipment and all communications ports.

   c. Functional testing and validation of equipment settings shall be performed on all equipment.

   d. Any commercial off-the-shelf equipment that shares a common interface shall be assembled, integrated, and factory tested for compatibility.

2. Field Inspection

   a. Field inspection of the Fare Collection LAN shall verify the following:

      1) Equipment not damaged in transit.

      2) Equipment, port, and cable labeling are correct.

      3) Power supply integration and mounting.

      4) Cable routing.

      5) Unobstructed air flow to vented equipment.
3. **Field Test**
   
a. The tests shall be performed in the presence of the Authority.
   
1) **Functional testing from each TVM to the CTS Interface.** If required, utilize a data test set at the demarcation point to validate connection and data transfer from each TVM.

2) **Failover testing,** if applicable.

3) **Verify power connections,** test and record for proper voltage level.

4. **End-to-End Acceptance Test:** Not Required.

5. **System Integration Test.** Contractor shall provide sufficient technical staff to support the following testing activities during the Authority’s system integration test:
   
a. **Full path Ethernet connectivity testing between TVMs and Fare Collection DSC.**

b. **Functional testing between Fare Collection DSC and each networked TVM.**

c. **TVM intrusion alarm operation and reporting.**

**PART 4 - MEASUREMENT AND PAYMENT**

4.1 **GENERAL**

A. The Work specified in this Section will not be measured separately for payment.

4.2 **PAYMENT**

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16869
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Grounding and Bonding for communications systems to be designed, provided, installed, and tested under this Contract. See the Contract Drawings for more details on Grounding and Bonding for communications systems. Work scope includes:

1. Designing, providing, installing and testing Grounding and Bonding for all communications systems at Communications Facilities, Communication Interface Cabinets (CIC’s), Traction Power Substation (TPSS) and Signal Houses in accordance with these Specifications and Contract Drawings.

1.2 REFERENCE STANDARDS

A. ASTM International (Formerly known as American Society for testing and Materials) (ASTM)

1. ASTM B187/ B 187 M - Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes

2. ASTM B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft


4. ASTM D5 - Standard Test Method for Penetration of Bituminous Materials


B. Institute of Electrical & Electronics Engineers (IEEE)


C. Lightning Protection Institute (LPI)

1. LPI 175 – Standard of Practice

D. National Fire Protection Association (NFPA)

1. NFPA – 70 National Electrical Code

E. National Electrical Safety Code (NESC)

F. Telecommunications Industries Association (TIA)/ Electronic Industries Alliance (EIA)

1. TIA/EIA-607 - Commercial Building Grounding and Bonding Requirements for Telecommunications-Replaced by J-STD-607

G. Underwriters Laboratories (UL)

1. UL 467 - Safety Grounding and Bonding Equipment

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements further listed herein.

B. Preliminary Design Review (PDR) Technical Requirements

1. Contractor shall include the following information as part of the PDR for the Grounding and Bonding of communications systems:

   a. Manufacturer’s catalog data for all proposed materials with installation recommendations.

   b. Drawings showing grounding arrangement for communications facility and CIC, including locations of ground rods, cables and connectors.

   c. Drawings showing details of ground connections, terminations and access points, including details of all daisy chain connections of panels and its end connection to the Chassis Main Grounding Busbars (CMGB).

   d. Drawing showing mounting details of all ground buses (CMGB, TMGB, CGB and TGB).

   e. Grounding calculations to demonstrate the installation meets the Specification requirement of the 3 ohms.

C. Final Design Review (FDR) Technical Requirements

1. Contractor shall include the following information as part of the FDR submittal
package for the Grounding and Bonding of communications systems:

a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

b. Final installation details.

D. Installation Work Plans

1. The Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activity in accordance with these Specifications. The installation Work plan shall include the following:

a. Locations of ground rods, connectors, cables, and details of connections, terminations and access points.

b. Manufacturer’s installation recommendations.

E. Certifications

1. Certified test reports verifying that ground resistance of each ground grid when installed and each ground bus when connected to the ground grid does not exceed specified values.

F. Product Samples

1. Product samples shall be provided and demonstrated when requested by the Authority.

G. Test Plan and Procedures

1. Submit, no later than 75 days prior to the scheduled date of the corresponding test, procedures and equipment for testing resistances and electrical continuity for each location.

H. Test Records

1. Contractor shall submit the Test Records and Results for review one week after the completion of each test, in accordance with these Specifications.

I. As-Built Documentation

1. Contractor shall submit complete As-Built documentation and drawings for the Grounding and Bonding of all communications systems completed in this Contract.

1.4 QUALITY ASSURANCE

A. Contractor’s design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein. All equipment and methods shall comply with the latest version of the standards as applicable in paragraph 1.2 in this Section.

B. Material and Workmanship Requirements.

1. All equipment and material provided under this Section shall be UL listed.

2. All grounding shall be in accordance with local standards, and specifications required by this Contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

3. Discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service shall not be used.

C. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. Subsystem

1. Facilities Lightning Protection

a. A lightning protection system shall be provided for all outdoor communications equipment and wayside facilities including Communications Facilities, outdoor Public Address/Visual Message Board (PA/VMB) equipment, Wayside Telephones, Passenger Emergency Call (PECs) and CICs. The lightning protection system shall be in accordance with the requirements of ANSI/NFPA 780, Lightning Protection Code. The lightning protection system shall consist of multiple rooftop/facility/equipment air (lightning) terminals, down conductors, equalizing conductors, and ground terminals. This hardware shall surround the Communications Facility for the purposes of intercepting, diverting, and dissipating direct lightning strikes.

b. The spacing and interconnection of the lightning protection system with the communications system grounds shall be in accordance with ANSI/NFPA 780. Communications grounds shall...
be bonded to the lightning protection system grounding within 12 feet of the base of the building. Communications conductors shall not be routed closer than 6 feet from any lightning protection system conductors. The Contractor shall submit an assessment for Lightning Protection System and bonding requirements as part of the Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) Control and Test Plan to the Contracting Officer.

c. Lightning protection systems and installers shall be certified to the Lightning Protection Institute's LPI-175 and LPI-176 standards.

2.2 GROUND RODS

A. Ground rods shall be copper-clad steel, of the non-rusting type as manufactured by Copperweld Corporation, or approved equal. The rod shall be at least ten feet in length and at least 0.75-inch in diameter.

B. Ground rod clamps shall be made of a cast bronze clamp body with non-ferrous setscrews as manufactured by Copperweld Corporation or an approved equal.

2.3 EXOTHERMIC WELDS

A. Welding material shall consist of copper exothermic mixture employing tin-metal in an amount to effectively constitute 4.5 percent to 5.5 percent of the resulting weld metal. The resulting weld metal shall be of high electrical conductivity and shall have a minimum tensile strength of 39,000 pounds per square inch (psi).

B. Coating Materials for Thermite Welded Connections; Use black, rubber based compound coating materials, which are soft, permanently pliable, moldable, and unbacked, not less than 1/8 inch thick, with properties as follows:

1. Solids: 100 percent
2. Density: 12.0 pounds per gallon minimum
3. Penetration: 90-130 ASTM D5
4. Water Absorption: 0.10 percent maximum ASTM D570
5. Dielectric Strength: 500 volts/ml ASTM D149
6. Volume Resistivity: 2,000 megohms-inches ASTM D257 5,000 megohms-cm ASTM D257
7. Service Temperature: -40 degrees F to +160 degrees F

8. Chemical Resistance: Melting point, none; flammability, slow burning (ASTM C653); resists alcohol, water, aqueous hydrochloride and sodium hydroxide; dissolved by carbon tetrachloride, naphtha gasoline, mineral, spirits, ketones, and benzene.

C. Highly cohesive and adheres strongly to metals and adhesive concrete and to itself.

2.4 GROUND GRID CONDUCTORS

A. No. 2 AWG bare solid tinned copper conductor, or as shown on Contract Drawings.

2.5 GROUND ELECTRODE CONDUCTORS

A. Insulated stranded copper conductor, as shown on Contract Drawings, in accordance with these Specifications, for single-conductor cable, 600 volts.

B. Size unless otherwise shown:

1. For use in connecting ground grid to CMGB and Telecommunications Main Grounding Busbars (TMGB) at Communications Facilities: insulated No. 2 AWG or as shown on drawings.

2. For use in connecting ground grid to Chassis Grounding Busbars (CGB) and Telecommunications Grounding Busbars (TGB) at CICs: insulated No. 4 AWG or as shown on drawings.

3. For other grounding electrode conductors: In accordance with NEC Table 250-94.

C. Equipment Grounding Conductors

1. Size in accordance with NEC article 250-95, unless otherwise shown on Contract Drawings.

2. Equipment grounding insulated conductor: Single conductor stranded copper as specified in these Specifications.

D. Static Dissipative Tile

1. Static Dissipative Tile (SDT) shall be used in Communications Facilities to prevent equipment damage due to static discharge. Ground SDT ground strips to the CMGB in accordance with the manufacturer's instructions using a minimum of No.12 AWG copper wire.

2.6 CHASSIS AND TELECOMMUNICATIONS GROUNDING BUSBARS

A. CMGB and Telecommunications Main Grounding Busbars (TMGB), located in Communications Facilities shall be as follows:
1. Predrilled electrotin plated copper busbar provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used.

2. Sized in accordance with the immediate requirements of the application and with consideration for future growth (provide approximately 50 percent spare holes).

3. Minimum dimensions shall be 1/4 inch thick x 4 inches wide and variable in length.

B. CGB and TGB, located in CICs and in the bottom of Communication Transmission Subsystem (CTS) cabinets in various locations, shall be as follows:

1. Predrilled electrotin plated copper busbar provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used.

2. Sized in accordance with the immediate requirements of the application and with consideration for future growth (provide approximately 50 percent spare holes).

3. Minimum dimensions shall be 1/4 inch thick x 2 inches wide and variable in length, or as shown on Contract Drawings.

2.7 TERMINAL LUGS

A. For No. 4/0 AWG and smaller conductors, use copper compression terminal lugs.

B. For No. 250 MCM and larger, use long barrel, copper, double-compression terminal lugs.

2.8 GROUND CONNECTOR

A. O-Z Gedney, Type KG or approved equal.

B. Two-piece, designed for connecting grounding conductor to bus bar.

C. Copper alloy body and silicon bronze bolt, nut and washer with interlocking clamp.

D. Exothermic weld: Size and type per manufacturer’s recommendations.

2.9 JUMPERS

A. Jumpers shall be insulated copper braided or leaf-type flexible jumper, size as required.

2.10 BUSBAR INSULATORS

A. Fibrous glass reinforced polyester insulator with 1/2 inch diameter by 2 inches length, threaded holes at both ends for CMGB, TMGB, CGB, and TGB installation.

2.11 COAL TAR EPOXY

A. Polyamide cured coal tar epoxy, Dupont Corlar 823 CTE, Koppers Company No. 300M, PPG Industries 97-640 or 97-641 or approved equal, applied to a dry film thickness of 8 mils. per coat.

2.12 EPOXY RESIN ENCAPSULATION

A. Two-component epoxy resin type with plastic snap mold, as manufactured by Duriron Company, 3-M Company or approved equal.

2.13 COMMUNICATIONS FACILITY ROOM HALO GROUND RING

A. The halo shall be No. 4 AWG bare stranded copper conductor. It shall encircle the perimeter of the interior walls of the Communications Facility at a uniform height of 3 inches to 12 inches from the ceiling. The halo shall be bonded to the CMGB also using a No. 4 AWG bare stranded copper conductor and approved ground connector.

2.14 COMMUNICATIONS CIRCUIT PROTECTION

A. Copper cables shall enter all Communications Facilities, CIC’s and Wayside Telephones at a Local Distribution Frame (LDF). All signal cables shall terminate on Protected Terminal Blocks (PTBs) located within the LDF, which shall conform to these specifications. Cable sheath shall be neatly trained and soldered to a No. 8 AWG insulated ground conductor and grounded at the TMGB or TGB.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Grounding Connections

1. Weld buried ground connections exothermically, in accordance with manufacturer’s recommendations. Clean and coat with coal tar epoxy applied with a 32 mils dry film thickness using multiple coats. Allow drying between coats and before backfilling. Encapsulate with epoxy resin all buried ground connections of grounding electrode conductors running to ground buses.

2. Use terminal lug to connect grounding conductor to equipment enclosure. Secure connector or terminal lug to the conductor so as to engage all strands equally by using tools and pressure recommended by the manufacturer.

3. Exothermically weld connections for ground rods in manholes and handholes, or as shown.

4. Splices in grounding conductors are not permitted.
B. Ground Grid

1. Install ground grid consisting of bare solid tinned copper conductors and ground rods buried in earth in the pattern and at the locations shown on Contract Drawings. Install ground rods vertically if possible. If this is impossible, rods may be at an angle or (as a last resort) buried horizontally 30 inches (minimum) below grade.

2. Bury top of ground rod 30 inches minimum below grade or as shown on Contract Drawings.

3. Provide 24-inches minimum horizontal separation between ground rods and concrete structures.

4. Interconnect ground rods using bare solid tinned copper conductors as shown on Contract Drawings.

5. For Communications Facilities and CICs, unless otherwise shown, provide two pigtails of grounding electrode conductor of sufficient length above finished floor for connection to the TMGB and CMGB or TGB and CGB. The two pigtails shall be exothermically welded or bonded in an approved manner to the grounding grid at a single point.

C. Grounding Bars

1. Install separate CMGBs and TMGBs, CGBs and TGBs in Communications Facilities, CIC’s and other locations as shown on Contract Drawings.

2. Mount Communications Facility TMGB’s and CMGB’s on insulators 2 feet above finished floor using cap screws and expandable threaded anchors, unless shown otherwise on Contract Drawings.

3. Install CIC and CTS cabinet TGBs and CGBs in the bottom of the cabinet, on insulated spacers which electrically isolate them from the cabinet.

4. Provide insulator support at each end of grounding busbars and at intervals not exceeding three feet.

5. Bond the grounding electrode conductors to the grounding busbar using an approved ground connector in accordance with this Section.

D. Grounding of Separately Derived AC Power System

1. Bond the safety ground conductor (green wire) to the CMGB using a minimum of No. 4 AWG insulated stranded copper wire, as shown on Contract Drawings. For additional guidance refer to the NEC.

E. Grounding for Personnel Safety

1. In Communications Facilities, CICs, bond equipment enclosures and racks, ductwork, conduit, metal cable trays, the LDF ground bolt, PTB grounds, and the room halo ground ring to the local CMGB or CGB using a minimum of No. 6 AWG insulated stranded copper conductor or as specified on Contract Drawings.

2. Wayside metal equipment including, but not limited to, cabinets, poles, pullboxes, equipment enclosures, and junction boxes: bond and ground each item using No. 6 AWG (minimum) copper conductor to one or more ground rods to provide 3 ohms or less resistance to ground. Wayside metal equipment on a bridge structure should be attached to the structure using a minimum of No. 6 AWG (minimum) copper conductor.

F. Electronic Equipment Signal Grounding

1. Where electronic equipment is provided with separate ‘Signal’ or ‘Telecommunications’ ground connections, a separate isolated TGB shall be provided in the equipment rack or enclosure. These connections shall be grounded to the TGB using a minimum of No. 10 AWG insulated stranded copper conductor.

2. Within the Communications Facility or other electronic equipment room, a separate TMGB shall be provided. All individual equipment rack or enclosure TGBs shall be grounded to the TMGB using a minimum of No. 8 AWG insulated stranded copper conductor.

3. The TMGB shall be grounded to the same point on the ground grid (or to the structural steel) as the CMGB using the same AWG grounding electrode conductor. Both grounding electrode conductors shall be insulated.

G. Cable Shield Grounding

1. One end of all cable shields shall be grounded to the TMGB or TGB. Use the following guidelines to determine which end of the cable to ground:

   a. When a cable goes between Communications Facilities, ground the shield at the southern most facility.

   b. When a cable goes between a Communications Facility and any other facility (TPSS, Signal House, and CIC), ground the shield at the Communications Facility.
c. When a cable goes between the CIC and station equipment, ground the shield at the CIC.

H. Fiber Optic Cable Jacket Grounding

1. Armored jackets on all fiber optic cables shall be grounded to the CBG or CMGB using a minimum of No. 8 AWG insulated stranded copper conductor.

3.2 TESTING AND INSPECTION

A. The Contractor shall perform the following inspections and tests on Grounding and Bonding. The Authority shall be given at least 10 days written notification prior to each test and inspection so that the Authority may be present as desired.

1. Factory Test and Inspection: Not Required.

2. Field Test and Inspection. The Contractor shall make the following Field Inspections and Tests:

a. Inspect ground grid installation, installation depth, conductor sizes, connections to ground rods and foundation rebars prior to backfill, for conformance to Specification requirement.

b. Inspect installation of all main ground busbars for proper mounting.

c. Test ground resistance of each ground grid after installation and each ground bus when connected to ground grid, using approved test procedure.

d. Resistance to ground for Communications Facilities and CIC’s is not to exceed three ohms.

e. To meet resistance requirements, install additional ground rods. If resistance requirements can still not be met, install a sacrificial anode to be Authority approved.

f. Test metal conduit and raceways, equipment enclosures, metal cable troughs, fences, metal structures, and light poles for ground resistance not to exceed three ohms.

B. End-To-End acceptance Test:

1. Not required.

C. System Integration Test:

1. Not required.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for the Communications Transmission Subsystem (CTS) to be designed, provided, installed, and tested under this Contract. Work scope includes:

1. Local installation, turn-up, and testing of all new CTS nodes and associated CTS interconnect equipment required for network expansion to support communications to line sections defined under this Contract.

2. Design, install and test of the fiber optic backbone cable, as well as installing and patching fiber distribution panels in accordance with Contract Drawings.

B. The existing CTS provides communications links between the field terminal equipment at Communication Interface Cabinets (CIC), Communication Facilities, Substations, Signal Houses, and office terminal equipment at Operation Control Center (OCC) Equipment Room. The CTS currently transmits voice, signaling, and data circuits between field locations and the OCC, and include:

1. CISCO ONS15454 Synchronous Optical Network (SONET) Add-Drop Multiplexers (ADM), Telco Model DCB-24 channel banks, DSX-1 jack fields, wiring distribution terminals, fiber slack enclosures and fiber distribution panels at the OCC, Headquarters building, and Communications Facilities on the existing Authority System.

2. Other supporting hardware, as shown on the Contract Drawings and described in these Specifications.

3. The existing CTS system architecture utilizes a single-mode fiber optic backbone with CISCO ONS15454 OC-48 ADM nodes. The ONS15454 platform provides T-1 drops, and integrated Ethernet services at each communications node. Voice and dial-up data services for Traction Power Substation (TPSS), Signal Houses, Communications Facilities, and designated Station facilities are groomed onto the CTS channel bank equipment and digital cross-connect systems (DCS).

4. The SONET ring network topology structure consists of two separate backbone Unidirectional Path Switched Rings (UPSR) described below, both terminated into a node at the OCC. The two nodes at the OCC are connected via OC-48. Each ring is implemented in a collapsed, staggered configuration as shown in the Contract and Reference Drawings. A single backbone fiber optic cable is used between each communication facility, with ADM connections between every other node on separate strands of the same fiber.

   a. Ring No. 1 includes NC1, NC2, NC3, NC4, NC5, NW1, NW2, NW3, NW4, I1 and I2 line section nodes.

   b. Ring No. 2 includes the CBD, OC1, OC2, SE1, SE2, G1, G2, G3 and R1 line section nodes.

C. New CTS Work shall include expanding the current physical topology by implementing new 1 Gb/s Ethernet switches at each new communications room or facility and also at each of the two nearest existing Communications Houses with SONET OC-48 nodes. CTS Ethernet traffic for the new systems shall be routed to the existing CTS SONET network to completely interface all new facilities and systems to the existing CTS. Specific Work to be performed includes:

1. Provide, install and locally configure new 1 Gb/s Ethernet switches.

2. Wire from the local CTS interfaces, through patch panels, intermediate distribution frames and interconnect equipment to each field instrument, appliance, or other equipment as shown on Contract Drawings.

3. Provide and install interface equipment to TPSS and Signal Houses required to transport data and voice from these locations onto the CTS.

4. Locally test all CTS interfaces and connections installed under this Contract.

5. Network provisioning of existing Network Management System (NMS) and SONET Ring 2 system to accommodate the new Ethernet traffic and required new Virtual Local Area Networks (VLANs).

1.2 REFERENCED STANDARDS

A. Contractor’s design and installation shall comply with the latest editions of all applicable Standards and Codes included herein. Work shall meet or exceed the standards and procedures specified.

B. Alliance for Telecommunications Industry Solutions (ATIS)
1. IEEE 802.1D – IEEE Standards for Local and Metropolitan Area Networks: Media Access Control (MAC) Bridges
2. IEEE 802.1Q-2011 – IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks
3. IEEE 802.1Qaz - IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks: Amendment 18: Enhanced Transmission Selection for Bandwidth Sharing Between Traffic Classes
4. IEEE 802.1Qbb IEEE Standard for Local and Metropolitan Area Networks – Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks: Amendment 17: Priority-based Flow Control
5. IEEE 802.3AD – IE Standards for Information Technology – Local and Metropolitan Area Networks – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Methods and Physical Layer Specifications – Aggregation of Multiple Link Segments

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications and the specific technical requirements further listed herein.

1. Manufacturer Qualifications: Any manufacturer differing from those specified herein shall require Authority prequalification and approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, and compliance with standards specified herein, and full compatibility with the Authority’s existing system.

2. Preliminary Design Review (PDR) Technical Requirements Contractor shall include the following information as part of the PDR submittal package for CTS subsystem:

a. Network Block Diagrams
   1) Physical node diagrams.
   2) Logical network topology.

b. Material Specification Data Sheets and Product Samples. Contractor shall submit complete product data including description and model number, shop drawings, catalog cuts, technical literature, software descriptions, and samples (as requested by the Authority), for all equipment provided under this Contract.

c. Identification and specification of all external interfaces to existing network components, other subsystems provided under this Contract, and to any other contracts.

d. Descriptions of modifications required to existing CTS equipment in order to interface new subtended rings or to add local voice or data services.

e. Complete wiring diagrams for all field CTS equipment, including intermediate patch panels, protection, and interconnect equipment provided and installed under this contract.

f. Complete terminal cabling and interconnection diagrams for all Outside Plant (OSP) fiber optic cable (backbone and distribution) provided and installed under this contract.

g. Proposed rack layouts and elevations for new or modified field nodes, including assembly drawings, installation drawings, component level inventories and parts lists.

h. Preliminary fiber optic link loss budgets for all fiber optic spans (backbone and distribution) installed under this Contract. Calculations shall show total anticipated optical loss in dB for each span compared to the published link or span loss budget for that particular piece of optical transmission gear.
3. Final Design Review (FDR) Technical Requirements: Contractor shall include the following information as part of the FDR submittal package for the CTS.

   a. Updated PDR information. All drawings, calculations and design information shall reflect a final design.

   b. Shelf layout and inventory within equipment chassis.

   c. Final fiber optic link loss budgets for all fiber optic spans installed under this contract, sufficient to show that all proposed spans meet published link loss budgets.

4. Installation Work Plans and Detailed Documentation: Contractor shall submit the following installation document for each site no later than 60 days prior to the schedule installation activities. The Installation Work plan shall include:

   a. Drawings and Diagrams

      1) Cable pair and fiber strand usage diagrams

      2) Local Distribution Frame (LDF) wiring and termination assignments

      3) Interconnect and wiring diagrams to include ADM, media converters, Supervisory Control and Data Acquisition (SCADA) points, power supply, fuse panels, and other required equipment.

   b. Installation Procedures

      1) New ADM equipment

      2) New channel bank and media converters

      3) New Fiber Distribution Panel (FDP) components and equipment

      4) Procedures for installing new equipment into existing nodes to interface with new subtended rings.

5. Calculations and Certifications:

   a. Calculation as listed in the PDR and FDR.

   b. Certifications: Copy of the following certifications shall be included:

      1) ISO certification for all proposed manufacturers.

      2) CCNA certification and Cisco ONS15454 Installation Training for any technician performing installation, test, or turn-up work on any CTS equipment.

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.

7. Test Plan and Procedures. Contractor shall submit the following plan and procedures for the CTS:

   a. Test program plan: Contractor shall include all the required information for the CTS in the Test Program Plan as required by these Specifications.

   b. Factory Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements in Section 3.2 of this Specification.

   c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements in Section 3.2 of this Specification.

   d. System Integration Test: Contractor shall provide qualified staff to support this test as required in Section 3.2 of this Specification. System Integration Test will be directed by the Authority.

8. Test Records: Contractor shall submit the Test Records for review 1 week after the completion of each test, in accordance with these Specifications.

9. As-Built Documentation

   a. Drawings

   b. Final Configuration and Provisioning Information: Contractor shall submit, within 30 days of installation, detailed information, if modified from default settings, for each programmable piece of equipment to allow System Integration by follow-on contractors.
1.4 QUALITY ASSURANCE

A. Applicable Standards and Codes: Contractor’s design and installation shall comply with all applicable Standards and Codes as listed herein. All CTS equipment shall comply with the latest version of standards as applicable in Section 1.2 of this Specification.

B. Material and Workmanship Requirements

1. All equipment provided under this Section shall be UL listed.

2. All grounding shall be in accordance with local standards, and specifications required by this Contract. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

3. Discontinued product models, refurbished equipment, or products scheduled for either end-of-life, end-of-sale, or end-of-service within 1 calendar year of the installation date shall not be used.

4. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process (i.e. ISO-9001).

C. Manufacturer Pre-Qualification Requirements: All new equipment provided and installed under this Contract shall be compatible with existing CTS equipment installed in field and central locations in order to perform the intended use set forth by the Authority.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. CTS Ethernet equipment reliability shall be assured by installing one fully equipped, provisioned and tested “cold-standby” switch for every switch required.

B. Power sources to 1 Gb/s and 100 Mb/s CTS Ethernet equipment shall be isolated and redundant, in accordance with these Specifications and Contract Drawings.

C. Unless otherwise directed by the Authority, manufacturer’s latest hardware revisions shall be provided and installed for all specified equipment.

D. Contractor shall be responsible for all cabling between CTS and any Communications Facility equipment, including, but not limited to Ethernet cabling, SCADA alarm cabling, power cabling.

E. Install all factory provided covers and protectors onto backplane assembly.

F. Install all required CTS equipment in racks as shown on Communications Facility elevation drawings.

G. Standard Warranty and Ownership: Contractor shall ensure all remaining standard manufacturer’s warranty (hardware and software) and any other service or support entitlements for CTS equipment (for example – technical support, return material authorization, software maintenance releases) is transferred, at no cost, expressly into the Authority’s name after Contractor’s Warranty period expires.

2.2 CTS 1 Gb/s Ethernet Switches

A. Gigabit Ethernet switches shall be provided at Communication Facilities. Each location shall be equipped with 2 Gigabit Ethernet switches, a normal and a standby. The standby switch shall be identical to the normal and shall be activated by manually moving all connections from the normal to the standby.

1. Each Ethernet switch shall be hardened for temperature and humidity

2. Each Ethernet switch shall be equipped with 2 Gigabit singlemode sets of Tx/Rx optical ports.

3. Each Ethernet switch shall be equipped with 24 10/100 Mb RJ45 Ethernet ports.

4. Each Ethernet switch shall be equipped with 36 100 Mb multimode sets of Tx/Rx optical ports.

5. Unless otherwise directed, manufacturer’s latest hardware and software revisions shall be provided and installed for all specified equipment.

6. Network Ethernet Switches shall be Layer 3-capable, where applicable.

7. Contractor shall be responsible for all cabling between any communications facility equipment and end devices, including, but not limited to Ethernet cabling, SCADA alarm cabling, power cabling.

8. Install all factory provided covers and protectors onto backplane assembly.

9. All switches shall support Resilient Ethernet Protocol (REP) and other network-level-resilience protocols, where applicable for loop-free operation and mechanisms for fast convergence.
10. All switches shall be configured for device-level-resilience, where applicable for dual power supplies, stackwise, HAS, etc.

11. All switches will be managed and will require configuration for the following protocols.
   a. IEEE 802.1D
   b. IEEE 802.1Q-2011
   c. IEEE 802.1Qaz
   d. IEEE 802.1Qbb
   e. IEEE 802.3AD

12. All Ethernet switches shall be rack mountable and purchased with all hardware necessary to mount in 19 inch rack or cabinet.

13. All media converters shall be Small Form-factor Pluggable (SFP) type converters installed directly into switches.

14. All media converters used in the network shall be Gigabit SFP.

2.3 CTS 100 Mb/s Ethernet Switches

A. 100 Mb/s Ethernet switches shall be required for aggregation of local Ethernet traffic at substations and signal houses.
   1. Each 100 Mb/s Ethernet switch shall be hardened for temperature and humidity
   2. Each 100 Mb/s Ethernet switch shall be equipped with 12 10/100 Mb RJ45 ports
   3. Each 100 Mb/s Ethernet switch shall be equipped with 2 100 Mb singlemode sets of Tx/Rx optical ports
   4. Contractor shall be responsible for all cabling between CTS switch equipment and end devices, including, but not limited to Ethernet cabling, SCADA alarm cabling, power cabling.
   5. 100 Mb/s Ethernet switches will be managed and will require configuration for the following protocols.
      a. IEEE 802.1D
      b. IEEE 802.1Q-2011
      c. IEEE 802.1Qaz
      d. IEEE 802.1Qbb
      e. IEEE 802.3AD

6. 100 Mb/s Ethernet switches shall be wall mountable and purchased with all hardware necessary to mount in a wall mounted cabinet.

7. All switches shall be configured for device-level-resilience, where applicable for dual power supplies, stackwise, HAS, etc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
   1. Any technician performing installation, test, or turn-up work on any CTS equipment shall be a Cisco Certified Network Associate (CCNA) and shall have attended the Cisco ONS15454 Installation, Test, and Turn-up Training Course (or approved Operations, Administration, and Maintenance training course). Certificates of completed training and certifications shall be provided to the Authority prior to receiving authorization to perform any Work.
   2. All equipment accessories shipped with the product and not used for installation such as installation hardware, covers, removable doors or enclosures, security keys, cables, cable connectors, fiber boots, adaptors, labels, filters, spare parts, and documentation shall be provided to the Authority.

B. Factory Installation
   1. Mount all equipment within cabinets and racks on 19 inch rails with EIA-310D Standard hole spacing.
   2. Pre-wire all circuits in accordance with these Specifications.
   3. Utilize connectorized cables for external connections.
   4. Label all connections.
      a. Transfer labels to As-Builts.
      b. Label all circuit cards.
   5. Dress all cross-connections with dielectric cable ties. Trim ties with flush-cut pliers and locate to eliminate any hazard to personnel from sharp edges.
C. Field Installation

1. Equipment may be installed in cabinets and racks prior to shipment to the Authority.

2. Cabinets shall be installed and securely bolted to the floor.

3. Cabling shall be secured to racks and cable trays using approved cable management equipment to avoid any pinching or microbends. Fiber optic cables shall be secured only with Velcro type cable ties.

4. Fiber boots shall be installed on fiber jumper connectors at connection points requiring a 90 degrees or greater bend within 6 inches of the connector.

5. Install all cables and secure to trays and cabinets with dielectric ties. Trim ties with flush-cut pliers and locate to eliminate any hazard to personnel from sharp edges.

6. All cables shall be routed in cable tray between racks.

3.2 TESTING

A. All testing shall be performed in accordance with the general requirements within these Specifications.

B. Contractor shall perform the following inspections and tests on the CTS. The Authority shall be given at least 10 days written notification prior to each test and inspection so that the Authority may be present as desired.

1. Factory Testing. Factory Testing shall be conducted on individual equipment or assembled subsystems after all mounting, installation, wiring and other activities to support turn-up are complete.

   a. Factory test configuration shall be provided, including equipment layouts, connections, and interfaces to be tested.

   b. Optical light levels for all optical ADM cards (working and protect), fiber optic media converters, or other fiber optic transmitters.

   c. If an LED lamp test function is available, perform this test and verify proper operation of all lamps on chassis, cards, or any other component of equipment.

   d. Port-to-port continuity and wiring polarity testing between DSX and fiber distribution panels and all wired or patched equipment ports.

2. Field Inspection

   a. Correct equipment quantities on-hand for installation.

   b. Equipment damage in transit

   c. Equipment, port, and cable labeling

   d. Power supply integration and mounting

   e. Cable routing

   f. Unobstructed airflow to vented equipment

   g. Cable crimps, constrictions, and micro-bends.

3. Field Test. Contractor shall perform the following field tests on all CTS equipment installed:

   a. Confirm no standing alarms were generated on any equipment during transit or installation by way of front panel LED, LCD display, or other visual check. If standing alarms exist, Contractor shall resolve and retest prior to system final acceptance.

   b. Verify and record all power connections and levels.

   c. Verify ADM fan operation and airflow.

   d. Verify software / firmware revisions match existing CTS equipment.

   e. Verify and record dipswitch positions or other physical board level settings.

   f. Verify and record all switch configuration and software settings.

   g. Power shall be removed from the primary interfaces to ensure separate and operational secondary source.

   h. Ethernet continuity testing over media converters and fiber extension links from Communications Facilities to Substations, Signal Houses, or any
other remote facility utilizing media conversion equipment over fiber optic cable.

i. Contractor shall provide sufficient resources to correct deficiencies found under the Field Testing prior to Field Acceptance.

4. Systems Integration Test (SIT)

a. Contractor shall provide qualified technical staff to support this test as directed by the Authority’s System Integration Consultant.

b. Contractor shall provide sufficient resources to correct system integration defects, found during this testing period, within 10 days after notification.

c. Contractor shall demonstrate to the Authority that all defects found under the System Integration Testing were corrected and no new defects exist.

C. Other Required Tests. Existing System, Pre-Possession, and Equipment Validation Test.

1. Display and record any standing alarms on chassis prior to any modification activity. All attempts shall be made to rectify any alarm that may adversely affect modifications.

2. Existing nodes into which new subtended rings shall be terminated, shall be tested prior to any modification or integration.

   a. Test existing chassis power input and calculate the additional estimated load from new hardware additions to ensure that the modified configuration shall still operate within published power parameters.

3. The Authority provided fiber optic cable to be installed under this Contract shall be inspected and tested prior to installation in accordance with these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes the detailed technical requirements for Power Supplies and Distribution to be designed, provided, installed and tested under this Contract. See the Contract Drawings for more details on Power Supplies and Distribution. Scope of Work for the Authority Light Rail Communications System includes:

1. Design, provide, install and test Alternating Current (AC) and Direct Current (DC) power supplies for communication equipment in Communications facilities, Communication Interface Cabinets (CIC), signal houses and Traction Power Substations (TPSS) as described in these Specifications.

2. Provide and install all power distribution related cables in accordance with these Specifications.

3. Provide and install grounding for all power supply equipment in accordance with these Specifications.

1.2 REFERENCED STANDARDS

A. Institute of Electrical and Electronics Engineers (IEEE):


2. IEEE 1100 - Powering and Grounding Sensitive Electronic Equipment

B. International Organization for Standardization (ISO):

1. ISO 9001 – Quality Management Systems - Requirements

C. National Fire Protection Association (NFPA):

1. NFPA 70 - National Electric Code (herein after referred to as NEC)

2. NFPA 75 - Standard for Protection of Electronic Computer/Data Processing Equipment

D. Underwriters Laboratories, Inc. (UL):

1. UL 1778 – UL Standards for Uninterruptible Power Supply Systems

1.3 SUBMITTALS

A. Submittal format and content shall comply with the general requirements of these Specifications.

1. Manufacturer Qualifications

a. Any manufacturer differing from those specified herein shall require the Authority prequalification and approval.

b. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications, (i.e. ISO 9001), equipment reliability, and compliance with referenced standards, and full compatibility with the Authority’s current system.

2. Preliminary Design Review (PDR) Technical Requirements. Contractor shall include the following information as part of the PDR submittal package for the Power Supplies and Distribution:

a. Manufacturer Data Sheets for Uninterruptible Power Supply (UPS), including batteries, battery charger, transformer, transfer switch, inverter and converter.

b. Manufacturer Data Sheets for DC Power Supplies.

c. A description of the power supply for each equipment site, including:

1) Configuration including dimensions, plan and elevation.

2) Power Draw.

3) Standby Time.

4) Battery dimensions and weight.

d. Schematic diagram of UPS components including, but not limited to the AC to DC converter, batteries and battery charger, inverter, transformer, transfer switch and ground connections.

e. Drawings showing the layout and rack mounting details of the UPS equipment.

f. Detailed drawings of connections to Chassis Main Grounding Buss.
bar (CMGB) and Chassis Ground Buss bar (CGB) showing routing of ground wires and mechanical details of connections.

g. Single line diagrams for communications house/ Facility and CIC. Drawings shall show utility feeds, transfer switches, generator connections, UPS, and all power panels.

h. Calculations for each power supply demonstrating the capability of the proposed equipment to adequately serve the load demands of the connected equipment.

3. Final Design Review (FDR) Technical Requirements. Contractor shall include the following information as part of the FDR submittal package for the Power Supplies and Distribution:

a. Updated PDR information. All drawings, calculations and design shall reflect a final design.

b. Final and detailed wiring drawings ready for construction and installation.

c. Final equipment list.

d. Final equipment installation details.

e. Final cable and equipment ID.

4. Installation Plan. Contractor shall submit the following installation document for each site no later than 60 days prior to the scheduled installation activity:

a. Step-by-step plan for installing each piece of equipment, interconnecting raceway and cabling details, including estimated time required for the installation.

5. Calculations and Certifications

a. Calculations as listed in the PDR and FDR.

b. Certifications: Copy of the following certifications shall be included:

1) ISO certification for all proposed manufacturers.

6. Product Samples: Product samples shall be provided and demonstrated when requested by the Authority.

7. Test Plan and Procedures. In accordance with the format and requirements described in these Specifications, as a minimum, the Contractor shall submit the following plan and procedures to satisfy the Power Supplies and Distribution testing requirements:

a. Test program plan: Contractor shall include all the required information for the communications Power Supplies and Distribution in the Test Program Plan as outlined in these Specifications.

b. Factory and Inspection Test Procedure: Contractor shall submit a complete factory test and inspection procedure to satisfy all the requirements outlined in Article 3.2 of this Specification.

c. Field Test Procedure: Contractor shall submit a complete field test procedure to satisfy all the requirements outlined in Article 3.2 of this Specification.

d. End-To-End Acceptance Test: There is no requirement for an End-to-End Test performed.

e. System Integration Test (SIT): Contractor shall provide qualified staff to support this test as described in Article 3.2 of this Specification. SIT will be directed by the Authority.

8. Test Records: Contractor shall submit the Test Records and Results for review 1 week after the completion of each test, in accordance and format in these Specifications.

9. As-Built Documentation: Contractor shall submit complete As-Built documentation and drawings for the communications Power Supplies and Distribution, and the contents.

1.4 QUALITY ASSURANCE

A. Contractor’s design, fabrication, inspection, installation and testing shall comply with all applicable Standards and Codes as listed herein. All equipment and methods shall comply with the latest version of the standards as applicable in Article 1.2, Reference Standards.

B. Material and Workmanship Requirements:

1. All equipment provided under this Section shall be UL listed.
2. All grounding shall be in accordance with local standards, and specifications required by this Contract except as modified herein. Each piece of equipment shall be grounded in accordance with the recommendations of the manufacturer.

3. Discontinued product models, refurbished equipment, products at their end-of-life, end-of-sale, or end-of-service shall not be used.

4. All products specified herein shall be subject to the Authority approval based on the Contractor’s ability to demonstrate adherence to the specified requirement and approval of the manufacturer’s quality process.

5. Any manufacturer differing from those specified herein shall require the Authority prequalification and approval. Acceptability of the manufacturer shall be based on the manufacturer’s experience, qualifications, certifications (i.e. ISO-9001), equipment reliability, and compliance with standards specified herein, and full compatibility with the Authority’s current system.

PART 2 - PRODUCTS

2.1 GENERAL DESIGN REQUIREMENTS

A. Uninterruptible AC Power Supply

1. This type of power supply shall be utilized to provide conditioned AC power to equipment during normal operation and to provide temporary backup AC power in case of a failure of normal AC.

2. UPS shall be provided at Communications Houses and Facilities, and CICs to supply power for all of the vital systems at locations shown on the Contract Drawings.

   a. Batteries shall provide 8 hours of backup power at Communication Houses and Facilities. Redundancy shall be provided as shown on the Contract Drawings.

   b. Power supplies shall provide DC power to equipment during normal operation. All DC power supplies used for communications equipment shall receive power from a UPS power source.

C. AC Power Supply

1. AC power for the Communications Houses and Facilities shall be provided either from a Station Electrical Panel, a TPSS, or Texas Utility.

   a. One 125A circuit shall provide power to all Communications equipment at each location.

   b. AC power distribution within the Communications House and Facility shall be in accordance with Contract Drawings.

   c. Contractor shall provide and install all required cables and connections between the TPSS breaker and the Communications House.

2. AC Power for Station CIC shall be provided from the Station electrical panel and distributed as shown on the Contract Drawings.

   a. A minimum of 3 separate circuits (UPS, AC Unit, and Non-Essential loads) from the Station electrical enclosure panel shall be provided for each CIC.

   b. Contractor shall provide and install all required cables and connections between the Station electrical enclosure panel and the CIC.

D. Grounding

1. Equipment within Communications House and Facility, and CIC shall be grounded to the building CMGB and CGB respectively, independent of the power supply ground or neutral connections.

2. The safety ground for UPS and power supplies shall be bonded to the CMGB or CGB, which provides a single point earth ground.

2.2 UPS SYSTEM

A. Each UPS system shall be sized for a minimum of 125 percent of the peak load connected. The
backup time shall be for full load, or as specified for the particular site.

B. Each UPS shall include a ferroresonant transformer, battery float charger, batteries, static inverter, and microprocessor controlled switch circuitry.

1. The load shall normally be powered from the secondary of the ferroresonant transformer; the primary of the transformer shall normally be powered from one of 120/208/240 VAC, 60 Hz sources, from either a TPSS, a station electrical power panel or the Texas Utility for a Communications House or Facility, and from a station electrical power panel for the CIC.

   a. Manual bypass switch shall be provided and installed as shown in Contract Drawings for the UPS such that the load can be powered from the normal source for maintenance without service interruption.

   b. Manual AC Disconnect Switch shall be provided as shown in Contract Drawings, if it is not an integral part of the UPS, to facilitate disconnecting the equipment for maintenance service.

   c. In the event of a UPS failure, the load shall revert to the normal AC source (even if that source is unavailable).

2. The static inverter shall normally be off, but shall be switched on automatically upon detection of a failure or irregularity in the normal power input and shall then supply power to the transformer primary. The batteries shall power the inverter.

3. The batteries shall be maintained at full charge by the battery charger. The battery charger shall be powered from the normal AC source in parallel with the transformer primary.

4. The microprocessor controlled switch circuitry shall monitor the AC input and output and the DC voltage and current levels. Switching from normal to battery power and back to normal shall be automatic and shall not affect output voltage and current waveforms.

C. Each UPS system shall provide power quality consistent with the equipment connected. In addition, the UPS shall meet or exceed the following specifications:

   1. Input Voltage: 120 VAC, Nominal

   2. Output Voltage: 120 VAC, Nominal

   3. Voltage Regulation: within plus or minus 3 percent with input 96 V AC to 138 VAC

   4. Spike Attenuation: 2000:1 (up to 6000 V and 200 A)

   5. Noise Attenuation: 120 dB Common Mode, - 60 dB Transverse Mode

   6. Output Frequency: 60 within plus or minus 0.005 Hz

   7. Input AC Overload Capacity: 125 percent Rated (10 Min), 150 percent (Surge)

   8. Output Waveform Distortion: 3 percent (Max) Single Harmonic, 5 percent Total Harmonic Distortion

   9. Operating Temperature: 32 degrees F to 104 degrees F

   10. Operating Humidity: Up to 95 percent Relative Humidity (R.H.)

   11. Line Powered Efficiency: 88 percent

   12. Audible Noise: 51dB

   13. Mean Time Between Failures: 100,000 Hours

D. Transformer: The ferroresonant transformer shall provide complete isolation from input to output. It shall be rated for continuous supply of 125 percent of the maximum draw of the communications equipment with input voltages in the range 96 to 138 V.

E. Inverter: The inverter shall utilize all solid state components and be rated for 125 percent of the continuous output required such that the transformer coupled output, as specified above, shall be realized when the inverter is on. There shall be no interruption of service to the load when the inverter is switched on or off.

F. Batteries: The battery shall be a multi-cell bank composed of sealed maintenance free cells. The battery bank shall be rated to provide power to the inverter such that 125 percent of the current draw of the protected equipment can be provided upon complete failure of the AC input for a period as stated in Paragraph 2.1A.2 of this Specification. The battery life shall be at least 200 charge/discharge cycles and 10 years.

G. Battery Charger: The battery charger shall utilize all solid-state components and shall be rated to fully charge the batteries within 24 hours from a fully discharged state while the normal load is connected. The battery charger shall include automatic tapering and floating controls.
H. Microprocessor Control: The microprocessor control and switching circuitry shall continually monitor the AC input voltage, current, and frequency. If one of these parameters is outside the range where the output voltage or frequency remains within the specified tolerances, the inverter shall be switched on-line within 8 milliseconds and the AC line disconnected. If the AC input comes back within range, the inverter shall be disconnected and the AC line re-connected automatically.

I. Light Emitting Diode (LED) indications for the following shall appear on the front panel of the unit: AC Line, Ready, Charging, Battery Power, and Alarm. In addition, the following functions shall be available on a keypad with Liquid Crystal Display (LCD) that shall be mounted on the front panel of the UPS, or plugs into a diagnostics output port:

1. Meter Functions
   a. AC Volts Output
   b. AC Volts Input
   c. Battery Voltage
   d. AC Current Input
   e. AC Current Output
   f. VA Load
   g. DC Current Input
   h. Frequency
   i. Heat Sink Temperature
   j. Projected Run Time Available
   k. Log of Power Outages and Alarms

2. Alarm Messages
   a. Low Battery
   b. Near Low Battery
   c. High Battery
   d. Low Run Time
   e. Low AC Output
   f. High AC Output
   g. Output Overload
   h. Ambient Temperature High
   i. Heat Sink Temperature High
   j. Transformer Temperature High
   k. Check Battery
   l. Check Inverter
   m. High AC Input
   n. Alarm Test

3. Operating Modes
   a. Off
   b. Automatic
   c. Line Conditioning
   d. Inverter On

4. Set Operating Parameters
   a. High AC Voltage
   b. Low AC Voltage
   c. High Battery Voltage
   d. Low Battery Voltage
   e. Near Low Battery
   f. High Ambient Temperature
   g. Frequency Tolerance
   h. Battery Capacity (run time)

J. Relay Alarm Contacts. Each UPS shall include 2 sets of alarm contacts (2 NO and 2 NC) rated at 125 VDC and 1 Amp. The following outputs shall be wired to the Remote Terminal Unit (RTU) equipment, to be provided by others, at the corresponding Communications House or Facility.

1. UPS Trouble: This relay shall change state when any of the parameters listed above move beyond the pre-established range. In addition, any faults with the battery chargers, batteries, or inverters shall cause this alarm to activate.

2. Loss of Primary AC: This relay shall change state when the primary 120 VAC power is lost and reset when it is restored.

2.3 DC POWER SUPPLIES

A. Communication equipment that requires other than –48 VDC shall be provided by manufacturer recommended power supplies. Data sheets for such power supplies shall be provided with the equipment data sheets for approval.
B. The DC power supplies shall be grounded in accordance with the manufacturer recommendations and the system designer to allow proper operation of all the equipment powered by the –48VDC, including use of investigative tools or equipment (such as laptops).

C. If DC power is required, the power supply cabinet shall be equipped with a fuse panel. Each panel shall have a minimum of 8 separately fused power output positions. The fuse current ratings shall be in accordance with equipment manufacturer recommendations. The fuses shall be indication type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Each power supply, including batteries shall be provided and installed as shown on the approved Contract Drawings.

B. All cabling from the power supplies to communications equipment and the power panel shall be routed as Authority approved and so as not to interfere with other cables or equipment.

C. All cabling from the AC breaker panel to the power supply, where both are located within the same building, shall be installed within Electrical Metal Tubing (EMT) conduit.

D. Grounding

1. General Equipment Grounding: Within each Communications Facility, and CIC, power supply equipment and racks shall be grounded to the CMGGB and CGB per these Specifications. A power source neutral lead shall not be used as a ground.

2. Power Supply Grounding: The safety ground for all UPS and power supplies shall be bonded to the CMGGB or CGB per these Specifications and Contract Drawings.

3.2 EQUIPMENT MOUNTING

A. cabinets and Racks

1. The UPS components, exclusive of batteries shall be mounted within a freestanding cabinet with removable panels (except in the CIC, where UPS and batteries shall be mounted within the CIC). The cabinet shall include a ventilation opening for convection cooling such that the unit shall operate within the specified temperature range. The cabinet shall have an enamel finish, in a color that shall be Authority approved.

2. Equipment racks for mounting 19 inch EIA Standard equipment shall be in accordance with these Specifications.

B. Battery Racks: The batteries shall be mounted in a rack, or as recommended by the battery manufacturer. The battery rack shall be made of channel steel with an acid resistant gray paint finish. The battery racks shall allow access to all battery terminals without removing batteries from the rack.

C. Power Plug Mold Strip – Equipment Cabinets:

D. Contractor shall provide the required sized and rated UL power plug mold strip in each equipment rack or cabinet. The power plug mold strip shall be powered from the UPS AC source that is shown on the Contract Drawings. The plug mold strip shall be mounted vertically in the cabinet and contain a minimum of 10 power outlets.

3.3 TESTING

A. Testing of each power supply shall be conducted in accordance with these Specifications. Tests shall verify the following:

1. Output Power Levels
2. Output Quality
3. Transfer of load to standby source.
4. DC equipment holdup in the event of single rectifier failure.
5. Backup power holdup times under full load.
6. Accuracy of all meters.
7. Proper grounding connections and levels.
8. Functionality of all alarms, indications, and controls.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16879
PART 1 - GENERAL

1.1 DESCRIPTION

A. The manuals and training provided under this Section shall provide the Authority personnel with the knowledge to operate, maintain, troubleshoot, and repair the equipment provided by these Specifications.

B. Existing Manuals

1. Rail Operations Controller (ROC) Manuals
2. Applications System Management Manuals (ASMM)
3. Distributed System Management Manuals
4. Operations and Maintenance (O&M) Manuals
5. Remote Terminal Unit (RTU) Operation and Maintenance Manuals
6. Communications System Maintenance Manuals (CSMM)

C. New Work: Provide new and customized information corresponding to the Authority’s design and equipment being provided under this Contract.

D. Manuals

1. General requirements and specifications for all manuals required under this Contract can be found in these Specifications.
2. Specific content requirements for Communications and Control System elements or subsystems shall be contained in this section.
3. The information to be provided shall include all required information required for the operation, maintenance, troubleshooting, repair, and restore of the equipment and systems.

1.2 SUBMITTALS

A. Manuals

1. Preliminary copies of all manuals shall be submitted for approval no later than 90 days following Final Design Review (FDR) submittal Authority approval.
2. Final copies of all manuals shall be submitted for Authority approval. Contractor developed manuals shall be provided in an Authority approved machine-readable format. When available, manufacturer manuals and
technical data shall be provided in an Authority approved machine-readable format, suitable for microfilming. Final copies of all manuals shall also be provided electronically, in both their native software format and PDF format, complete with any associated appendices.


4. The Training Manual shall be submitted as an electronic copy prior to training for record purposes. The printed quantities for the Training Manual to be provided shall be as described in Part 2 of this Specification.

B. Training Plan. Contractor shall submit a complete training plan for Authority approval. The training plan shall include the following information:

1. A proposed schedule for each course, including syllabus for training and lesson plan
2. Resumes of personnel proposed to be instructors for each course
3. A statement of the purpose of the training
4. An overview of the subjects to be covered in each course
5. An overview of the hands-on experience to be included as part of each course
6. A list of the manuals, As-Built Documentation, and other printed materials to be utilized as training aides
7. A description of the pre-requisite knowledge for each course

C. Training Course Program. Contractor shall submit 6 copies of a complete program for each course, at least 60 days prior to the scheduled start of the course for Authority approval. Each training program shall contain the following information:

1. A detailed outline of the material to be covered in the course and the duration in hours of the training for each topic
2. Course scheduling plan to cover all shift personnel.
3. Copies of all visual aides, manuals, As-Built Documentation, and other printed materials to be used during the course.
4. Detailed descriptions of the procedures to be performed by students during hands-on training, including test equipment to be used
5. Specific pass/fail criteria for the course, including a sample test, and a statement of the knowledge and skills students should possess at the conclusion of the course
6. Instructor Evaluation Survey

D. Training Materials. Contractor shall deliver all training materials to the Authority 5 days prior to the commencement of the associated training class.

1. Delivery location of associated materials shall be coordinated with the Authority personnel.
2. Sufficient copies shall be provided to accommodate all class attendees as well as auditors.
3. The Authority reserves the right to duplicate all training material to accommodate additional personnel.
4. Additional personnel may be added to the attendance roster at no additional cost to the Authority.

PART 2 - PRODUCTS

2.1 CONTRACTOR FURNISHED MATERIALS

A. Contractor shall provide new custom manuals for each subsystem provided under this Contract. Specific manual volumes are listed in Sections 2.2 and 2.3 of this Specification.

B. General requirements in addition to those specified in other sections of this contract include:

1. Manufacturer’s standard O&M Manuals, documentation, and configuration software provided with each piece of equipment furnished under this Contract.
2. Manufacturer’s Contact Information
3. Manufacturer’s Basic Product Information, including:
   a. Literature describing each piece of equipment, including major assemblies and subassemblies, and giving manufacturer’s model number and drawing number.
b. Catalogue cut sheets, illustrated parts list and parts breakdowns.

4. Release notes for new revisions of any software product provided, upgraded, or modified in any subsystem.

5. Safety Procedures and Precautions
   a. Ensure safety procedures and precautions are included and highlighted.
   b. These shall include procedures and precautions required to prevent damage to equipment, injury to personnel, or unsafe operational conditions.

2.2 O&M MANUALS

A. O&M manuals shall include each make and model of equipment installed or modified under this contract.

B. Identify O&M tasks including recommended periodic maintenance, precautions to be observed during maintenance work, degree of on-line repairs, numbers, qualifications and skills of personnel, special tools and test equipment, and estimates of maintenance time.

C. Prepare O&M manuals providing detailed instruction for the operation of each system condition; maintenance and safety actions required to ensure the operational requirements of the systems, subsystems, and equipment. Identify any safety markings, tags or similar identifiers to be maintained on any equipment.

D. Prepare the O&M manuals for each system and supplement with vendor instructions and data covering the O&M of individual items and equipment provided. This includes all configuration and software documents or CDs supplied with the equipment. Use this data as the training material for the individuals tasked to operate the installed equipment and systems.

E. Include in the manuals system-level step-by-step O&M procedures to be performed by journeyman operators or technicians, and provide the following elements, as required:
   1. Complete description of all systems with data sheets, bill of materials, flow, control and electrical circuit and wiring diagrams
   2. System Operation: This information describes the system operation, including operating parameters, interfaces with other systems, major equipment, and their physical and operating characteristics.
   3. Pre-operation Checkout: Include the required steps or tasks to completely check out the system and prepare it for operation following a shutdown condition.
   4. Operator’s instructions covering startup, shutdown and all procedures required to ensure safe operation. Repeat these instructions in a durable printed notice and mount in the operator’s area.
   5. Preventive Maintenance: Describe all maintenance to be performed on a periodic basis, e.g., inspection, calibration, voltages and amperage. Prepare scheduled maintenance checklists for each unique type of maintenance significant equipment. Submit the checklists to the Authority approval prior to implementation.
   6. Fault Isolation: Describe the procedures to be followed in determining the cause of a failure or malfunction. Base fault identification on monitoring devices and visual observations. Progressively order fault isolation, with the most likely fault listed first.
   7. Maintenance: Describe all maintenance that can be performed on installed equipment, including removal, replacement, and repairs that can be performed.
   8. System Restore: Describe step-by-step procedures for complete system restore in case of a catastrophic failure. Identify any specific tools required for system restore. Provide details of all user configurable settings for each piece of equipment.

F. Organize the O&M procedures in such a manner that all required preventive maintenance activities be accomplished without interference with operations. Emphasize in these procedures accessibility, ease of equipment or component removal and replacement, visual indications of component deterioration, and localization of failures. Where practical, configure subsystems so that failed components may be removed and operable replacements installed. Minimize requirements for repair-in-place activities.

G. Provide all like assemblies having identical characteristics interchangeable without altering unit or adjacent equipment except for adjustment. Provide assemblies interchangeable without selection for fit of performance, and without modification.
H. Logistics Data:

1. Provide a logistics plan of O&M, which encompasses the following aspects:
   a. Provide the required data on requirements for O&M logistics, support and procedures. Include the following:
      1) Identification of the extent to which preventive maintenance is performed on installed equipment as opposed to corrective maintenance performed at a maintenance facility.
      2) Identification of equipment requiring special handling or unique maintenance procedures.
      3) Determination of procurement lead times based on total order and shipping time to site for critical equipment and spares, and minimum and maximum inventory requirements.
      4) Identification of O&M personnel skills levels.
      5) Identifications of training requirements.
      6) Formulate and recommend operating rules for personnel.
   b. Vendor Data: Submit the following types of data and incorporate in the O&M manuals:
      1) Manufacturers’ brochures, catalogs, charts, performance curves, and parts bulletins
      2) Complete vendor list for each system subassembly
      3) Installation, operations, and service instructions
      4) Service bulletins.
      5) Shop drawings and other special drawings such as wiring diagrams, system schematics, assembly drawings, and interconnection diagrams.
      6) Illustrated parts breakdowns.
      7) Installation drawings.
      8) Performance data, e.g., maximum, minimum, and recommended speeds, capacities, voltage, amperage, wattage, temperatures, and other related operating information.
      9) Operating procedures.
      10) Preventive maintenance and inspection requirements and procedures
      11) Emergency operating procedures
      12) Removal and installation procedures
      13) Disassembly and assembly procedures
      14) Calibration instructions, including points of application, frequency, method of calibration, and special tools required.
      15) Troubleshooting procedures.
      16) Repair and overhaul instructions.
      17) Cleaning instructions.
      18) Include industry or generic part numbers with component parts.
      19) Special tools and test equipment.
      20) Hazards from unsafe operations, emergency release/stop functions

2. Provide a list of special tools and test equipment for each equipment item, including tools and equipment designated specifically for use with the item, or usual tools and equipment required for operation maintenance of the
items but not normally available to maintenance journeyman. Include the following data on the list for each item:

a. Nomenclature
b. Purpose
c. Manufacturer's part number or drawing number
d. Manufacturer's name and address
e. Quantity recommended by manufacturer
f. Unit price
g. Recommended source of supply
h. Estimated lead-time

2.3 TRAINING MANUALS

A. The Training Manuals shall supplement the O&M manuals. The Training Manuals shall focus on guiding technicians in identifying the source of a problem to a specific subsystem and a specific replaceable element as well as identifying, and describing interrelationships and with other subsystems. References to required replacement procedures within manufacturer's manuals shall be provided.

B. Provide a printed copy of the Training Manuals for each trainee and auditor attending training classes per Part 3 of this Section.

C. The Training Manuals shall at a minimum include the following sections and information:

1. Safety Procedures and Precautions: This section shall cover safety procedures and precautions required to prevent damage to equipment, injury to personnel, or unsafe operational conditions. Items to be addressed shall include:
   a. Safety with AC Power Sources.
   b. Safety with and verification of polarity of DC sources and batteries.
   c. Electrostatic procedures for handling circuit cards.
   d. Necessity for grounding of equipment.
   e. Procedures and tests that should only be done on unpowered or de-activated equipment

2. Test Equipment and Tools: This section shall contain an overview of the test equipment and tools required to troubleshoot and maintain the system.
   a. Tests performed by each piece of test equipment shall be described.
   b. Typical values for tests shall be provided.
   c. Sensitivity ranges and polarity checks of test equipment shall be discussed.

3. Public Address/Visual Message Board (PA/VMB) Remote Components: This section shall contain a discussion on the operation and maintenance of the PA/VMB components that are included in the Communications House and at Stations. This section shall identify and describe interrelationships between other subsystems and troubleshooting methods spanning between related or dependent subsystems.

4. Communications Transmission Subsystem: This section shall contain an overview of procedures for tracing circuit continuity from end to end, isolating noise sources, measuring levels at interfaces, determining bit error rates and cleaning equipment. This section shall identify and describe interrelationships between other subsystems and troubleshooting methods spanning between related or dependent subsystems.

5. Fire Detection and Alarms: This section shall contain an overview of procedures for checking detector circuits, checking detector sensitivity, cleaning detectors, verifying operation of control panels and batteries, maintenance of fire suppression systems, verifying operation of sensors, and verifying IP Communicator interfaces and RTU interfaces to the supervisory control system. This section shall contain detailed programming and wiring information for each Fire Alarm Control Panel (FACP) provided. This section shall identify and describe interrelationships between other subsystems and troubleshooting methods spanning between related or dependent subsystems.

6. Intrusion Alarms: This section shall contain an overview of procedures for checking detector circuit, alignment and sensitivity, cleaning detector, verifying operation of detector, alarm panel, keypad and batteries, and verifying RTU interfaces.
7. Telephones: This section shall contain an overview of procedures for testing and isolating problems with all telephone equipment and circuits provided and provisioned. This section shall identify and describe interrelationships between other subsystems and troubleshooting methods spanning between related or dependent subsystems.

8. Central Control System: This section shall be processed as a supplement to the existing DART manuals providing information regarding modifications to the DART CCS and the associated RTU’s.

9. CCTV: Provide an overview of the expansion of the DART CCTV system to include the new stations.

PART 3 - EXECUTION

3.1 SUPERVISOR FAMILIARIZATION AND OPERATIONS TRAINING REQUIREMENTS

A. Contractor shall develop and provide Familiarization and Operations Training thoroughly describing the modifications and additions made to each communications subsystem.

B. Personnel and Course Composition

1. Training shall consist of at least 2 classes, each class designed for 3 operational personnel supervisors, 3 maintenance personnel supervisors, and 2 auditors [16 total personnel]. Each class shall be at least 8 hours in length, unless otherwise Authority approved.

2. Auditors shall be provided the same class materials, handouts, and access to the instructor, hands-on activity or demonstration as class participants.

C. Training Goals: The goal of the Initial Familiarization and Operations Training is to provide the O&M supervisors with a high-level understanding of the subsystems provided under this Contract, sufficient for the supervisors to perform the following functions

1. Assign maintenance personnel required for routine maintenance and troubleshooting.

2. Assist maintenance personnel with use of manuals and As-Built Documentation.

3. Evaluate actual system performance vs. intended system performance.

4. Support additions to and expansions of any new or modified subsystem.

5. Coordinate with equipment manufacturers support personnel for obtaining warranty support and troubleshooting support.

D. Topics: Training shall include familiarization with system modifications, upgrades, or additions made to the following subsystems and equipment as a result of Work performed under this Contract:

1. Updated CTS topology and functional description with emphasis on issues that may impact network maintenance. Include complete description of the Gb/s Ethernet network configuration and its interface to the existing SONET.

2. Fiber optic communications equipment including Gb/s Ethernet Network switches, 100 Mb/s network switches, VoIP gateways and routers, optical modems, media converters, data switches, power supplies, and any other communications equipment provided under this Contract.

3. Fiber optic cable, connectors, distribution panels and splicing.

4. Communications cable, interface cabinets, junction boxes and terminations.

5. Fire and intrusion alarm control panels, IP-based DACT, IP based Fire Alarm Reporting unit (DACR), sensors, and annunciation devices.

6. PA and VMB subsystem and detailed description for all stations.

7. Telephone subsystem.

8. Changes to the Central Control System and new PLC equipment.

9. Additions to the CCTV system for the new stations.

3.2 TECHNICIAN FAMILIARIZATION AND OPERATIONS TRAINING REQUIREMENTS

A. Contractor shall develop and provide Familiarization and Operations Training thoroughly describing the modifications and additions made to each communications subsystem under this Contract.
B. Personnel and Course Composition

1. Training shall consist of at least 2 classes, each class typically designed for 12 maintenance technician personnel and 2 auditors for a minimum total of 28 total personnel. Each class shall be at least 16 hours in length, unless otherwise Authority approved.

2. Auditors shall be provided the same class materials, handouts, and access to the instructor, hands-on activity or demonstration as class participants.

C. Training Goals: Initial Familiarization and Operations Training goal shall be to provide O&M technicians with a high-level understanding of the subsystems provided under this Contract, sufficient to perform the following functions

1. Perform routine maintenance and troubleshooting.

2. Identify single points of failure and restore the affected subsystem in case of a catastrophic failure or incident.

3. Become familiar with the use of manuals and As-Built Documentation.

4. Test and evaluate actual system performance vs. intended system performance.

5. Support additions to and expansions of the CTS subsystem.

6. Coordinate with equipment manufacturers support personnel for obtaining warranty support and troubleshooting support.

D. Topics: Training shall include familiarization with system modifications, upgrades, or additions made as a result of Work performed under this contract.

3.3 OTHER O&M TRAINING REQUIREMENTS

A. For equipment for which a Part Number or Model Number is not expressly specified for use in these Specifications, or if equipment is provided in lieu of that for which a Part Number or Model Number is specified in these Specifications, the Contractor shall provide both Familiarization and Operations Training as well as product or subsystem specific Operations and Maintenance Training.

B. Course Goals: Each training course shall provide maintenance personnel with the knowledge and skills required to:

1. Gain a thorough understanding of the operation of the equipment.

2. Gain familiarity with the specific components and their role.

3. Gain familiarity with drawings and other design and installation documentation.


5. Be adept at using all tools, test equipment and built-in diagnostics and monitors.

6. Be adept at performing preventative maintenance.

7. Be adept at identifying the root cause of a subsystem failure and restoring the affected subsystem in the event of a catastrophic failure or incident.

8. Gain familiarity with system safety procedures and the potential for creating unsafe conditions during operation or maintenance.

9. Be adept at performing first level maintenance (to the Field Replaceable Unit), including:
   a. Using facilities, tools, test equipment and troubleshooting strategies and procedures to efficiently recognize problems, troubleshoot equipment in the field, isolate the problem, and determine units which have failed or are operating incorrectly.
   b. Removing failed or incorrectly operating equipment from service safely and with minimal impact on continued operation of the system.
   c. Capturing and recording supporting diagnostic data to help further troubleshooting of the FRU.
   d. Planning and implementing temporary workarounds.
   e. Ensuring candidate replacement units are operating correctly, and have correct settings.
f. Installing replacement units safely and correctly, checking that the replacement unit is operating correctly, and introducing the replacement unit into the operating system with minimal impact.

10. Be adept at performing shop maintenance to the Lowest Level Replaceable Unit and including:

a. Using tools and test equipment to efficiently isolate the problem within the subject FRU, troubleshoot, and determine which replaceable unit has failed or is operating incorrectly.

b. Removing replaceable units from the field replaceable units.

c. Capturing and recording diagnostic data.

d. Coordinating with manufacturer's support staff and information centers as needed, including actions such as downloading, installing and testing new firmware.

e. Rebuilding, configuring and verifying correct operation of higher-level replaceable units; up through and including field replaceable units.

PART 4 – MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this Section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith shall be considered incidental to the Work specified under Section 16801 “Basic Technical Requirements - Communications System.”

END OF SECTION 16897
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the technical support services, materials, and equipment to be provided:

1. Maintenance Until Final Acceptance
2. Warranty and Extended Services
3. Test Equipment
4. Spares

1.2 SUBMITTALS

A. Recommended Spare Equipment Listing

1. Contractor shall submit a list of recommended spares for a period extending from installation of the equipment to 1 year of operation of the equipment following Final Acceptance.

2. The list shall include all spare parts, by manufacturer and model number that the Contractor intends to provide in accordance with the minimum spares requirements defined below. In addition, the proposed quantities, unit prices, and total prices for spares shall be provided.

3. The submittal shall also include recommendations for changing quantities of spares, adding and/or deleting items in order to meet the Authority's goals of having spares for 1 full year of operation after system acceptance. Complete descriptions, part numbers, and prices for spare equipment, recommended to be added, shall be provided.

B. Specific Spare Parts: Contractor shall provide the specific spare parts listed in this Specification.

C. Recommended Test Equipment Listing

1. Contractor shall submit a list of required and recommended test equipment and special tools for performing maintenance and trouble shooting on the communications system.

2. The list shall include itemized pricing for all test equipment and tools.

3. The submittal shall also include a list of any additional test equipment that the Contractor recommends for the long-term maintenance and trouble shooting of the system in order to meet the system Mean Time to Repair (MTTR) goals. Complete descriptions, part numbers and itemized pricing for recommended test equipment shall be provided.

D. Specific Test Equipment: Contractor shall provide the specific test equipment listed in this Specification.

E. Warranty

1. Contractor shall submit warranty information as described in this Specification.

2. Contractor shall submit point-of-contact information as described in this Specification.

PART 2 - PRODUCTS

2.1 MAINTENANCE UNTIL FINAL ACCEPTANCE

A. Maintenance

1. Contractor shall perform all maintenance on the Communication Transmission Subsystem (CTS) and all other installed subsystems, equipment and software, from the time that the equipment is installed until Final Acceptance.

a. Contractor shall maintain inventory records of all spare equipment utilized in maintenance and the replacement of spare equipment for items covered under the manufacturer's warranty or the warranty specified herein.

b. Any equipment removed from service shall be made available to the Authority for inspection prior to return to manufacturer.

2) Equipment that is removed from service and is not returned to the manufacturer for replacement or repair shall be delivered to the Authority.

2. The maintenance to be performed shall include repair and/or replacement of all communications elements that fail prior to final system acceptance by the Authority.

a. Contractor shall commence repair of any CTS component that fails within 4 hours of notification of the failure by the Authority or discovery of the failure by the Contractor's personnel. For all other equipment elements, the Contractor shall commence within 24 hours of notification of the failure by the Authority or discovery of the failure by the Contractor's personnel. Contractor shall notify the Authority immediately upon discovery of an equipment failure and shall provide written notification within 24 hours.

b. Contractor shall perform all routine and preventive maintenance and clean all
installed equipment, in accordance with the equipment manufacturer’s recommendations.

c. Contractor shall repair any equipment that is damaged by vandalism.

2.2 WARRANTY AND EXTENDED SERVICES

A. Contractor shall warrant all equipment (including spares and test equipment), materials, software, and installation Work for a period starting upon installation and ending 1 year after Final Acceptance. This period is also referred to as the “Warranty Period.”

1. Contractor shall maintain all manufacturer warranties, prior to final acceptance. Contractor shall warranty any equipment if manufacturers’ warranty runs out prior to end of the Warranty Period.

2. Where a manufacturer’s warranty extends beyond the Warranty Period, the balance of manufacturer’s warranty shall be transferred to the Authority (at no cost to the Authority) at the end of the Contractor’s Warranty Period. Contractor shall provide complete warranty documentation to the Authority upon completion of the Warranty Period.

3. Contractor shall replace or repair any item that fails, at no additional cost to the Authority, during the Warranty Period.

4. Contractor shall provide the Authority with the name, address and telephone numbers of the warranty-period firm and of the primary contact person.

B. On-Call Support. During the Warranty Period, the Contractor shall provide on-call technical support.

1. Calls initiated by the Authority between 8:00 AM and 5:00 PM Central time shall be answered within 2 hours.

2. Calls initiated by the Authority between 5:00 PM and 8:00 AM Central time shall be answered no later than 10:00 AM Central time.

C. On-Site Support

1. If during the warranty period, the Authority determines the system is not meeting the equipment reliability requirement or system availability requirement, the Contractor shall provide on-site technical support to fully understand the problems identified and to correct the deficiencies.

2. Contractor shall coordinate all Work with the Authority in order to avoid any existing warranty disqualification on any component or system.

3. Contractor shall be responsible for reinstating or otherwise providing warranty for any component or system whose original warranty has been voided due to lack of coordination.

2.3 TEST EQUIPMENT – SPECIFIC

Not Used

2.4 SPARES – SPECIFIC

A. Ethernet Switches

1. Contractor shall provide 1 spare 1 Gb/s Ethernet switch of each type provided under this contract. The Ethernet switch shall include fiber optic interface and copper Ethernet ports as equipped for each station.

2. Contractor shall provide 1 spare 100Mb/s Ethernet switch of each type provided under this contract.

B. Fiber Optic Patch Cables

1. Contractor shall provide the following equipment, which shall conform to these requirements:

   a. A total of 24 SC to SC, singlemode duplex, 1 meter length patch cables.

   b. A total of 24 SC to SC, multimode, duplex, 1 meter length patch cables.

2. Media Converters

   a. Contractor shall provide 1 spare media converter of each type for every 10 installed under this Contract.

C. Public Address (PA) Subsystem Spares. Contractor shall provide the following PA subsystem spares:

1. One audio processor.

2. Two audio power amplifiers of each type.

3. One digital signal processor.

4. One speech processor.

5. Twelve speakers with backboxes.

6. One microphone.

D. Visual Message Board (VMB) Subsystem Spares. Contractor shall provide the following VMB subsystem spares:

1. One Local Video Message (LVM) (Laptop PC) equipped with proper software to maintain, program and troubleshoot the PA/VMB system.
2. One RS-232 to RS-422 converter if applicable.
3. Two strobes.
5. Six power supplies.

E. Power Supplies Spares

1. Contractor shall provide 1 spare power supply of each voltage rating, current rating, and application power supply that the Contractor provides in accordance with these Specifications.
2. Contractor shall provide 1 complete spare UPS of each type provided in accordance with these Specifications.

F. Protected Terminal Blocks (PTB) and Modules

1. Contractor shall provide 1 spare PTB, including enclosure, of each type and size, per these Specifications.
2. Contractor shall provide 100 spare protector modules of each type provided, per these Specifications.

G. Miscellaneous

1. Contractor shall provide 1 spare CCTV camera of each type for every 20 installed. A minimum of 1 spare of each type is required.
2. Contractor shall provide spare connectorized cables sufficient for complete wiring of 1 drop and insert node
3. Contractor shall provide 1 set of spare fire alarm equipment, sufficient to completely replace the fire alarm equipment at one Communications House.
4. Contractor shall provide 1 set of spare intrusion alarm equipment, sufficient to completely replace the intrusion alarm equipment at one Communications House.
5. Contractor shall provide 1 spare intrusion detection magnetic door switch for every 10 switches installed in CICs in accordance with these Specifications.
6. Contractor shall provide 1,000 feet of 50 pair cable if 50 pair is required per design plans. The cable shall in be in accordance with these Specifications.

PART 3 - EXECUTION

Not Used
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes concepts and basic technical requirements for Work to be performed by the Contractor to provide a signal system. This section is applicable for cab-signaled territories by substituting “interlocking indicator” or “junction indicator” for “signal.”

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Communications and Signals Manual of Recommended Practice (C&S Manual)

B. American National Standard Institute (ANSI)

2. ANSI/ISO/ASQ Q9001 – Quality Management Systems - Requirements

C. Institute of Electrical and Electronic Engineers (IEEE)

3. IEEE Standard 1012 – Software Verification and Validation

1.3 ABBREVIATIONS AND DEFINITIONS

A. Abbreviations

1. AC Alternating Current
2. AREMA American Railway Engineering and Maintenance-of-Way Association
3. C Celsius
4. DACT Digital Alarm Communications Transmitter
5. DC Direct Current
6. F Fahrenheit
7. Hz Hertz
8. LCP Local Control Panel
9. LRT Light Rail Transit
10. LRV Light Rail Vehicle
11. OCC Operations Control Center
12. PC Printed Circuit
13. RTU Remote Terminal Unit
14. SCS Supervisory Control System
15. SPDC Signal Power Distribution Center
16. TCC Train Control Center
17. TWC Train-to-Wayside Communications
18. UPS Uninterruptible Power Supply

B. Definitions

1. Refer to the AREMA C&S Manual for definitions.

1.4 SUBMITTALS

A. Design Review Submittals - General Requirements

1. This subsection defines the minimum set of design reviews to be conducted by the Contractor, and the minimum information and process requirements for Authority reviews.

2. Design Review Submittals shall be submitted to the Authority and shall consist of a complete design description, including detailed drawings, specifications, and submittals of all subsystems and elements within the subsystem. Each calculation, test procedure, final drawing and submittal shall be reviewed, signed and sealed by a licensed Texas Professional Engineer. The final design document shall contain sufficient details for construction and shall be approved prior to construction.

3. The Contractor shall include in each submittal phase all materials, equipment, assembly and installation required to carry out the functions and purposes indicated in these Specifications, and to make the system suitable for the purpose for which it is intended, whether or not such materials, equipment, assembly and installation are...
specially indicated in the requirements of these Specifications.

4. The design proposed by the Contractor shall be subject to Authority approval. The Authority may disapprove the proposed design if it fails in any way to achieve the result intended by the requirements of these Specifications or is not in accordance with sound engineering principles. If the design or any portion of the design is disapproved by the Authority, the Contractor shall revise the design until it meets with Authority approval in accordance with the requirements of these Specifications.

5. No Authority approval or disapproval, or failure to approve or disapprove shall relieve the Contractor of any responsibilities under this Contract including the responsibility to provide a sound and practicable system design, suited for the intended purpose outlined in these Specifications.

6. Where requirements posed by individual subsystems, as defined in other sections of these Specifications, are different or greater than those specified in this subsection, those other requirements shall be deemed to augment the requirements specified herein. Design requirements for each submittal are further defined within the individual subsystem Specification Sections. Conceptual, Preliminary and Final Design Review packages shall each be one complete submittal sufficient to provide all the required details for construction, overall system integration, and operation.

7. Contractor shall order the designated equipment and material only after Authority approval of the PDR submittal, which includes design, calculations, operational as well as the entire product data for that subsystem.

B. Conceptual Design Review (CDR) for Signal System

1. Documentation of a conceptual design for the signal system shall include product data for all proposed products, as well as typical circuits and application logic.

2. Present the documentation with a narrative describing the system and system products. The narrative shall address any areas where problems could arise in the application of the Contract requirements.

C. Preliminary Design Review (PDR) for Signal System

1. Documentation of a preliminary design for the signal system shall be organized by equipment location and shall form the preliminary drawing set plan book for each location. Documentation shall include preliminary material reference lists/apparatus tabulations, cable plans, circuit drawings, house/case layouts and rack layouts.

2. Preliminary Design package shall be submitted after submittal and approval of the conceptual design.

D. Final Design Review (FDR) for Signal System

1. Documentation of a final design for the signal system shall include apparatus tabulations, circuits and layout drawings with completed wiring details. Documentation shall also include application logic in ladder logic format.

2. Final Design documentation shall be submitted at least 30 days prior to factory test.

E. Installation Drawings

1. Installation drawings shall include typical installation drawings modified and annotated to provide installation instructions for each installation at the location.

2. Final design installation drawings shall be submitted with the final design documentation.

3. As-built installation drawings shall be submitted with the as-built signal system drawings.

F. As-Shipped Drawings and Documentation for Signal System

1. As-shipped drawings shall include any changes to the final design for a location made in the factory test of the location. As-shipped documentation shall include printed and electronic versions of application logic for the location, and checksums of application logic.

2. As-shipped drawings and documentation shall be submitted within 15 days after completion of factory tests for the location.

G. As-Installed Drawings for Signal System

1. As-installed drawings shall include any changes made during installation and field
testing. Installation drawings shall be included in as-installed drawing packages.

2. As-installed drawings for each location shall be submitted within 15 days of completion of field tests for the location.

H. As-Built Drawings for Signal System

1. As-built drawings shall include all changes to the as-installed drawings made during the integrated testing.

2. As-built drawings shall not be accepted until all punch-list items have been cleared and all Non-Compliance Reports have been resolved.

3. If errors or other discrepancies are identified by the Authority within 1 calendar year of the Substantial Completion date, the Contractor shall correct such deficiencies and provide the Authority electronic and hard copies of all revised drawings. Contractor shall provide 2 sets of drawings. One set will show the corrections clouded. The second set shall be free of revision clouds. The revision history shall be shown on the revised drawings.

I. Software Quality Assurance Plan

1. Contractor’s Software Quality Assurance Plan (CSQAP) shall be submitted for Authority approval no later than 60 days after Notice to Proceed (NTP). The CSQAP shall be submitted for each organization, e.g., Contractor or Subcontractor, which will be developing or modifying software or firmware or application required by this Contract.

2. The submittal shall include documentation of all referenced processes, procedures, standards, practices, and forms.

J. Software Verification and Validation

1. Contractor’s Software Verification and Validation Plan shall be submitted for Authority approval no later than 60 days after Notice to Proceed (NTP). The Software Verification and Validation Plan shall be developed and apply to each subsystem which contains firmware or application software which will be developed or modified as a direct result of this Contract.

2. The submittal shall include documentation of all referenced processes, procedures, standards, practices, and forms.

3. Software verification and validation activities and actions developed under this contract shall include Authority approved applicable tasks as listed in Table 1, “V&V Tasks, Inputs and Outputs,” Clause 5.4 Process: Development, Software Integrity Level 4 of IEEE Standard 1012.

1.5 QUALITY ASSURANCE

A. Contractor shall develop and employ a Contractor Software Quality Assurance Plan (CSQAP) for Signal System firmware, software, and applications. The CSQAP shall be consistent with the provisions of Standard Specification 01450, “Quality Control”, and the CSQAP shall address ANSI/ISO/ASQ Q9001 Section 4.0. The CSQAP shall include a Contractor Software Quality Control Plan (CSQCP) that contains written procedures for performing quality control objectives stated in the CSQAP.

B. The CSQAP shall be implemented to satisfy the requirements of the Software Quality Assurance Plan as described in IEEE Standard 730. The CSQAP shall be based on the requirements for Signal System engineering, manufacturing, software, firmware, and applications, inspection and quality procedures for the design, development, testing, and installation of Signal system software.

C. Contractor Software Quality control Engineers shall have relevant, actual and verifiable software experience commensurate with the required Quality Control duties and responsibilities. Software Quality Control Engineers shall have previous working experience in both software engineering and systems quality engineering.

D. Contractor Software Quality Assurance Engineers shall be assigned to the project from the software preliminary design through system integration and final acceptance. Software Quality Assurance Engineers shall have previous working experience in both software engineering and systems quality engineering.

E. Contractor Software Quality Control Engineers shall be members of the organization’s Quality Assurance Department or division, and they shall report to management in that department or division or to the Software Quality Assurance Manager.

1.6 DESIGN INTERFACE

A. Contractor is responsible for interfacing the new design with the existing system.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used
2.2 CONTRACTOR FURNISHED MATERIALS

A. General

1. Material Requirements: Discontinued product models, refurbished equipment, or products scheduled for end-of-life, end-of-sale, or end of service within three calendars year of the installation date shall not be allowed.

2. Cables between instrument houses, cases and wayside equipment shall be:
   a. In conduit
   b. In ductbank
   c. In cable trough
   d. Any combination of the above

3. Direct buried cable is not approved for this Contract.

B. Modular design shall be used throughout the systems. Electrical and mechanical components shall be organized in plug-in assemblies wherever practical and be rack mounted. Mixing of equipment associated with 2 subsystems in 1 plug-in assembly shall not be accepted.

1. Where practical, configure subsystems so that failed components may be removed and operable replacements installed. Minimize requirements for repair-in-place activities.

2. Provide all like assemblies having identical characteristics interchangeable without altering unit or adjacent equipment except for adjustment.

C. Rack Mounting

1. All equipment and components mounted on racks shall be accessible for testing or replacement without removal of other components.

2. Design shall provide for cooling air space around all transformers, rectifiers, reactors and other heat generating devices.

3. All relays, equipment and entrance racks shall have reference test points for all voltages that are associated with the equipment installed on such racks. Reference test points shall be located at the top of racks and clearly identified.

4. Rack-mounted equipment that has a switch or switches on the faceplate shall be mounted so that the switch(es) shall not be activated inadvertently. Where the equipment cannot be located in a manner that protects the switches, covers shall be provided over the switches.

D. Electronic

1. Printed Circuit (PC) Cards
   a. PC cards shall be in accordance with these Specifications, and be housed in card files within dust-proof enclosures.
   b. Printed circuit wiring shall be organized so that wires serving the same function shall be connected to the same terminal of PC cards. PC cards containing similar circuitry and programming, where applicable, shall be interchangeable between subsystems.
   c. Design and construction of PC cards of the same subsystems shall be similar. Cards of different subsystems shall be the same design and construction wherever practicable.

2. Card Files
   a. Card file plugboards shall be registered to agree with registry of the associated PC card. PC cards shall not project beyond the front of a card file when mounted.
   b. Card files shall be installed in an enclosed cabinet designed to protect against dust buildup.
   c. Insulated cable-clamping devices shall be located on the back of the file in such a way that wires terminating in the files are installed in a neat and secure bundle, rigidly supported and protected to prevent chafing of insulation. Cabling provisions on the file shall permit wires to enter or leave the enclosure from both right and left sides. Such cabling shall not restrict access to the card file when rear covers of card files are removed.

3. Adjustments, Test Points and Visual Indications
   a. Adjustable components for electronic equipment shall be avoided by the use of required circuitry, stable components, and high-tolerance circuits. Adjustable components used to
experimentally determine correct operational settings shall be eliminated in the final design. Adjustable components shall have locking devices or be self-locking to prevent inadvertent operation, subject to Authority approval. When practical, 2 or more points of adjustment which are required during the same operation shall be located within 12 inches of each other and in such a way as to be operated by 1 person. Interacting adjustments shall not be acceptable. Replacement of a component or PC card with a spare shall not require compensating adjustments to other components or modules.

b. Test points shall be provided for checking essential voltages and waveforms and injecting test signals. Test points shall permit detection of defective PC cards and equipment modules without disconnection of wires. All test points shall be readily accessible when the equipment is in the normal operating position and be clearly labeled. Test points shall be capable of accepting probes and connectors used with test equipment such as voltmeters and oscilloscopes.

c. Where built-in indicators or meters are associated with adjustments, the adjustment point shall be sufficiently close to the associated indicator so as to be observed simultaneously by 1 person. Built-in indicators or meters shall be provided when frequent observation or adjustments are required or when portable test equipment will not provide required information or accuracy.

E. Environment

1. Physical

a. All equipment housed in instrument houses and cases shall function in accordance with the specifications and without damage within a temperature range of negative 40 degrees F to 159.8 degrees F and relative humidity from 0 percent to 95 percent, except as otherwise specified.

b. All equipment shall withstand without damage, storage conditions of negative 40 degrees F to 159.8 degrees F and relative humidity from 0 percent to 95 percent.

2. Physical – Wayside: Signal equipment installed outside of instrument housings shall be designed to operate satisfactorily in all weather conditions such as rain, snow, dirt, temperature variations and humidity variations. These conditions shall be as defined below and as determined by the climatic conditions from data published by the United States Government, National Oceanic and Atmospheric Administration for Dallas and surrounding areas. In addition, recommendations of the AREMA C&S Manual, Part 2.4.25, shall be followed to minimize condensation buildup.

3. Climatic Conditions. The following particular conditions shall be used as design guidelines and shall be considered as operational requirements. Actual localized temperatures and conditions within spaces and enclosures may be more severe than the ambient climatic conditions and the Contractor shall be responsible for evaluating these during the design effort. Additionally, the Contractor shall be responsible for advising the Authority if there are any special environmental factors to which its equipment may be sensitive that are not listed below. Contractor shall insure that no equipment damage occurs during manufacture, storage, and shipment as a result of climatic conditions which differ from those below:

a. Temperature & Solar Load:

1) Minimum ambient air temperature external to equipment: negative 5 degrees F

2) Maximum ambient air temperature external to equipment: 115 degrees F

3) Maximum solar radiation: 275/BTU/hr-ft²

4) Maximum daily temperature range: 50 degrees F

5) Average days under 32 degrees F: 38 days

b. Precipitation:

1) Maximum rainfall rate (may occur simultaneously in a
worst case wind): 7 inches /hr

2) Maximum snowfall: 12 inches in 24 hours
3) Ice: Measurable quantities: (infrequently)
4) Average Relative Humidity
   a) Morning: 82 percent
   b) Afternoon: 56 percent
   c) Max Avg: 87 percent

c. Wind:
   1) Average speed: 11 miles per hour (mph)
   2) Maximum sustained for 1 minute: 73 mph
   3) Maximum gusting: 100 mph

d. Air Contamination: The equipment shall operate as specified in the atmosphere commonly found in rail vehicle environments and the Dallas Metropolitan region. These include the following:
   1) Particulates:
      a) Average: 0.175 mg/m³
      b) Maximum: 0.324 mg/m³
   2) Ozone: 0.200 ppm, max.
   3) NO2: 0.25 ppm, max.
   4) SO2: 262 µg/m³
   5) CO: 20 ppm, max.
   6) Chloride: 13.9 mg/m³
   7) Moisture Acidity pH: 4.41

2.3 FUNCTIONAL REQUIREMENTS

A. Fail-Safe Criteria

1. Component or system failures that are not self-detecting shall not cause unsafe conditions, even if added to other failures. Any number of simultaneous component or system failures attributable to the same cause or related causes shall not cause unsafe conditions. Any component or wire becoming grounded or any combination of such grounds shall not cause unsafe conditions.

2. Vital signal equipment and the circuit design proposed for this Contract shall have a minimum in-service operation history of 5 years in the United States. Certification shall be provided showing installed dates and locations.

3. All vital repeater relay circuits shall be designed on the cascade principle. Paralleling of vital repeater relays shall not be permitted.

4. Repeater relay contacts shall be assigned so safety shall not be compromised by a failure of any repeater relay to energize.

B. Unless otherwise specified, the signal system and signal equipment shall perform functions and requirements that include the following as a minimum:

1. Locking shall prevent unsafe switch operation and prevent the clearing of signals for opposing or conflicting routes. The types of locking to be provided are as follows:

   a. Approach locking shall lock all switches within a route governed by a cleared wayside signal when a train is occupying or has occupied
the approach limits to such signal while the signal is cleared.

1) Approach locking shall prevent clearing of wayside signals for opposing or conflicting routes for a predetermined time after a cleared wayside signal has been reset to stop, unless the approach to such signal is unoccupied. Approach locking shall not be reset by the loss of shunt of a train occupying the approach.

2) Approach locking shall also prevent simultaneous clearing of 2 opposing signals within the interlocking. Approach locking shall be provided for all controlled signals.

3) Approach locking shall be released without operation of the timer by acceptance of a cleared route by a train occupying the first 2 track circuits of the route.

b. Time locking shall be provided for electric lock hand operated switches within a route governed by a cleared wayside signal. Opposing or conflicting routes shall be locked until released by TCC or the local control panel. Time locking shall also prevent simultaneous clearing of 2 opposing signals. One time locking relay shall be provided for each wayside signal and electric lock. Time locking shall not be compromised by loss of power.

c. Route locking shall lock switches within a route after a train has accepted the wayside signal governing such route and shall prevent clearing of conflicting or opposing signals. Route locking shall also lock switches outside the route when required by the route-selection system.

d. Detector locking shall lock switches within the limits of a track circuit when such track circuit is occupied. It shall also lock any switches that could be fouled by train occupancy of an adjacent track.

e. Switches at interlockings shall be locked by approach locking, time locking, route locking and detector locking.

f. Switch locking shall be released when approach or time locking, route locking and detector locking are released.

g. Route locking circuits shall be designed with sectional switch release. Such design is required to release each switch after the final axle of a vehicle has cleared the detector locking track circuit.

h. Traffic locking prevents clearing of opposing signals into a section of track. Individual traffic locking circuits shall be provided for each section of track between signaled interlockings. Simultaneous opposing requests shall not prevent setting of traffic.

i. Direction of traffic shall be locked on a section of track over which traffic locking is provided when any track section is occupied, or when traffic direction is requested into that track section or when approach or time locking is effective for a signal which had been cleared into that track section. Once established, traffic direction shall remain in the last established direction until unlocked and a call is made requesting entrance from the opposite end.

j. A signal governing movement into a section of track for which traffic locking is effective shall not clear until traffic direction has been established and locked in the direction of movement and the individual traffic logic in each location is set in proper alignment for that direction of traffic.

k. Clearing of Automatic Block Signal (ABS) shall be controlled by the direction of traffic. ABS signals shall not clear until traffic relays for the proper direction are energized.

2. Switch Control and Indication Requirements

a. Switch operating circuits shall cause track switch movements to operate when locking is not in effect.

b. Switch correspondence circuits shall indicate correspondence
between switch position and switch request. One normal and one reverse switch correspondence circuit shall be provided for each turnout or crossover track. Switch correspondence circuit shall be energized when the position of the switch points, motor/hand selector lever locked in motor, and as indicated by the switch repeater circuit agrees with the switch request as produced by switch control circuits. Any switch not in correspondence shall cause the signal(s) governing movement over that switch to be red.

c. A switch blocking circuit shall be provided for each switch within an interlocking. The block shall be initiated from TCC and the local control panel. This block shall be vitally interfaced with switch and signal circuits to prevent operation of such switch when blocking is in effect.

3. Entrance-Exit System. The following functions shall be performed as part of the non-vital entrance-exit system at TCC and on the LCP:

a. Route initiation shall respond to a route entrance request and indicate all available exits. Available exits shall be flashed at the signal pushbutton for such exits. Logic shall permit pocket signals to be selected as exits. Pocket signals shall be entrances when the signal button is pressed while there are no other entrances initiated.

b. Where applicable, through routing shall be provided at adjacent interlockings. This function shall combine multiple routes with a single entrance/exit selection.

c. Completion of the route request shall determine positions to which track switches are to be called. Route completion line-of-lights shall respond to entrance and exit point designations produced by the route initiation. Route completion also shall select proper switch control and signal clearing circuits.

d. Switch control circuits shall call track switches to the required position and energize switch operating circuits.

e. Switch indication circuits shall indicate switch point position. Switch indication circuits shall flash the position indication when switch is not in correspondence. Such indication shall be provided for all powered and hand-operated switch locations specified in Contract Documents.

4. Automatic Mode Operation

a. Automatic mode shall allow override by:

1) LRT vehicle operator selecting a train route via TWC through train destination.

2) TCC Command when Local Control is not selected.

3) LCP Switch when TCC Control is not selected.

b. TCC shall have provisions to override TWC established route.

5. Signal Control and Indication Requirements

a. Route check circuits shall be provided to initiate signal clearing for each signal that governs movement over a track containing a track switch. A route check circuit shall be energized to initiate wayside signal clearing only when track switch positions correspond to positions required for the selected route, opposing signals have not been called and no conflicting movement is in progress.

b. Signal clearing shall be effective for the route called when the proper route check circuit is energized and approach, time, or traffic locking for an opposing route is not in effect. For signals that do not govern movements over track switches, signal clearing shall be initiated directly from the entrance point provided an opposing signal has not been called and an opposing train movement is not in progress.

c. Signal indication circuits shall indicate and distinguish between a signal being called, the same signal being clear and such signal being in time locking.
BASIC TECHNICAL REQUIREMENTS - SIGNAL SYSTEM


d. Fleeting Circuit Requirement

1) Fleeting circuits shall automatically re-establish energy to the signal clearing circuit, after train passage, whenever the control button for a signal has been placed in the fleeting position. Fleeting shall be provided for normal and reverse direction of traffic.

2) When a signal has been fleeted, it shall not re-clear until the circuit requirements are met as defined by control lines.

3) Canceling the fleeting feature shall not cancel the route.

e. Signal Blocking Circuits shall be provided for each interlocking signal. Blocking circuits shall be initiated from TCC and the LCP. Signal exit block circuits shall be interfaced with vital home relay circuits to prevent an exit at the signal selected and interfaced with nonvital circuits to prevent a preliminary exit indication at the signal selected.

f. Call-on Routes

1) A call-on signal shall allow a train to enter any section within the interlocking or junction that is already occupied by another train to enable coupling and shall permit 2 trains within a single track circuit.

2) Call-on routes shall only be available if the approach section is occupied.

3) Call-on routes shall be available for 1 signal at a time and only if the requested route has been previously established.

4) Call-on routes shall be available for the over-the switch (O/S) and exit track circuits.

5) Call-on’s shall be initiated by request from the operator to the TCC dispatcher or from the LCP.

TCC shall be able to set call-on routes for any occupied section within the interlocking or junction.

6) Call-on routes shall also be able to be set from the local control computer. Only parallel routes shall be allowed through the interlocking or junction when a call-on is lined.

7) Conflicting routes shall not be permitted through the interlocking or junction until the section is cleared.

6. Repeater circuits shall be provided as required. Circuit design utilizing repeater relays shall use accepted design practice and shall be subject to the Authority's approval. Home signal circuit design shall use the last repeater for all front contacts and the primary repeater for back contacts.

7. Switch lever and switch movement repeater requirements:

a. Auxiliary switch operation shall establish a call for a switch position.

b. Switch repeater circuits for switch-and-lock movements shall indicate the normal or reverse position of the track switch. One normal and one reverse switch repeater circuit shall be provided for each crossover or turnout. The normal switch repeater circuit shall indicate when the switch-and-lock movement is mechanically locked in the normal position and the point detector contacts correspond to proper normal switch point closure. The reverse switch repeater circuit shall indicate when the switch-and-lock movement is mechanically locked in the reverse position and the point detector contacts correspond to proper reverse switch point closure. If the switches are not in the locked normal or locked reverse positions, the circuit shall be shunted. When the switch repeater circuit is controlled by multiple switches of a crossover, all switches shall be mechanically and electrically locked in a normal or reverse position before switch repeater circuits can be energized.

c. Switch correspondence circuits shall be separate from switch
repeat circuits and indicate when position of the switch in the field is in agreement with the requested position.

d. Switch overload circuit shall protect each switch-and-lock movement by using a switch overload stick relay. Provide 1 overload stick relay for each switch machine. Overload circuit shall remove energy from a switch-and-lock movement if the operating current rises above the desired maximum due to a stalled switch or other overload. Once the overload has occurred, energy shall remain off until the switch call is canceled or the switch is called to the opposite direction. Where an electronic switch controller is allowed, all motor power to the electronic switch controller shall be controlled by a Vital Switch Control Relay, (VWCR) designed to break power through its heel/front heavy duty contacts for normal and overload operation.

8. Other circuit requirements shall include, but not be limited to, the following:

a. All timed circuits shall have their total adjustment time effective in switch locking.

b. Circuits shall be so arranged that a momentary loss of shunt for 5 seconds or less shall not cause flashing of proper cab signals or permit release of electric locking.

c. Circuits shall be so arranged that when cab signals or indicators are changing aspects, no other signal or code shall change or appear to change required code or aspect.

d. Cab signals shall progressively upgrade.

e. All nonvital circuits and those vital circuits which are entirely within 1 housing may be single-wire, single-break type. All other circuits shall be double-break.

f. Interlockings shall be provided with track circuits on all tracks and with no "dead" sections within the interlocking limits. Virtual track circuits shall not be used.

9. Circuit nomenclature shall be as designated in the Contract Drawings and be consistent with existing Authority signal practice, as shown on Contract Documents.

10. All vital and nonvital relay circuits shall be protected by ground detectors.

11. Primary power for all communications equipment within each signal house including RTU’s, media converters, Ethernet switches, etc. required to ensure communication of Signals, SCADA or Fire Alarm subsystem status to the Control Center shall be extended from a UPS or battery system. When the AC supply is interrupted, the UPS or battery backup system shall supply the RTU with the required power for a minimum of 8 hours.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The payment for this Work, as specified, shall be full compensation for providing and installing the signal system complete in place including finalizing design, shop drawings, submittals, testing, and inspection, and for all Work as described in the Contract Drawings and in this Section and related Specifications sections; and for all operations, materials, tools, labor, equipment and incidentals required to complete the specified Work.

4.2 PAYMENT

A. The Work described in this section will be paid as a lump sum.

END OF SECTION 16901
SECTION 16902
BLOCK DESIGN CRITERIA - SIGNAL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section shall include verification of the safe braking and headway design of the signal system with normal and reverse traffic direction capability. Contractor’s verification shall include applicable signal system components, including block signals, interlocking indicators and signals, and speed limit signs.

1.2 REFERENCED STANDARDS

A. Dallas Area Rapid Transit (DART) Light Rail Project Design Criteria Manuals
   1. Volume 2: Systems Design

1.3 SUBMITTALS

A. Contractor shall submit details of the software proposed for block design analysis for the Engineer approval. The software details shall include a program description, formulas used in the program, and sample input and output data.

B. Contractor shall submit a Preliminary Block Design Analysis for the Engineer approval and then as required by completion of track design and finalization of civil data. Analysis shall be finalized as the civil design of each line section alignment is finalized.

1. Contractor shall perform block design and headway analyses and verification using the approved program and submit the analyses. Submittals shall include all program input data.

2. The Block Design shall be an iterative process, in that the Contractor shall ensure that the design satisfies the design criteria throughout the duration of the Contract. Contractor shall ensure that the actual conditions that comprise the basis for the design are included in the design. As such, the design shall not be considered complete until analysis has been performed using final design alignment data and the design has been approved by the Engineer.

C. Contractor shall submit Control Line Diagrams in the format similar to the Contract Drawings at a scale of 2000 ft per sheet. The Drawings shall be updated as the design progresses and shall be confirmed in the Field Testing.

1.4 QUALITY ASSURANCE

Not Used

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

Not Used

2.3 FUNCTIONAL REQUIREMENTS

A. Contractor shall analyze the Signal System block design and layout as shown on the Contract Documents and latest version of the required line section track plans. Contractor shall use analysis to determine final speed limit sign locations, signal control lines, and final track circuit boundaries. Contractor shall determine the speed codes to be transmitted to maintain safe spacing between following trains at the highest operating speed consistent with braking requirements.

B. All design details, such as track circuit boundaries, signal control lines, interlocking charts, signal aspects and speed sign locations to be utilized in each block shall be submitted to the Authority for review and approval before proceeding with the Work.

C. The design shall provide required headway for following moves for normal direction of traffic. Reverse operation on either mainline track shall be designed for maximum attainable headways for reverse signals located at normal-direction signal locations. Reverse headways shall be calculated and submitted to the Authority.

D. The block design shall include such track circuit boundaries as may be required for safe braking distance at maximum design speed, to maintain design headway, for crossbonding, for the initiation of crossing warning systems, to denote stations and for the operation of interlockings.

E. Contractor’s block design verification effort shall include analysis of the efficiency of the design and shall include recommendations of possible methods to increase MAS and throughput for the system.

F. Speed Limits

1. Maximum design speed in either direction on either track shall be 65 mph.

2. The speed limit in all station platform areas shall be 25 mph. For calculations, maximum allowable speed (MAS) approaching stations shall be considered according to the speed of a train applying full-service braking to the 25 mph limit, except where there is a mandatory station
stop. Where a station stop is mandatory, MAS shall permit sufficient braking distance for a worst case train.

3. Speed limits for curves shall apply to adjacent spirals as a linear progression from the MAS at the entrance to the spiral to the curve speed restriction at the entrance to the fixed curve section. Speed restrictions for track curves shall be calculated using a full-service brake rate.

4. To optimize performance and minimize run time, the speed restrictions through spiral portions of curves are calculated to establish detection criteria so that speed code reductions are made as close to the restriction as possible. Calculations are made to release the train as soon as the rear of the train reaches a point in the exiting spiral where the calculated speed restriction corresponds to the next higher speed command.

G. Vehicle Criteria: For direct requests for additional detailed information contact the Authority.

H. Brake System Characteristics for Calculations

1. Power removal time is defined as the time required for on board equipment to recognize that a penalty stop sequence has been initiated by the train passing over an active train stop and to remove power from the vehicle traction motors through train line controls.

2. Mode change dead time is the maximum time it takes for the vehicle control equipment to change between control modes, i.e. change from power mode to brake mode. During the mode change time the vehicle will be assumed to travel at a constant velocity.

3. Brake build up time is the interval required for the brakes to build up to full brake rate. The design shall assume during this time period the vehicle travels at constant velocity.

4. The design brake rate shall be adjusted for worst-case adhesion conditions.

5. Safe Stopping Distance Calculation

   a. The braking rate shall be based on an application of the friction disc brake system applied in a modified emergency mode. Block length shall be based on the braking distance calculated using the friction brake rate adjusted for rail adhesion and safety factors.

   b. Safe Braking Distance for determination of proper speed codes shall be based on a braking model that simulates the worst case braking effort. The model shall simulate braking as a series of consecutive events, defined as follows:

   1) Primary Reaction Distance – The distance traveled by a vehicle at the initial velocity as it crosses a block boundary. The distance is that traveled through the “dead” section where a valid code may be unavailable. The initial velocity to be used is the previous speed code plus the overspeed tolerance of the vehicle cab signal equipment. In the model, acceleration due to downhill slope should be considered.

   2) Code Recognition Time – The worst-case period that the vehicle equipment would take to recognize a valid speed code. Assume the vehicle is speed-maintaining through this period. Include acceleration due to downhill slope.

   3) Runaway Acceleration – Assumes a propulsion system control failure that sends the vehicle into full acceleration at the maximum available rate adjusted for grade. The runaway acceleration occurs for the duration of the Overspeed Detection time.

   4) Mode Change Time – The time for the vehicle equipment to remove power and initiate a brake command after an overspeed has been detected. During this period, power is removed and acceleration force of grade is included.

   5) Brake Build-up Time – The time from the initiation of braking until full deceleration is achieved. During this period, braking shall be calculated as a
6) Constant Braking – When the brakes have built up to maximum deceleration, the braking model shall complete the braking at a constant brake rate adjusted for grade. Final stopping point shall include allowances for vehicle overhang and track circuit characteristics.

c. Safe braking calculations shall be made using each possible consist of 1 to 4 LRVs, and the calculation that produces the longest safe braking distance shall govern the design.

I. Safety Requirements: The distance between the front of a worst-case train and the rear of the train that it is following shall always be greater than the distance required for the worst-case train to stop before reaching the train it is following. The distance between the front of a worst-case train and an interlocking signal displaying a stop aspect, when time locking or approach locking is not in effect shall always be greater than the distance required for a worst-case train to stop before reaching the interlocking signal. For such calculations, it shall always be assumed that the worst-case train is approaching a stationary train.

J. Location of Block Boundaries

1. Block boundaries and track circuits shall be located to ensure compliance with safety.

2. Block design shall permit required negative traction power return bonding and crossbonding. Track circuit boundaries shall be located adjacent to Traction Power Substations (TPSS).

3. Track circuits shall be provided for each station platform area, with circuit boundaries located so that that occupancy of the platform track circuit with adjacent circuits unoccupied provides an indication to the control center that a train is berthed, or nearly berthed. Track circuit boundaries shall be as near the platform ends as is practical. In no case, shall the boundary be near enough that an adjacent circuit is shunted with a train in the platform. The local control panel shall not display track circuits extending through grade crossings. If necessary, provide insulated joints to define the platform area.

a. Maximum authorized speed (MAS) over the platform track is 25 mph. The platform MAS command shall be maintained until the train exits the platform track circuit.

b. Except where the platform track circuit is used in a crossing approach thus requiring a mandatory station stop to satisfy minimum warning time or preemption time to the crossing, speed commands for track circuits approaching the platform track shall be designed with alignment MAS available. Where a station stop is mandatory, MAS for track circuits approaching platform track shall provide sufficient braking distance for the worst-case train to the near edge of crossing.

c. A speed limit sign shall be placed at the location for a train approaching at MAS to slow to 25 mph by the near edge of platform at a full-service brake rate.

4. Speed Restrictions

a. The block design shall include B-points or block boundaries in the approach to near-side stations and terminal stations that will cause speed codes to bring trains to a stop at the proper berthing locations.

b. B-points or block boundaries shall be used to slow trains for civil speed restrictions where a separate track circuit is not required. The initiating point of any speed reduction shall be optimized to be as near to the restriction as is safely possible. B-points or block boundaries shall be provided to allow trains exiting speed restriction zones to accelerate to the maximum allowable speed as soon as the rear of the train clears the speed restriction.

c. The signal system shall allow for defining and adjustment of speed codes of individual track circuits within a block. The endpoints of any track circuit controlled from a particular CIH shall be shown on the local control panel of that CIH.

5. Block boundaries shall ensure that any train traveling at MAS, and brought to a stop by an occupancy or interlocking signal at STOP, shall receive at least 1 non-zero speed command less than MAS prior to
arriving at a track circuit with a zero code. Braking profiles from MAS speeds greater than 40 mph shall contain at least 2 non-zero speed commands less than MAS.

6. Speed limit signs shall be used where civil speed restrictions are not enforced by the cab signal system.

K. Headway Analysis

1. The system design shall support a 2-1/2 minute scheduled operation in the Central Business District (CBD). Design headway for operations into the CBD and through junctions shall be 90 seconds. Design headways for all other sections shall be 180 seconds.

2. Headway analysis shall be determined using a 20 second dwell time for station stops.

3. The headway design analysis shall assume that every train stops at every station.

4. Exceptions to the design headway criteria shall be subject to the Authority’s approval.

L. The signal system shall be optimized at terminal interlockings to provide best achievable headway.

PART 3 - EXECUTION

3.1 PRODUCTION

A. Contractor’s final block design shall conform to the design criteria and train protection requirements as herein specified.

3.2 DELIVERY STORAGE AND HANDLING

Not Used

3.3 INSTALLATION

Not Used

3.4 TESTING

A. Field tests of block layout and train protection circuits and equipment shall be in accordance with these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

END OF SECTION 16902
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section describes concepts and basic technical requirements for the wayside Cab Signal system.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1.3 DEFINITIONS

A. Definitions
   1. Refer to the AREMA C&S Manual for definitions.

1.4 SUBMITTALS

A. At least 30 days prior to the Conceptual Design Review, the Contractor shall submit drawings showing the physical characteristics, ratings, and operating characteristics for the proposed Cab Signal equipment.

B. At least 30 days prior to the Preliminary Design Review, the Contractor shall submit the following for approval:
   1. Drawings for Cab Signal transmitters and associated equipment with a bill of materials.

C. Contractor shall submit Test Procedures and Results in accordance with Section 16998, "TEST AND INSPECTION."

D. Prior to Field Testing of the first Audio Frequency (AF)/Cab Signal track circuit, the Contractor shall furnish 15 manuals describing operation and maintenance of Cab Signal equipment.

1.5 QUALITY ASSURANCE

A. Cab Signal equipment shall be manufactured and installed in accordance with the Contractor’s Authority approved Quality Assurance program. Cab Signal Equipment shall be tested according to Authority approved test procedures.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

Not used.

2.3 FUNCTIONAL REQUIREMENTS

A. Contractor shall supply a system to provide Cab Signals using equipment that is fully compatible with the Light Rail Vehicle (LRV) carborne Automatic Train Protection (ATP) equipment. Cab Signals shall transmit speed codes using a fixed frequency that is on/off modulated at specific rates.

B. Cab signal and track circuit system frequencies, modulation methods and modulation coding shall be non-proprietary. Contractor shall not introduce any element to the wayside/vehicle interface that could be considered proprietary. Contractor shall make full disclosure of any and all details, including tolerances necessary for others to correctly decode or produce Cab Signals.

C. Cab signals shall provide the following speed codes at frequency and modulation rates defined by the carborne ATP Equipment supplier:
   1. 0 mph.
   2. 10 mph.
   3. 15 mph.
   4. 20 mph.
   5. 25 mph.
   6. 30 mph.
   7. 35 mph.
   8. 45 mph.
   9. 55 mph.
  10. 60 mph.
  11. 65 mph.

D. The absence of code (No Code) in the CAB Mode of Operation shall be interpreted by the Carborne ATP equipment as a failure.
E. The Cab Signal generation equipment shall operate within the tolerances established by the carborne ATP equipment supplier.

F. Except for the special cases of Cab Signal Loops.

G. Cab Signals shall be applied to the exiting end of an associated track circuit.

H. Speed codes on each track circuit shall be as required by Section 16902, “Block Design Criteria” and Authority approved Control Line Drawings.

I. The carborne ATP equipment will reject any Cab Signal less than 75 mA. The Cab Signal generating equipment shall ensure that valid Cab Signals are above the minimum threshold accepted.

J. A single cable pair to each impedance bond shall be used for speed code frequency transmission on track circuits across the impedance bond. Contractor shall provide multiplexing and/or coupling devices as well as Cab Signal Loops as required. Frequency selection shall ensure that the combined signals do not interfere or cause interference with the operation of any other equipment.

K. Except for the special cases of Interlockings and Insulated Joint locations, speed codes shall be transmitted in the rails only when the track circuit for which it is intended is occupied.

L. At locations where the entrance boundary is equipped with insulated joints, the Cab Signal speed code shall be applied when the advance track circuit is occupied.

M. Apply Cab Signal speed codes inside interlockings when a track circuit in advance to interlocking boundary insulated joint is occupied. Apply valid speed codes to all track circuits or Cab Signal Loops in the route where a valid route is established.

PART 3 - EXECUTION

Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The payment for this Work, as specified, shall be full compensation for providing and installing the signal system complete in place including finalizing design, shop drawings, submittals, testing, and inspection, and for all Work as described in the Contract Drawings and in this Section and related Specifications sections; and for all operations, materials, tools, labor, equipment and incidentals required to complete the specified Work.

4.2 PAYMENT

A. The Work described in this section will be paid as a lump sum

END OF SECTION 16903
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the producing and providing of Signal System drawings. It describes the general format of drawings, types of drawings and the manner in which information shall be displayed on such drawings.

1.2 STANDARDS

A. DART Design Criteria Volume 3: Drafting (CADD) Standards Manual

1.3 SUBMITTALS

A. Submittals shall be in accordance with the requirements of these Specifications

1. Submit plans produced using Microstation software.

1.4 QUALITY ASSURANCE

A. The Contractor shall inspect drawings for form and content prior to submittal. Points to be checked shall include the following:

1. Conformance to the Authority Drafting Standards.
2. Conformance to Specifications.
3. Logical grouping and arrangement of subject matter.
4. Accuracy
5. Legibility
6. Neatness
7. Line Quality
8. Lettering Quality
9. Reproduction Quality
10. Inclusion of contract specified interfaces with related contracts.

B. The Authority will review drawings for conformance with the criteria listed above.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. None

2.2 CONTRACTOR FURNISHED MATERIALS

A. The types of drawings to be provided shall be as defined herein and in the Authority Drafting Standards.

1. Standard Abbreviations
2. Standard Signal Aspects and Indications
3. Material Reference List
4. Cable Assignments in Ductbanks: Provide drawing showing ductbank cable assignment including how cables are assigned to each duct.
6. Route and aspect charts.
7. Interlocking Track Circuit Drawing. Show all terminations and all transformer, relay and track connections.
8. Track Circuit Repeater Drawings
9. Line Circuits
10. Traffic Circuits
11. Signal Control Circuits
12. Route Check Circuits
13. Approach and Approach Stick Circuits
14. Route and Switch Locking Circuits
15. Signal Lighting Circuits
16. Train Stop Circuits Wayside
17. Switch Correspondence and Switch Repeater Circuits
18. Switch Control Circuits
19. Alternating Current (AC) and Direct Current (DC) Ground Detector Circuits
20. Supervisory Control System (SCS) Control Circuits
21. Non-Vital Signal and Switch Initiation Circuits
22. Non-Vital Switch and Signal Completion Circuits
23. Non-Vital Automatic Routing Logic Circuits

24. Local Control and Train Control Center (TCC) Control Circuit Drawings

25. Local Control and TCC Indications Circuit Drawings

26. Local or TCC Control Transfer Drawings

27. Entrance Rack Drawings

28. Signal Power Distribution Drawings

29. Relay Rack Drawings / Vital Processor Rack Drawings

30. Miscellaneous Rack Drawings

31. Wayside Cases Rack Layout Drawings

32. Wayside Cases Schematic Drawings

33. Signal Grounding System

34. Train to Wayside Communications (TWC) Circuit Drawings

35. Control Line Diagrams: Show single line representation of the tracks with stationing of all items relevant to the signal system. Drawings shall include:
   a. Insulated joints
   b. Signal equipment enclosures
   c. Automatic Train Protection (ATP), B-point and TWC Loops
   d. Speed restrictions
   e. Switch points
   f. Stations
   g. Signals and indicators
   h. Highway crossings
   i. Bridges, tunnels and structures
   j. Approach limits, average speed and calculated warning time for highway crossing warning systems. Show limits of advance approach sections
   k. Limits of approach locking
   l. Approach circuits for route requests
   m. Track circuits
   n. Indications of route indicators with control limits for each indication
   o. Civil and operating limits and maximum speed limits
   p. Maximum allowable speed commands
   q. Speed commands for each route and for each following move possible for each route
   r. Operations and Maintenance (O&M) signs
   s. Timer settings for any delay applied to an approach circuit

36. Input/Output Charts: The drawing shall include charts for all vital and non-vital inputs and outputs.

B. All equipment rack drawings:
   1. At bottom of each device shall be the part reference number.
   2. At top of each device shall be page number for schematic drawing of the circuit.
   3. Each relay contact shall show page number where the contact is used.
   4. Each relay contact shall show by shading when in use and when not.
   5. All resistors shall show reference number, size and page number where used on schematic drawing.

C. Application Logic
   1. Logic shall be documented in ladder logic format.
   2. Logic shall be bound for each processor.
   3. Each logic listing shall include annotation briefly describing the function of each variable and named bit used in the logic.
   4. When a logical name is an acronym, the definition shall be noted.
   5. Each type of logic shall be annotated with the logic type and basic function.

D. Each circuit drawing shall include a track layout at the top of the page showing all signals
switches, and track circuits relating to the circuits on that sheet.

E. Basic Drawing Format Requirements

1. Each drawing shall be of a standard size. Any other size drawing shall require the Authority approval.

2. Drawings shall not be crowded or cluttered, and shall be easily readable. Circuitry shall be presented on the drawing with a minimum of crossed or offset lines.

3. All symbols and circuit nomenclature shall conform to that indicated on Contract Drawings. Any additional symbols or nomenclature needed shall be submitted for Authority approval.

4. Single line Track and Signal Plans shall identify the starting point and show the effective distance of all approach locking and Automatic Highway Crossing Warning (AHCW) system approaches.

5. Complete circuits shall be shown on each drawing insofar as possible. A minimum of circuit continuations shall be used. When continuations are used they shall be clear and specific and include the identity of the continuation sheet.

6. Local circuits shall be drawn with relay coils, timers, motors, or other operated devices shown near the right or left border of the drawing wherever practical. Where there is a choice the right border shall be favored. Contacts in circuits shall be laid out in geographical succession insofar as possible.

7. Line circuits shall be arranged to geographically match the track layout. On line circuit plans, only line circuits shall appear on the right and left sides of the drawing. Relay contacts shall be lined up one below the other insofar as practicable.

8. Relay nomenclature shall be printed in three lines, as follows:

<table>
<thead>
<tr>
<th>Top - Rack No. and Position:</th>
<th>(7A6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle - Name Identification:</td>
<td>2N</td>
</tr>
<tr>
<td>Bottom - Function Description:</td>
<td>ASR</td>
</tr>
</tbody>
</table>

9. Relay nomenclature and rack location shall appear above the relay coil or contact symbol.

10. Stick contacts shall line up under the coil of controlling relay.

11. A minimum distance of 0.20 inch shall be maintained between lines representing circuit wiring. Lettering or printing shall be at least 0.10 inch high. All spacing shall be in multiples of tenths of inches.

12. All Track and Signal Plans shall show the survey station for all wayside signals, interlocked and non-interlocked track switches, track circuit cut sections, switch locks, signal housings and wayside cases.

13. Schematics and circuit drawings shall accurately depict the actual connection and termination arrangements. Arrangement of circuitry shall be in such a manner that no more than two wires shall be shown connected to a single terminal or contact pin. A uniform method shall be used to indicate the actual location of double wire connections when it is not desirable to show both wires at the point of termination.

14. Contract Drawings included with these Specifications do not dictate the location of double wire connections, but shall guide the Contractor insofar as circuitry, symbols, lettering and drawing layout are concerned.

15. Circuit drawings shall provide sufficient information by means of contact type, terminal numbering and relay location to easily enable tracing and testing of such circuits.

16. All circuit drawings shall have a reference to all detailed drawings associated with each individual circuit drawing.

17. When the final circuit is not wired as shown on the Contractor's drawing, Contractor shall revise its drawings to indicate actual wiring before final As-Built prints are made.

18. Rack layouts, contact assignments and terminal details shall make reference to the page on which they are found. This information shall remain on the final As-Built.

19. Numbering: Sheets shall be numbered using the Authority's drawing number format.
F. Plan Books

1. The Contractor shall organize drawings for each field location into plan books as follows:

a. One set shall consist of all circuit drawings for the area controlled from a particular Instrument House include applicable prints from adjacent housings to show the non-local portions of traffic and other line circuits appearing in the local instrument housing.

b. A second set shall consist of detail drawings and arrangement of internal layout plans and wiring diagrams for the various pieces of equipment located in or controlled from the particular instrument housing.

PART 3 - EXECUTION

3.1 PRODUCTION

A. The effective date and identification number, to be inscribed on the final drawings, will be provided by the Authority prior to the time drawings reach As-Built condition and are ready for the Contractor's final processing.

B. The Contractor shall be solely responsible for the accuracy of wiring diagrams and final circuit drawings. The Contractor shall be responsible for the correctness of any drawings for existing circuits or equipment details that he reuses as part of a complete working system.

C. The Contractor shall prepare relay contact, relay location, and detail wiring assignments for the final design and provide arrangement drawings where contact usage of each relay is recorded. These arrangement drawings shall contain relay nomenclature and relay terminal identification. Time settings of timed relays shall be shown on circuit plans beneath the corresponding time element relay symbol.

D. Where vital or non-vital processors are provided, the Contractor shall provide drawings that use contact symbols to show the logic of application engineering. The symbology shall be an accurate representation of the application engineering interface.

E. The Contractor shall anticipate that Station names may change during the course of the Project and shall not have basis for claim due to changes of station names prior to the completion of the As-Built Drawings. Where a station is changed during the course of the Project, the Contractor may, at his discretion, retain Contract designated names on design drawings until the As-Built drawings are produced. As-Built Drawings shall include any name changes made prior to the completion of field testing.

F. Where an existing system is to be modified, the Contractor shall mark changes to an As-Built drawing for the existing system. Hard copy and, if available, electronic As-Built drawings will be provided to the Contractor. The modified drawings shall be incorporated into the working and As-Built drawing sets. Modifications shall be identified by clouding the modification and indicating addition or deletion using "X" or "O" on the clouding, where "X" shows deletion.

3.2 INSTALLATION

A. Not used

3.3 TESTING

A. Not used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 "Signal System Basic Technical Requirements."

END OF SECTION 16904
SECTION 16908
EXTERNAL CABLE - SIGNAL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be completed under this Section consists of designing, providing and installing all various types of cable required for signal system wiring external to wayside housings, cases, factory wired mechanisms and buildings.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)
   1. Communications and Signals Manual of Recommended Practice (C&S Manual)

B. American Society for Quality (ASQ)
   1. ASQ Q9001 - Quality Management Systems – Requirements

C. ASTM International (Formerly known as American Society for Testing and Materials)
   1. ASTM B3 – Standard Specification for Soft or Annealed Copper Wire
   2. ASTM B8 – Standard Specifications for Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard or Soft
   3. ASTM B33 – Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
   5. ASTM D470 – Method of Testing Crosslinked Insulations and Jackets for Wire and Cable
   7. ASTM D1248 – Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
   9. ASTM D2765 – Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics

D. Insulated Cable Engineers Association (ICEA)
   1. ICEA S-19-81 – Rubber-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy
   2. ICEA S-66-434 – ICEA/ANSI Standards Publication for Ampacities of Cables in Open-Top Cable Trays
      a. ICEA/NEMA Method 4 – Neutral or Single-Color Compounds with Surface Printing of Numbers [Control Cable Only]
      b. ICEA/NEMA Method 6 – Layer Identification
   4. ICEA S-61-402 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
   5. ICEA S-73-532 – Standard for Control, Thermocouple Extension, and Instrumentation Cables

E. The Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 383 – IEEE Standard for Type Test of Class 1E Electric Cables, Field Splines and Connections for Nuclear Power Generating Stations

1.3 SUBMITTALS

A. Contractor shall submit the following to the Authority for approval:
   1. List of each cable manufacturer’s railway signal installations.
   2. Each cable manufacturer’s Quality Assurance Program.
   3. Full technical data for each type of cable, which each manufacturer intends to provide.

B. Contractor shall provide to the Authority product data cut-sheets and a sample specimen of a 4 foot length identical to each proposed cable type. Samples shall remain the property of Authority. Each sample shall contain at least 2 cable identification markings as described in Paragraph 2.2.D.
C. Contractor shall submit 2 certified copies of the following to the Authority for approval:

1. Prior to the purchase of any cable, the Contractor shall submit the qualifications of each proposed cable manufacturer for Authority approval.
2. Cable test reports for all demonstration tests required by the Authority.
3. Cable test and inspection reports for tests and inspections required by these Specifications.
4. Test reports of cable tests conducted in the field in accordance with approved testing procedures.
5. Certification that each cable provided complies with the requirements of these Specifications.
6. Information to be provided by certified cable test reports shall include the following:
   a. Report Number
   b. Date and location of test.
   c. Description of test and test conditions.
   d. Complete cable or wire description.
   e. Lot, batch, or reel identification number.
   f. Quantitative Test Results.
   g. Test Results Summary.
   h. Information on components of the cable tested to include batch numbers and physical and electrical properties.
   i. Contractor shall submit a complete, signed and notarized standard Wire and Cable Test Report Sheet as part of each cable test report.

D. Contractor shall submit to the Authority as required herein the cable manufacturer's instructions and procedures together with 1 sample end seal specimen for dressing of each type underground cable to be provided and installed under this Contract.

E. Contractor shall submit for approval detail plans of cable duct, cable trough and conduit installations showing all hardware to be used, methods of attachment, cable routing through manholes, hand holes, and fill.

1.4 QUALITY ASSURANCE

A. Contractor shall submit a notarized copy of the Engineering Report, Attachment A to this Section, and a notarized copy of the Quality Assurance Program Form, Attachment B to this Section.

B. All cable manufacturers supplying cable for this Contract shall be meet the qualification requirements described in this Section. Contractor shall provide all of the data required for the Authority's evaluation and make arrangements for all required demonstrations and tests.

C. Supplier qualifications shall be based on the following criteria:

1. Cable manufacturer(s) shall demonstrate previous successful experience in providing the type cable to the transit/railroad industry.
2. References shall be provided that identify past performance to the transit and/or railroad industry for vital signal control.
3. Provide an installation client list that indicates a minimum of 15 years successful operation shall be provided. The list shall contain three installations and the name, telephone number, company official, and title to be contacted.

D. Cable manufacture shall be in accordance with the requirements of this Specification and in compliance with a Quality Assurance Program that meets the requirements ASQ Q9001.

1. Quality compliance shall promote a thoroughly tested cable that will render 40 years service life.
2. Primary concern shall be focused on formal assurance requirements to ensure that cable failure cannot be attributed to a cause that is traceable to the manufacturer.

E. Contractor shall provide full technical data, which demonstrates compliance with the requirements of this Specification for each cable type to be provided.

F. Manufacturer shall certify compliance with the following warranty conditions prior to selection:

1. Manufacturer warrants that design, material and workmanship incorporated in each item of cable shall be the highest grade and consistent with established and accepted standards for underground, tunnel, and ductbank cable for vital railroad and transit signal circuits and that each such item and every part and component thereof shall comply with this Specification.
2. Manufacturer agrees that the warranty period shall commence with final system
acceptance and continue in force for each item of cable for a period of 40 years thereafter.

3. Manufacturer agrees that the warranty shall provide for replacement of defective cable should a patent or latent defect be discovered during the warranty period.

4. The warranty shall cover any length of defective cable.

5. The manufacturer shall replace any and all defective cable and a replacement cable warranty shall begin anew for a period of 40 years following final acceptance of replacement cable.

6. If a failure is found to be of major importance and affects any other item of cable, the affected item of cable shall also be replaced and its warranty reinstated herein Paragraph 1.4.F.5.

7. The warranty reinstatement provided for shall apply only to the first replacement of any such item and, in the case of failure of major importance, to the first warranty extension of affected items.

8. The foregoing warranties are exclusive and in lieu of all other warranties written, oral, implied, or statutory (except as to title and freedom from lien).

9. Manufacturer shall verify by written guarantee, signed by an officer of that company, that the wire and cable to be provided meets or exceeds the qualifications of this Specification.

G. Contractor shall monitor the manufacturer of wire and cable to assure that approved Quality Assurance Program is being closely adhered to and the wire and cable is being manufactured in accordance with this Specification and the approved submittals.

H. Each finished wire and cable shall be traceable to the test data on file for each step in its manufacturing process.

I. The Authority shall have the right to make such inspection and tests as required to determine if the cable meets the requirements of this Specification.

1. The Authority shall reserve the right to reject cable that is defective in any respect.

2. The Authority shall be given 10 days advance notice of the date the cable will be ready for final testing so that the Authority may witness the tests.

3. Physical tests shall be made on samples selected at random at the place of production.

4. Each test sample shall be taken from the accessible end of different reels.

5. Each reel selected and the corresponding sample shall be identified.

6. The number and lengths of samples shall be as specified under the individual tests.

7. All applicable tests for cable materials and cable construction specified shall be performed.

8. Manufacturer shall provide, at the point of production, apparatus and labor for making any or all of the following tests under the supervision of the Authority’s inspector, to include:

   a. Conductor size and physical characteristics.

   b. Insulation HV and IR tests.

   c. Physical dimension tests.

   d. Special tests on materials in coverings.

   e. Final HV, IR, and conductor resistance tests on shipping reels.

1) Certified electrical and physical test reports shall be provided for the finished multiple conductor cables no later than time of shipment.

2) Each test document shall, in addition to test results, indicate the date tests were performed and signature of manufacturer’s authorized representative.

3) The Authority reserves the right to perform any and all additional tests as the Authority shall deem pertinent to further satisfy the Authority that the cable is manufactured in accordance with all Specification requirements.

4) Contractor shall provide all required test samples as directed by the Authority at no additional cost to the Authority.
1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Cable Shipping and Handling shall be as follows:

1. All cable shall be shipped on reels, adequately protected from damage in shipment by heavy wrapping or wood lagging; to include the hazard of reels moving obliquely against each other.

2. Manufacturer shall be responsible for any change in the shape of the cable occurring in transit, which results in an increase in the maximum diameter beyond that specified.

3. External protective wrapping on reels shall be secured by at least 2 steel bands to insure damage free shipment.

4. Each length of cable shall be wound on a separate reel. Reels shall be substantial to withstand handling and be so designed that the inner end of the cable will be secured and accessible but protected from injury.

5. If the inner end of the cable projects through the flange of the reel, the inner end shall be protected by a suitable cover of metal having rounded ends and sides and securely fastened in place to protect the cable end. Both ends of cable on reel will be secured in place, to prevent their becoming loose in transit or handling of reel.

6. Reel drum diameter shall be at least 14 times the cable diameter to prevent damage to the cable during reeling operations. The arbor hole shall admit a spindle 2 1/2 inches in diameter without binding. The reels shall be designated and constructed as non-returnable when drum size and cable weight and volume permit. Maximum width of reel shall not exceed 48 inches unless otherwise specified.

7. After passing factory tests, cable shall be effectively sealed against entrance of moisture. Both ends of each length of cable shall be protected by heat shrink end caps or other suitable means that has Authority approval. Use of friction tape, other than as external mechanical protection over an adequate rubber and/or plastic tape, will not be accepted. Cable end protection will be adequate to protect the cable in shipment and prolonged external storage in the weather without regard to the position of the reel while so stored.

8. Cable shall be closely and tightly wound, in a uniform manner, in each layer on reels.

9. An arrow shall be painted on one head of each reel pointing the opposite direction from the outer end of the cable with the words "Roll This Way" employing letters not less than 3/4 inch height and an arrow not less than 6 inches in length and 1/2 inch in width.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Maintenance Materials: Contractor shall furnish 1,000 feet of each type of wire and cable used on this contract.

B. General requirements for signal cable provided under this Specification shall be as follows:

1. Material and workmanship shall be of the highest quality assuring durability for minimum life expectancy of 40 years. Single conductors and the individual conductors of multi-conductor signal cables shall be suitable for use in the environment to be encountered on a rail transit signal system and certified for continuous operation at 194 degrees F in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than 1 megohm per 1000 feet for the insulation resistance constant.

2. Multi-conductor main cable containing more than 2 conductors shall contain 20 percent spare conductors or 2 spare conductors, whichever is greater. Local distribution cable shall contain 10 percent spare conductors or 1 spare conductor whichever is greater. Two conductor cables will not require spare conductors.

3. Contractor shall provide and install signal cables in tunnel area with low smoke and low toxicity.

C. Material Requirements. Conductors shall satisfy the following:

1. Material: Soft Annealed Copper ASTM B3

2. Coating: Continuous tin, ASTM B33

3. Resistance: ICEA S-19-81, Section 2.6

4. Stranding: Class B ASTM B8

5. The conductor shall be free of longitudinal or lateral nicks or scratches and be uniform in gauge.

D. Single and multi-conductor cable jackets shall identify the cable using durable markings with the following data where markings are written in contrasting ink and repeated every 3 feet as follows:

1. Manufacturers Name (A) (B)/C (C) AWG CU Insulation Type (EP) (D) volts (Year of Manufacture); where
2. (A) = Manufacturers Plant Number
3. (B) = Number of Conductors
4. (C) = Conductor Size
5. (D) = Voltage Rating
6. The Multiple conductor cables shall have the marker tape so located as to be readily identified.

E. Requirements for low smoke signal cable provided under this Specification shall be as follows:

1. Insulation material shall be Ethylene Propylene Rubber (EPR) and have moisture and heat resistance characteristics suitable for operation at 194 degrees F continuously, 266 degrees F emergency overload for standard prescribed periods, and 482 degrees F for short circuits.
2. Substances that are injurious to the conductor or insulation shall be tested in accordance with the latest revision of ASTM D470 and Table B-III.
3. Insulation shall be properly vulcanized, homogeneous in character, tough, elastic and applied concentrically about the conductor and shall fit tightly thereto; the insulating compound shall be clean and free stripping, leaving the coated conductor, upon stripping, unimpaired and ready for soldering.
4. Insulation thickness shall be in accordance with Table A-I and Table A-II.
5. Average insulation thickness shall be no less than the specified thickness. The thickness at any point shall not be less than 90 percent of that specified.
6. Insulated conductors intended for assembly into multi-conductor cables shall be imprinted with the conductor identification at intervals of not more than 6 inches. The identification shall be in the form of numbers (both number and work number, i.e., "1-one") per ICEA S-58-679 Method 4.
7. Printed legend shall be duplicated on opposite sides of each conductor. A tracer wire is required in each layer per ICEA S-58-679 Method 6.
8. Smoke generation values also apply to the EPR insulation. All smoke tests are in 3-inch by 3-inch square slabs of material having a thickness of 100 mils.
9. Each length of conductor, insulated with prime insulation, prior to application of any outer jacket and prior to cabling or twisting, shall be randomly wound on spools and immersed in water for 24 hours, then subjected to the AC test voltages given in Tables A-I or A-II for 5 minutes, without showing signs of puncture, overheating, or self-healing of punctures. Voltage to be applied between conductor and water (ground).
10. Immediately after the AC test specified above and while still submerged, an insulation resistance test shall be made on each length of conductor. The insulation resistance constant shall not be less than 35,000 megohms per 1000 feet when corrected to 60 degrees F.
11. The DC test may be done either following an insulation resistance test or at least 8 hours prior to the AC test, providing the insulated conductor has been continuously immersed for a period not less than 16 hours prior to the DC voltage application. Each length of insulated conductor, while submerged, shall withstand, without failure, the high voltage DC test for 5 minutes at the potentials given in Tables A-I and A-II.
12. Single Conductor Cables shall be in accordance with attached Table A-1.
13. The test voltages for Tandem Extruded insulation and jacket for single conductor wire are as found in Table A-1, Modified.
14. Individual insulated conductors not intended for assembly into multi-conductor cables shall be covered with a low smoke cross-linked polyolefin compound sheath in accordance with the properties in Table A-IV. Testing of single conductors shall be done on finished composite of insulation and jacket, per Table A-I. The average thickness of sheath compound shall be not less than the value specified for single conductors in Table A-III.
15. The sheath of single conductor cables shall be surface painted with a legend identifying the manufacturer, year of manufacture, conductor size and voltage rating in contrasting ink; durable surface colors are required.
16. Multiple conductor cables shall be made by assembling individually insulated, printed conductors into a tight cylindrical form. Individual conductors in a cable having 2 or...
more conductors shall be assembled helically and with adjacent layers wound in opposite directions.

17. When fillers are required to make the cable round, they shall be non-hygroscopic and flame retardant.

18. Cable tape shall be applied around the cable core of multiple conductor cables and be non-hygroscopic and flame retardant.

19. Cable tape shall conform to Section 4.4 of ICEA, except that compound-filled tape shall be treated on both sides and thoroughly filled with a rubber compound.

20. A continuous tubular outer sheath of high tensile strength moisture and flame-resistant properly cured base product of low smoke cross-linked polyolefin compound shall be tightly formed around the insulated conductor(s) to provide protection against mechanical damage and the entrance of moisture, earth acids and alkalis into the cable.

   a. The sheath shall not adhere to the insulated conductors of multiple conductor cables and shall conform to Table A-IV.
   b. The sheath shall be applied by the continuous tube method, without joints and be properly cured to meet test requirements
   c. Average sheath compound thickness for single conductor and multi-conductor cables shall be not less than values specified in Table A-III.

21. In addition, low smoke, thermoset jacket, when tested at a thickness of 100 mils for smoke generation, shall not exceed the values in Table A-IV. Low smoke thermoplastic jacket shall not exceed the values in Table A-IV Modified.

22. Where colored tapes are called for, the colors shall be clear, durable and of easily distinguishable shades; and have no harmful effect on any part of the cable.

23. The maximum outside diameter or finished wire and cable shall not exceed the nominal outside diameter by more than the following tolerances:

   a. Nominal Diameter (Inch) 0 to 0.600: Tolerance shall be 0.030 Inch
   b. Nominal Diameter (Inch) 0.601 to 2.000: Tolerance shall be 5.0 percent

24. Each completed multi-conductor cable, when on the shipping reel, shall be subjected to and successfully pass twice the AC test voltage levels given in Table A-II for 1 minute as applicable. This voltage to be applied to each conductor against all others grounded, or between conductors utilizing a midpoint grounded test transformer to assure that each conductor is tested against each adjacent conductor in its layer and conductors in adjacent layers. This required repeat application of test voltage should be done by reversing voltage combinations between layers. Cable shield, if any, shall be connected to ground. When a shielded cable is provided, voltage should not be doubled.

25. The insulation resistance test shall be made in accordance with Section 6.23 of ICEA, using a well insulated and sensitive galvanometer. When the temperature at which the cable is tested differs from 60 degrees F, the insulation resistance shall be corrected to that at 60 degrees F.

   a. The insulation resistance constant shall not be less than 35,000 megohms per 1000 feet when corrected to 60 degrees F.

26. All completed cable shall pass the IEEE 383, 70,000 BTU/Hr., Vertical Tray Flammability Test.

27. Requirements for underground signal cable provided under this Specification shall be as follows:

   a. Insulation of twisted pairs shall be polyethylene, ASTM D1248 Type I, Class C, Category 4 or 5, Grade J3 or E5 in accordance with ICEA S-61-402, Part 3. Insulation thickness shall comply with ICEA S-61-402, Part 7 Table 7-6.

   b. All single conductors shall be as follows:

      1) Insulation material shall be a vulcanized EPR. EPR shall be tested in accordance with the latest revision of ASTM D470 and Table B-III. Each individual insulated conductor shall be covered with a CSPE (chlorosulfonated polyethylene) outer jacket in accordance with Table B-I and B-II that meets the characteristics of Table B-IV.

      2) Conductor insulation shall be applied directly to the surface of the conductor and adhere tightly to that surface but be
free stripping and leave the conductor clean.

3) Organic matter or mineral substance which will in itself or in combination with other substances in the compound be injurious to the conductor or insulation shall not be used.

4) Insulation shall be applied by the continuous tube method without joints; it shall be properly vulcanized; homogeneous in character, tough, elastic and concentrically applied around the conductor. Application of subsequent CSPE sheath shall not destroy the properties of the conductor insulation, nor cause the conductor to shift or be displaced from the center of the insulation.

5) Repairs in the insulation shall be made in a workmanlike manner. The repair and all other parts affected by the Work shall be as strong and durable electrically and mechanically as the remainder of the insulation. The insulation thickness shall comply with Table B-I, Table B-II as applicable.

6) Average insulation thickness shall be not less than the specified thickness given in the required table. The thickness at any point shall not be less than 90 percent of that specified.

7) Single conductors of multi-conductor cables for underground installation shall have a composite insulation thickness consisting of EPR and CSPE per Tables B-I and B-II and AREMA Part 10.3.17, Table 1 and 2, underground Type II insulation.

28. Prior to assembly of the multi-conductor cable, individual conductors shall be tested as follows:

a. Dry "Spark" Test: The single insulated conductors shall be passed through high voltage test electrodes energized with a 10 Kilovolts, at no less than 3 KHz AC to insure detection of damaged insulation.

b. Each reel, before immersion for insulation testing will have its continuity and length checked by means of an end-to-end resistance check to an accuracy not less than three significant figures.

c. After 16 hours immersion, and while still submerged, each reel or reel length of insulated conductor shall be subjected to and withstand the DC voltage as indicated in Tables B-I and B-II as applicable, for the size conductor involved.

d. Every individual conductor, before any further assembly steps, shall be subjected to and withstand without failure for 5 minutes the AC - 60 Hertz test voltages as indicated in Tables B-I and B-II as applicable, for the size conductor involved. This test shall be made while still submerged after not less than 24 hours immersion in water.

e. After the AC Test and while the conductor is still submerged, an insulation resistance test shall be made on each length of conductor. The insulation resistance constant, "K", in the following formula, when corrected to 60 degrees F shall not be less than 35,000 Meg ohms-1000 feet where: 

\[ R = K \log_{10} \frac{D}{d} \]

29. Where used in this Specification, the term "multi-conductor signal cable" and "single conductor signal cable" shall be interpreted as meaning any cable applied in circuits, either vital or nonvital, the function of which has a direct effect upon the operation of trains or the ability of the system or subsystem to implement control upon the trains.
30. The outer jackets of completed cable shall be made of extruded black, low density, high molecular weight polyethylene of new unused Type 1, Class C, Grade E5, of ASTM D1248 with the following characteristics:

a. Melt Index: the melt index as determined by ASTM D-1238 (Condition E), on polyethylene removed from inner and outer cable jacket shall not exceed 0.4 grams per 10 minutes.

b. Tensile and Elongation: Samples of unaged polyethylene material removed from the inner and outer cable jacket shall meet the following requirement when tested in accordance with ASTM D470 having the speed of jaw separation of 20 inches per minute;

c. Tensile Strength: Minimum 1700 psi

d. Elongation: Samples of unaged polyethylene material removed from the inner and outer cable jacket shall meet the following requirement when tested in accordance with ASTM D470 having the speed of jaw separation of 20 inches per minute.

e. Elongation at rupture, minimum 400 percent.

f. After an air oven test at 212 degrees F within plus or minus 1.8 degrees F for 48 hours.

g. Tensile Strength and elongation at rupture shall have 85 percent of unaged values.

h. Impact: A polyethylene jacketed cable specimen of approximately 15 inches in length is secured across the bottom of a tube 1-1/4 inches in diameter. This assembly is placed on a firm surface in a cold chamber at a temperature of negative 49 degrees F within plus or minus 1.8 degrees F, for 4 hours after which a weight is released at the top of the tube. The length of the tube and the weight used shall be such that a 3-pound/foot force is delivered to the jacketed specimen. The weight shall be a cylinder 1 inch in diameter with a flat striking face. The cable shall show no cracks after impact.

i. Environmental Stress Cracking - Test specimens die cut from the polyethylene jacket, both inner and outer shall be subjected to an environmental stress cracking test as described in ASTM D1693, except that the depth of the controlled imperfection shall be proportional to the jacket thickness.

31. Multi-conductor cable assembly shall be per ICEA S-73-532, Part 5, unless otherwise specified herein.

a. Multi-conductor underground cable shall be made by assembling individual and twisted pairs of insulated conductors into a tight cylindrical form.

b. Individual and twisted pair conductors in a cable having more than 2 conductors shall be assembled helically and with adjacent layers wound in opposite directions.

c. Twisted pairs, where required, shall consist of 2 individually insulated conductors cabled with a length of lay as short as good construction will permit, but not longer than 10 inches. Where more than 1 twisted pair is included, the length of lay of adjacent pairs shall differ by at least 1/2 inch.

d. The average mutual capacitance of all twisted pairs in any reel shall be 0.083 mfd. per mile within the limits specified by ICEA S-56-434, Part A, Section 16.

e. The output-to-output, far end cross-talk loss of twisted pairs shall comply with the provisions and tolerances of ICEA S-56-434, Part A, Section 17.

f. Twisted pairs, when provided, shall be located in the center of the cable and individual conductors arranged concentrically about the core thus formed.

g. Interstices shall be filled with material compatible with the insulation.

h. A moisture resistant marker tape printed with the name of cable manufacturer and the year in which the cable was manufactured, displayed at intervals of not more than 12 inches, shall be placed within the core. The marker tape shall also be printed with a numerical sequence of numbers at 1-foot intervals, to facilitate determination of cable length and/or cable remaining on reel. The material employed for tape, and the application of tape, shall be such that with use of number sequence at...
no time will a cable be shorter than the length indicated by the tape and cable will not exceed 1/2 of 1 percent actual length when cut in accordance with tape markings.

i. A shock-absorbing layer of moisture-proof elastomeric compound with a thickness of 45 mils shall be applied over the cable core.

j. A 10 mil flat bronze tape shall be helically wrapped and overlapped over this inner jacket so that at least 20 percent overlap is obtained. A 7 mil copper alloy tape C-19400 per ASTM B465 shall be acceptable.

k. An overall outer jacket shall be extruded over the bronze tape. The outer jacket shall be made of extruded black, low density, high molecular weight polyethylene conforming to new unused Type I, Class C, Category 4 or 5, Grade J3 or E5 of ASTM D1248 with thickness in accordance with Table B-VI as applicable.

Calculated Core Average
Inner Diameter, Inches Polyethylene Jacket Thickness
0.0 to 0.425 0.078 inches
0.426 to 0.700 0.094 inches
0.701 to 1.050 0.109 inches
1.051 to 1.500 0.125 inches
1.501 to 2.000 0.156 inches
2.001 to 3.000 0.188 inches
3.000 and larger 0.218 inches

32. In addition to the internal sequential marker tape, cables shall have the following cable identification and conductor marking information imprinted on the surface of the outer jacket at intervals of not more than 3 feet:

a. Manufacturer's Name
b. Number of Conductors
c. Conductor Size
d. Voltage Rating
e. Each conductor shall have its conductor number clearly marked on it per ICEA S-58-679 Method 4.
f. Each conductor shall have a tracer wire in each layer per ICEA S-58-679 Method 6.

g. Each completed multi-conductor cable shall be tested for conductor resistance. Voltage tests shall be performed between each conductor and every other conductor in the cable. Test voltage shall be AC and double the values shown for Alternate B as shown in Tables B-I or B-II, as applicable.

F. Contractor shall be responsible for sizing of all conductors and cable makeup. The cable consists and conductor sizes described herein and shown on the Contract Drawings specify the minimum that will be accepted. Contractor shall calculate all voltage drops and losses for each installation to ensure that the system will operate within accepted limits.

1. Low smoke type cable is required in tunnels.

G. Contractor shall provide track circuit connections for installation between instrument housings and the track riser as follows:

1. Cables shall be 2 individual twisted single-conductors, No. 6 AWG factory twisted together with at least three twists per foot.

2. Cable provided for installation between the track riser and web of rail shall be 2, single-conductor No. 6 AWG jacketed cables.

3. The cable shall be marked or color-coded to indicate the polarity of the track circuit connection.

4. Unless otherwise Authority approved color-coding shall be black and red to indicate instantaneous reference polarity, negative and positive, respectively.

5. Cable provided for installation between the impedance bond terminal lug and rails and between impedance bond neutrals shall be 535 KCMil 600 Volt Diesel Electric Locomotive and Car Wire with insulation thickness of 7/64". Cable shall have 194 degrees F continuous rating, 257 degrees F emergency overload rating and 482 degrees F short circuit rating.

H. Cable provided for installation between instrument housings and junction box or for each color light signal head shall be a 5 conductor, No. 14 AWG.

I. Cable provided for electric switch-and-lock movement installation between instrument housings and the switch junction box shall be a combination cable consisting of three No. 6 AWG and 12 No. 14 AWG conductors.

J. Cable provided for circuit controllers installation between instrument housings and circuit controllers, not associated with electric locks, shall be a 7 conductor, No. 14 AWG.
K. Cable provided for electric lock installation between instrument housings and electric lock junction boxes shall be a 12 conductor, No. 14 AWG.

L. Cable provided for train stop installation between junction box and train stop shall be a 2 conductor No. 6 AWG.

M. Underground express signal cable, or trough installed express cable provided for installation along the right of way shall be 7, 12, 19, 27, or 37 conductor, No. 14 AWG cables, or a combination thereof to provide the required spare conductors, as specified by these Specifications and support the functions of the system.

N. Cable provided and installed for other applications as indicated on the Contract Drawings shall be sized for requirements of the Contractor’s final design, i.e., interface with traffic signal controller and yard switch machine.

O. Fiber Optic Cable used for VMIS serial communication between locations shall satisfy Standard Specification Section 16845, “Fiber Optic Cable Subsystem - Communications System,”

**PART 3 - EXECUTION**

3.1 INSTALLATION

A. Contractor shall install 2 principal cable classes: Main Cable and Local Distribution Cable.

1. Main cables are defined as those cables that run between housings or those cables containing conductors for more than one system function.

2. Local distribution cables are defined as those cables that run between a housing and an individual equipment unit.

B. Splices: Contractor shall make no splices in any vital or nonvital signal cable.

C. Installation of wire and cable shall conform to Part 10.4.1 of the AREMA Manual, except as modified herein.

D. Contractor shall give the Authority 24 hours notice prior to installing cables.

E. Contractor shall provide sufficient slack in cable conductors at all terminating posts to enable three re-terminations of the conductor due to broken eyelets without re-servicing or re-dressing the cable.

F. In certain types of installation, the cable cannot be constrained; therefore, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

G. Cables shall not be bent to a radius less than 10 times the diameter of the cable during installation or as finally installed.

H. All signal cable runs shall be continuous without splices between cable terminating locations.

I. Tags to identify cables shall be of plastic material. Tags shall be lettered to correspond with the cable destination and number of conductors in the cable. The type of tag to be used shall be in accordance with these Specifications.

J. All cables shall be terminated in conductor order. Individual cable conductors shall be identified at each cable termination with plastic tags as specified in these Specifications. All spare conductors in each cable shall be terminated and identified.

K. All cable entrance openings in equipment enclosures and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, or ductbank. All spare conduits shall be sealed or plugged in an approved manner.

L. A suitable lubricating medium, noninjurious to the cable insulation, shall be used when pulling cables into conduit, or ductbank.

M. Where cable transfers from trays or troughs to conduit the ends of the conduit shall be fitted with plastic end bells to prevent damage to cable.

N. Wherever multiple conductor cables are terminated the outer sheath of the cable shall be carefully removed so insulation is not nicked to the point of cable entrance. At the end of cable sheath or covering, 2 layers of plastic electrical tape shall be applied.

O. Outdoor Locations Underground Buried Installation

1. Cable shall be buried to a uniform depth of 30 inches below the bottom of tie or 42 inches from top of rail when passing under tracks, whichever is deeper. Cable shall be laid loosely in trench with a sand bed and backfill in accordance with the requirements of this Specification.

2. Upon request, and only under extreme circumstances and because of installation hardship will installation of a cable be allowed to a depth of less than 30 inches, subject to the Authority’s approval. The cable shall be protected in a manner that has Authority approval.

3. Restoration of backfill and ballast shall be in accordance with the requirements of this Specification.
4. Should any signal cable pass under pavement or roadway, if existing conduit is not provided, cable shall be installed in a 4 inch galvanized rigid steel conduit, protected with bushings on each end. Conduit shall extend 2 feet beyond the edges of the pavement. It shall be the Contractor's responsibility to restore the pavement or roadway to its original condition, subject to the Authority approval. Polyvinyl Chloride Pipe (PVC) coated galvanized rigid steel (GRS) conduit shall be used at points 4 feet below grade to 2 feet above grade.

5. Where cable leaves the ground at other than buildings or in foundations, it shall be protected by a bootleg or other covering extending above the ground line. Top of such protective coverings shall be filled with a sealing compound.

6. Where buried cables enter a concrete foundation, junction box, or a case, a 5 foot slack coil in each cable shall be left in a trench below the foundation or pedestal. Cable marker tape shall be installed over the slack coil. Slack coils shall not be used for cables carrying solid state audio track circuit frequencies.

7. Cable carrying 480 or more volts shall not be installed in the same trench or conduit as signal or communication cable, except as otherwise provided for, herein.

8. Should signal or track cables be installed in the same trench, or required to intersect, with cable carrying 480 or more volts, due to installation hardships, these cables shall be installed so that the distance between such cable and the 480 Volts cable will not be less than 12 inches, while maintaining the depth of not less than 30 inches for the cable. The 12 inches between any intersecting direct burial cables of different voltages as specified herein shall be filled with sand to a distance of 2 feet from each cable from the point of intersection.

9. Contractor shall install polyethylene cable marking tape at a depth of approximately 12 inches below final grade while backfilling each cable trench. Tape shall be as specified in these Specifications.

10. Dressing of buried cables shall be applied whenever cable is terminated in signal equipment and such termination is within 2 feet of the grade level. Neoprene end seal pothead shall be installed in accordance with the manufacturer's instructions.

P. Ductbank Installation

1. Prior to cable installation, the Contractor shall ensure that each conduit to be used in the ductbank has been blown or swabbed dry, rodded and successfully mandrelled.

2. Cables shall be placed in the lowest available duct. All cables to be placed in 1 duct shall be installed simultaneously. Extreme care shall be used in installing cables so as to avoid twisting, kinking, or in any way injuring the cable or its sheath.

3. When pulling cable, an approved wire cable grip extending not less than 18 inches back from the end of cable shall be used and the clutch on the pulling device shall be set to slip at 50 percent of the weight per 1000 feet of cable to be pulled. Equipment used for pulling cable shall be equipped with a dynamometer that will indicate pulling force in pounds.

4. Glycerized liquid lubricant or other Authority approved lubricant shall be applied to the cable when installing cables in ducts.

5. Cable ends shall be immediately sealed until such time as terminating and protecting of the cable in manholes, cases and houses is effected.

6. All conduits entering manholes or housings shall be filled with sealing compound.

7. When required, the Contractor shall pump water out of manholes and handholes before installing cables and be responsible for maintaining manholes and pull chambers in a dry condition while cables are being pulled.

8. Cable installation in conduit shall not exceed 40 percent fill per conduit, unless otherwise allowed by the Authority.

9. Cables installed in manholes shall be properly constrained and fastened to the walls of manhole in accordance with approved installation drawings.

Q. Non-Buried Installation

1. Cable installed in trays or troughs shall be laid therein and not pulled in place. Cables installed in trays and troughs shall have a minimum amount of crossover and shall not be pulled tightly around bends. Cable troughs will be equipped with dividers to separate power, signal and communication cables.

2. Cables shall not cross one another when they are pulled into a conduit and care shall be taken not to have the conductors pulled tight or kinked in conduit fittings or boxes. All cables to be installed in a conduit shall be pulled and installed simultaneously.
R. Contractor shall provide required special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. Contractor shall be responsible for replacing, at no additional cost to the Authority, any installed cable that is damaged prior to acceptance as a result of the failure to provide such special protection.

S. Contractor shall install bonding or track circuit cabling in excess of 30 feet in trough or in buried galvanized rigid steel conduit in accordance with these specifications.

3.2 FIELD TESTING

A. All installed external cable shall be field tested. Test procedures for testing of insulation resistance shall include tests to verify the following:

1. All wire and cable installed along the right-of-way and wire and cable entering or leaving wayside instrument case shall be tested after installation. Test shall ensure insulation of wires and cable and connected equipment meet the specified resistance value. A direct reading instrument, having a 0-megohm to 200-megohm scale range and a self-contained DC power supply rated 500 volts minimum to 1000 volts maximum, shall be used to measure insulation resistance. Resistance between conductors, and between the conductors and ground shall not be less than 500,000 ohms.

2. Insulation resistance of each conductor to ground and between each conductor and all other conductors in each multi-conductor cable shall be tested. Power sources, made grounds and connections to rails shall be disconnected from the circuits during testing.

3. The point used as ground shall be the most convenient ground available.

4. Insulation resistance test values shall be recorded on Authority approved Insulation Resistance Record Forms and submitted for approval.

5. Defective Cables: Any Contractor installed cable that is found to be defective during testing shall be replaced with Authority approved cable at no additional cost to the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”
### TABLE A-I

**Insulation Thickness and Test Voltages for Single Conductor Wire Prior to Sheath Application**

<table>
<thead>
<tr>
<th>Rated Circuit Voltage</th>
<th>Size of Conductor AWG</th>
<th>Insulation Thickness 64&quot; Inch</th>
<th>Test Voltages 60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>AC Volts (RMS) DC Volts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5 Minutes 5 Minutes</td>
</tr>
<tr>
<td>0-600</td>
<td>14 to 8</td>
<td>4</td>
<td>8,000</td>
</tr>
<tr>
<td>7 to 2</td>
<td>5</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>1 to 0000</td>
<td>6</td>
<td>11,000</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE A-I Modified

**Test voltage for Composite Thickness**

<table>
<thead>
<tr>
<th>Insulation Thickness Mils</th>
<th>60 Hz Ac Volts (RMS) Test Voltage</th>
<th>DC Test Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>62.5 (4/64)</td>
<td>9.5kV</td>
<td>26kV</td>
</tr>
<tr>
<td>78.0 (5/64)</td>
<td>12.0kV</td>
<td>31kV</td>
</tr>
<tr>
<td>94.0 (6/64)</td>
<td>13.0kV</td>
<td>34kV</td>
</tr>
</tbody>
</table>
## Insulation Thickness and Test Voltages for Individual Conductors of Multi-Conductor Cable

<table>
<thead>
<tr>
<th>Rated Circuit Voltage</th>
<th>Size of Conductor</th>
<th>Insulation Thickness 64&lt;sup&gt;th&lt;/sup&gt; Inch</th>
<th>Test Voltages 60 Hz AC Volts (RMS)</th>
<th>DC Volts 5 Minutes</th>
<th>DC Volts 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-600</td>
<td>19 to 16</td>
<td>3</td>
<td>6,000</td>
<td>18,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 to 8</td>
<td>5</td>
<td>10,000</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 to 2</td>
<td>6</td>
<td>11,000</td>
<td>33,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 to 0000</td>
<td>7</td>
<td>12,500</td>
<td>37,500</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE A-III**

<table>
<thead>
<tr>
<th>Calculated Diameter of Cable Core Inches</th>
<th>Thickness of Insulation</th>
<th>Sheath in 64&lt;sup&gt;th&lt;/sup&gt; of an inch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Conductor</td>
<td>Multiple Conductor</td>
</tr>
<tr>
<td>0 to 0.425</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>0.426 to 0.700</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>0.701 to 1.050</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>0.051 to 1.500</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>1.501 to 2.000</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>2.001 to 3.000</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>3.000 and larger</td>
<td>10</td>
<td>14</td>
</tr>
</tbody>
</table>

Note: Sheath compound minimum thickness at any point shall not be less than 80 percent of the specified thickness.
## TABLE A-IV

### GUARANTEED VALUES

#### LOW SMOKE THERMOSET JACKET

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Tensile Strength, psi</td>
<td>1600</td>
</tr>
<tr>
<td>Original Elongation, %</td>
<td>150</td>
</tr>
<tr>
<td><strong>After Oven Aging, % of Original</strong></td>
<td></td>
</tr>
<tr>
<td>T.S./Elong., 7 days @ 100° C (212° F)</td>
<td>100/75</td>
</tr>
<tr>
<td>T.S./Elong., 7 days @ 125° C (257° F)</td>
<td>75/60</td>
</tr>
<tr>
<td>T.S./Elong., 7 days @ 150° C (302° F)</td>
<td>60/60</td>
</tr>
<tr>
<td><strong>Oil Immersion, % of Orig. ASTM #2 Oil</strong></td>
<td></td>
</tr>
<tr>
<td>T.S./Elong., 22 hrs @ 125° C (257° F)</td>
<td>60/50</td>
</tr>
<tr>
<td>T.S./Elong., 4 hrs @ 70° C (158° F)</td>
<td>80/80</td>
</tr>
<tr>
<td>E.S./Elong., 18 hrs @ 121° C (249.8° F)</td>
<td>60/50</td>
</tr>
<tr>
<td><strong>Durometer Shore A, min.</strong></td>
<td>90</td>
</tr>
<tr>
<td><strong>Low temp. Flex S-19-81, Pass Deg C (Deg F)</strong></td>
<td>-40 (-40)</td>
</tr>
<tr>
<td><strong>Grav. Water, 7 days @ 70° C (158° F), mg/in</strong></td>
<td>20</td>
</tr>
<tr>
<td><strong>Oxygen Index, %, ASTM D2863</strong></td>
<td>35</td>
</tr>
<tr>
<td><strong>Tear Strength, 1 lbs./in. D-624</strong></td>
<td>35</td>
</tr>
<tr>
<td><strong>Ozone Resis. 24 hrs @ 150 PPM</strong></td>
<td>Pass</td>
</tr>
<tr>
<td><strong>Heat Distortion</strong></td>
<td></td>
</tr>
<tr>
<td>%, 1 hr. @ 100° C (212° F), 2000 gm</td>
<td>10</td>
</tr>
<tr>
<td>%, 1 hr. @ 175° C (347° F), 2000 gm</td>
<td>10</td>
</tr>
<tr>
<td><strong>Smoke Generation: Flaming Ds4</strong></td>
<td>50</td>
</tr>
<tr>
<td>Flaming Dm4</td>
<td>150</td>
</tr>
<tr>
<td>N. F. Dx</td>
<td>50</td>
</tr>
<tr>
<td>N. F. Dm</td>
<td>250</td>
</tr>
<tr>
<td><strong>Smoke Index, NES 711, max.</strong></td>
<td>20</td>
</tr>
<tr>
<td><strong>Toxicity Index, NES 713</strong></td>
<td>1.5</td>
</tr>
<tr>
<td>Acid Gas Equivalent, MIL-C-24643</td>
<td>0.1</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Fluid Resistance, 24 hrs immersion, TR/ER</strong></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Fluid 17672 @ 49° C (120.2° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Hydraulic Fluid 5606 @ 49° C (120.2° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Hydraulic Diesel Fuel @ 50° C (122° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Hydraulic Diesel Fuel @ 99° C (210.2° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Lubricating Oil 23699 @ 99° C (210.2° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Lubricating Oil 23699 @ 50° C (122° F)</td>
<td>-----</td>
</tr>
<tr>
<td>Lubricating Oil 24467 @ 50° C (122° F)</td>
<td>-----</td>
</tr>
<tr>
<td>Methanol @ 20° C (68° F)</td>
<td>-----</td>
</tr>
<tr>
<td>Methanol @ 25° C (77° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Gasoline @ 20° C (68° F)</td>
<td>-----</td>
</tr>
<tr>
<td>Gasoline @ 25° C (77° F)</td>
<td>50/50</td>
</tr>
<tr>
<td>Salt Solution 10% NzCl @ 20° C (68° F)</td>
<td>90/90</td>
</tr>
<tr>
<td><strong>Solvent Extraction - Max. Extractables of polymer ASTM D-2765-90 Method of Test</strong></td>
<td>25%</td>
</tr>
</tbody>
</table>
### TABLE B-I

Individual Conductor Composite Insulation Thickness

<table>
<thead>
<tr>
<th>Conductor Size AWG</th>
<th>Conductor Insulation</th>
<th>CSPE Sheath</th>
<th>60 Hz AC Volts (RMS) 5 Minutes</th>
<th>DC Volts 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 to 8</td>
<td>63 mils</td>
<td>15 mils</td>
<td>10,000</td>
<td>30,000</td>
</tr>
<tr>
<td>7 to 2</td>
<td>78 mils</td>
<td>30 mils</td>
<td>11,000</td>
<td>33,000</td>
</tr>
<tr>
<td>1 to 0000</td>
<td>94 mils</td>
<td>45 mils</td>
<td>12,000</td>
<td>36,000</td>
</tr>
<tr>
<td>18 to 8</td>
<td>48 mils</td>
<td>15 mils</td>
<td>9,000</td>
<td>27,000</td>
</tr>
</tbody>
</table>

### TABLE B-II

Individual Conductor Composite Insulation Thickness

<table>
<thead>
<tr>
<th>Conductor Size AWG</th>
<th>Conductor Insulation</th>
<th>CSPE Sheath</th>
<th>60 Hz AC Volts (RMS) 5 Minutes</th>
<th>DC Volts 5 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 to 2</td>
<td>141 mils</td>
<td>30 mils</td>
<td>18,000</td>
<td>54,000</td>
</tr>
<tr>
<td>7 to 2</td>
<td>126 mils</td>
<td>30 mils</td>
<td>15,000</td>
<td>45,000</td>
</tr>
</tbody>
</table>
## TABLE B-III

Vital Circuit EPR Insulation

### Physical and Electrical Characteristics

<table>
<thead>
<tr>
<th>Physical properties</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original properties:</strong></td>
<td></td>
</tr>
<tr>
<td>Tensile strength - minimum psi</td>
<td>1100</td>
</tr>
<tr>
<td>Tensile stress @200% elongation - min. psi</td>
<td>900</td>
</tr>
<tr>
<td>Elongation at rupture - min. %</td>
<td>300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Properties after accelerated aging:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Air oven test - 168 hours - 121° C (250° F)</td>
<td></td>
</tr>
<tr>
<td>Tensile strength, minimum % of original</td>
<td>90</td>
</tr>
<tr>
<td>Elongation, minimum % of original</td>
<td>85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insulation resistance constant:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Megohms per 1000 ft. @ 15.6° C (60° F) minimum</td>
<td>30,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical water absorption:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7 days - 70° C (158° F) - mg/sq.in. - maximum</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accelerated electrical stability tested in water on insulated conductors only:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>80 volts/mil measurement stress 60 cycles - 90° C (194° F)</td>
<td></td>
</tr>
<tr>
<td>Dielectric constant - 1 day immersion – maximum</td>
<td>3.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Increase in dielectric constant:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 14 days - % maximum</td>
<td>3.0</td>
</tr>
<tr>
<td>7 – 14 days - % maximum</td>
<td>1.5</td>
</tr>
<tr>
<td>1 – 90 days - % maximum (1)</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Power Factor

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14 days - maximum %</td>
<td>1.0</td>
</tr>
<tr>
<td>90 days - maximum % (1)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accelerated insulation resistance stability test on insulated conductors only:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>@ 90° C (194° F) Megohms - 1000 ft.</td>
<td></td>
</tr>
<tr>
<td>1 day immersion – minimum</td>
<td>1000</td>
</tr>
<tr>
<td>90 days immersion - minimum (1)</td>
<td>1000</td>
</tr>
</tbody>
</table>
Accelerated voltage stability test (1):

A single conductor No. 14 AWG or larger size with 80 mils or thicker insulation wall, shall have at least 10 feet immersed in water at room temperature. The insulated conductor, without any coverings over the insulation, shall be continuously energized as follows:

<table>
<thead>
<tr>
<th>AC Voltage V/Mil</th>
<th>Time Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>325</td>
<td>2 or</td>
</tr>
<tr>
<td>280</td>
<td>3 or</td>
</tr>
<tr>
<td>240</td>
<td>4 or</td>
</tr>
<tr>
<td>200</td>
<td>6</td>
</tr>
</tbody>
</table>

No insulation failure shall occur within the test period.

Note: Smoke generation values also apply to the EPR insulation. All smoke tests are in 3 inch x 3 inch square slabs of material having a thickness of 100 mils.
### TABLE B-IV

Physical characteristics of the CSPE jacket

When tested in accordance with ICEA S-73-532, Part 4.2.f, the conductor jacket shall meet the following guaranteed values:

<table>
<thead>
<tr>
<th>Physical Requirements - Unaged: (ASTM die C)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, psi, minimum</td>
<td>1800</td>
</tr>
<tr>
<td>Tensile Stress @ 200% Elongation, min. psi</td>
<td>500</td>
</tr>
<tr>
<td>Elongation, % minimum</td>
<td>300</td>
</tr>
<tr>
<td>Set, maximum, %</td>
<td>30</td>
</tr>
</tbody>
</table>

Aging Requirements: Air Oven Test at 100° C (212° F), for 168 hrs.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, % of unaged value, min.</td>
<td>85</td>
</tr>
<tr>
<td>Elongation, % of unaged value, minimum</td>
<td>65</td>
</tr>
</tbody>
</table>

Oil Immersion Requirements in ASTM #2 Oil at 121° C (250° F), for 18 hours

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength, % of unaged value, min.</td>
<td>60</td>
</tr>
<tr>
<td>Elongation, % of unaged value, minimum</td>
<td>60</td>
</tr>
</tbody>
</table>

Heat Distortion

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>After 4 hours in Air Oven at 121° C (250° F), % max</td>
<td>15</td>
</tr>
</tbody>
</table>

Ozone Resistance

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>After 24 hours in 150 ppm Ozone</td>
<td>No Cracks</td>
</tr>
</tbody>
</table>

Cold Bend

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>After 24 hours @ -25° C (77° F)</td>
<td>No Cracks</td>
</tr>
</tbody>
</table>

Flame Resistance

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ICEA Vertical Tray Test on Insulated Single Conductors</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Moisture Absorption

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravimetric Method, 7 days @ 70° C (158° F), mg/sq.in</td>
<td>30</td>
</tr>
</tbody>
</table>

Specific Surface Resistance

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Megohms</td>
<td>200,000</td>
</tr>
</tbody>
</table>
ATTACHMENT A

Name of Company

ENGINEERING REPORT

INTRODUCTION

Certain railroad specifications call for rather specific qualification tests on the insulation. These tests involve long-term voltage aging, moisture resistance and thermal aging. __________________________ insulation used in railroad signal cable was tested according to these qualifications. Standard factory production cables were used as samples.

SUMMARY & CONCLUSIONS

_________________________ insulation tested in accord with the procedures below meets the requirements of the railroad specifications.
**DETAILS**

**Thermal Aging** - The specification reads as follows: “The insulation shall be tested in a circulating air oven on 80 mil thick slabs and shall have an elongation not less than 50 percent after a minimum aging time of 25 hours of 136°C and 100 hours at 121°C”. The insulation tested as above gave the following results:

- Elongation at Break - Initial: _______________%
- Elongation after 25 hours @ 136°C: _______________%
- Elongation after 100 hours @ 121°C: _______________%

**Moisture Resistance:** The specification reads: “A single conductor No. 14 AWG or larger size with 80 mils or thicker insulation wall, shall have at least 10 feet immersed in water at room temperature. The insulation conductor without any coverings over the insulation shall be continuously energized as follows:

<table>
<thead>
<tr>
<th>DC Voltage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/Mil</td>
<td></td>
</tr>
<tr>
<td>325</td>
<td>2 months, or</td>
</tr>
<tr>
<td>280</td>
<td>3 months, or</td>
</tr>
<tr>
<td>240</td>
<td>4 months, or</td>
</tr>
<tr>
<td>200</td>
<td>6 months,</td>
</tr>
</tbody>
</table>
No insulation failure shall occur within the test period. The bare ___________________ insulation 80 mils thick on a ________________ tinned copper conductor of ___________________ length was placed in tap water at room temperature for _______________ months at a stress of ___________________ v/mil. No failure occurred during the test period.

Voltage Aging

The dielectric strength stability shall have been demonstrated by voltage aging, a test sample of a single conductor No. 14 AWG or larger size wire with 80-mil or thicker insulation, shielded with the shield grounded. The cable shall be tested in free air with a minimum of 10 feet between terminals. One of the following voltage stresses shall have been applied to voltage age the sample.

<table>
<thead>
<tr>
<th>Test Voltage</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 - Hz AC</td>
<td>Time</td>
</tr>
</tbody>
</table>

Table I

<table>
<thead>
<tr>
<th>Voltage/Mils</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>490</td>
<td>for 6 months, or</td>
</tr>
<tr>
<td>315</td>
<td>for 1 year, or</td>
</tr>
<tr>
<td>225</td>
<td>for 2 years, or</td>
</tr>
<tr>
<td>180</td>
<td>for 3 years, or</td>
</tr>
<tr>
<td>135</td>
<td>for 5 years</td>
</tr>
</tbody>
</table>

No insulation failure shall occur within the test period. The shielded _______________ insulation 80 mils thick on a ________________ tinned copper conductor of ___________________ length was placed in free air at room temperature for _______________ months at a stress of ___________________ V/mil time for a duration of ___________________. No failure occurred during the test period.
QUALITY ASSURANCE FORM

This statement will certify that ____________________________________________

(Name of Company)

will manufacture and test the cable under the control of a quality assurance program which meets the requirements of Section 10CFR50, Appendix 8, of the Federal Register and ANSI N45.2.

________________________________________

Inquiry No.

________________________________________

Notary                                                                   Cable Co. Representative

END OF SECTION 16908
PART 1 - GENERAL

1.1 DESCRIPTION
A. Work to be performed under this Section consists of designing, providing and installing power cable for the Alternating Current (AC) signal power distribution system, auxiliary power supply and other AC power wayside applications as described herein.

B. Material and workmanship shall be of the highest quality assuring durability for minimum life expectancy of 40 years. Cables shall be suitable for use in the environment to be encountered on a transit or railroad signal system. Cables shall be certified for continuous operation at 90 degree Celsius (C) (194 degrees Fahrenheit (F)) in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than 1 meg-ohm per 1,000 feet.

1.2 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance-of-Way Association (AREMA)
B. American Society for Quality (ASQ)
    1. ASQ Q9001 - Quality Management Systems - Requirements
C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
    1. ASTM D257 - Standard Test Methods for DC Resistance or Conductance of Insulating Materials
    2. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire
    3. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
D. Insulated Cable Engineering Association (ICEA)
    1. ICEA S-95-658 – Non-shielded Power Cables rated 2000 Volts or less for Distribution of Electrical Energy
    2. ICEA S-105-692 - 600 V Single Layer Thermoset Insulated Utility Underground Distribution Cable
    3. ICEA S-81-570 - Direct Burial, 600 Volt Ruggedized Insulation
E. National Electrical Manufacturers Association (NEMA)
    1. NEMA WC 70 – Non-shielded Power Cables rated 2000 Volts or less for Distribution of Electrical Energy
    2. NEMA 6.4 – Test Samples and Specimens for Physical and Aging Tests
    3. NEMA 6.6 – Accelerated Water Absorption Tests
    4. NEMA 6.11 – Tests for Discharge Resistance
    5. NEMA 6.12 – Volume Resistivity
    6. NEMA 6.14 – Voltage Tests
    7. NEMA 6.15 – Insulation Resistance
F. National Fire Protection Association (NFPA)
    1. NFPA 70 - National Electrical Code (NEC)
G. Underwriters Laboratory (UL)
    1. UL 224 – UL Standard for Safety Extruded Insulating Tubing

1.3 SUBMITTALS
A. The Contractor shall submit the following for Authority approval:
    1. List of each cable manufacturer's railway/transit installations.
    2. Each cable manufacturer's Quality Assurance Program.
    3. Full technical data for each type of cable.
    4. Four foot samples of each type of cable proposed. Each sample shall include at least two identification markings as described in Paragraph 2.2.C.
B. The Contractor shall submit for approval:
    1. Projected loads and voltage drop calculations.
    2. Cable manufacturer's instructions and procedures for potheading of each type underground cable to be provided.
C. As required herein, the Contractor shall submit certified copies of the following for Authority approval.
    1. Cable test reports for all demonstration tests required by the Authority.
    2. Cable test and inspection reports for tests and inspections required and described by these Specifications.
    3. Test reports of cable tests conducted in the field in accordance with Authority approved testing procedures.
4. Certification that each cable provided complies with requirements of these Specifications.

5. Information to be provided by certified cable test reports shall include the following:
   a. Report Number
   b. Date and location of test.
   c. Description of test and test conditions.
   d. Complete cable description.
   e. Lot, batch, or reel identification number.
   f. Quantitative Test Results
   g. Summary of the test results.
   h. Information on the components of the cable tested to include batch numbers and physical and electrical properties.
   i. The manufacturer shall provide not less than six copies of instructions for splicing. The instructions shall be forwarded with certified test results for each reel of cable. The instructions shall specify exact nature of splicing materials to be employed and manner they are to be spliced.

D. The Contractor shall submit for approval detail plans of cable duct, cable trough and conduit installations showing all hardware to be used, methods of attachment, cable routing through manholes, hand holes, and fill.

1.4 QUALITY ASSURANCE

A. Pre-Qualifications

1. All cable manufacturers providing cable for this Contract shall be pre-qualified by the Authority. The Contractor shall provide all data required for the Authority's evaluation and make all arrangements for required demonstrations and tests.

2. Qualifications shall be based on the following criteria:
   a. Past Performance and Experience. Cable manufacturer(s) shall demonstrate previous successful experience in providing cable to the railroad/transit industry for use as AC power cables.
   b. References identifying past performances to the railroad/transit industry for signal power distribution systems are required. A list of such installation with a minimum 15 years successful operation shall be provided. The list shall contain a minimum of three installations and the name, telephone number and title of the company official to be contracted.
   c. Quality Assurance Program. The manufacture of cables, in accordance with the requirements of these Specifications, shall be accomplished in compliance with a Quality Assurance Program that meets the requirements of American Society for Quality (ASQ) Q9001 Quality Management Systems - Requirements. Such compliance shall promote a thoroughly tested cable that shall render long service life to the user. Prime concern shall be focused on the required formal assurance requirements to insure that cable failure cannot be attributed to actions or lack of actions by the manufacturer. The Contractor shall submit a notarized copy of the Engineering Report, Attachment A to this Section, and a notarized copy of the Quality Assurance Program Form, Attachment B to this Specification.
   d. Technical Data. The Contractor shall provide full technical data that demonstrates compliance with the requirements of these Specifications for each specified cable type the Contractor plans to provide.
   e. Manufacturer shall certify that he shall comply with the following warranty prior to selection:

1) Manufacturer warrants that design, material, and workmanship incorporated in each item of cable shall be of the highest grade and consistent with established, and generally accepted, standards for aerial and underground cable for railroad/transit AC power circuits; and each item of cables and every part and component comply with these Specifications.

2) The manufacturer agrees that this warranty shall commence with the acceptance of each item of the cable, whether the defect be patent or latent, and continue for a period of 40 years after initial satisfactory operation of the item.
3) Warranty covering any length of defective cable shall be replaced by the manufacturer under the above conditions and be reinstated for a period of 40 years. If the failure is found to be of major importance and affects any other item of cable, the reinstatement of the warranty shall then be extended to cover the item so affected as well and will start as of the date of such replacement. The warranty reinstatement provided for in this paragraph 3. shall apply only to the first replacement or repair of any such item and, in the case of failure of major importance, to the first extension of said warranty.

f. Foregoing warranties are exclusive and in lieu of all other warranties written, oral, implied, or statutory (except as to title and freedom from lien).

g. The Contractor shall verify by written guarantee, signed by an officer of that company, that the cables to be provided meets or exceeds the qualifications of the Specification.

B. After Selection

1. The Contractor shall monitor the cable manufacturer to assure Authority approved Quality Assurance Program is being closely adhered to and the cables are being manufactured in accordance with these Specifications and the Authority approved submittals.

2. Each finished cable shall be traceable to the test date on file for each step in its manufacturing process.

3. Inspection:

a. The Authority shall have the right to make such inspection and tests as required to determine if the cable meets the requirements of these Specifications. Inspector for the Authority shall have the right to reject cable, which is defective in any respect.

b. The Authority shall be given 10 days advance notice of final cable testing date so that the Authority may witness the tests.

c. Physical tests shall be made on samples selected at random at the place of production. Each test sample shall be taken from accessible end of different reels. Each reel selected and corresponding sample shall be identified. Number and lengths of samples shall be as specified under the individual tests. All applicable tests for the cable materials and cable construction specified shall be performed.

d. Manufacturer shall provide, at point of production, apparatus and labor for making any or all of the following tests under supervision of the Authority’s inspector, to include:

1) Conductor size and physical characteristics

2) Insulation HV and IR Tests

3) Physical Dimension Tests

4) Special tests on materials in coverings.

5) Final HV, IR, and conductor resistance tests on shipping reels.

e. Certified electrical and physical test reports shall be provided for the finished cables no later than time of shipment. Each test document shall, in addition to test results, indicate the date tests were performed and signature of the manufacturer's authorized representative.

f. The Authority reserves the right to conduct itself those tests it so elects to further satisfy itself that the cable is manufactured in accordance with requirements of these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Maintenance Materials:

1. The Contractor shall furnish one thousand feet of each type of wire and cable used on this contract.

B. AC Power Distribution Cables

1. AC power distribution cables for signal power supply, provide for utility wiring and other AC power requirements under 600 volts, shall be
Type RHH, RHW or USE, intended for use as direct burial, in raceways or aerial applications. Conductors shall be stranded copper per ASTM B-3 or B-8. Insulation shall be cross-linked polyethylene in accordance with NEMA WC 7/ ICEA S-66-524 standards.

C. Conductor Labeling
1. Conductors shall be marked indicating the manufacturer's name, conductor size, conductor material, insulation type, voltage rating and year of manufacture, repeated every 3 feet on the outside of the cable jacket.

D. Cable Connectors
1. Provide connectors for No. 8 AWG and larger of pressure indent type with nonflammable, self-extinguishing insulation of temperature rating equal to that of the cable being connected.
2. For conductors No. 8 AWG through No. 22 AWG, use low smoke, low toxic insulated compression terminals, or Authority approved equal.
3. Where insulated connectors are not required, use uninsulated terminals or Authority approved equal.
4. Terminate cable No. 6 AWG and larger using bolted, pressure-type connectors. Design connectors compatible with conductors for which they are used.
5. Provide connectors for connecting lighting fixtures to branch circuit wiring of the pre-insulated permanent pressure electrical spring connector type encased in an insulating cover.
6. Provide compression terminals for all control and instrumentation cables

E. Wye Resin Cable Splices
1. Splices in Signal Power cables shall be permitted only in electrical distribution boxes located in a signal equipment enclosure.
2. Cable splices for "T" tap cable connections shall be made using wye resin splicing kits with compression type connectors. Splice kit shall consist of a two-piece transparent mold body, tape for sealing mold ends, funnels, abrasive cloth strip and resin compound. Splices shall provide a waterproof seal for environmental protection.
3. Kits shall be factory engineered and shall accommodate any common form of cable construction without the need for special adapters. Kits shall accommodate a wide range of cable sizes and be completely independent of cable manufacturer's tolerances. Kits shall allow splicing of cables with different conductor sizes and shielded construction. Kits shall accommodate commercially available standard connectors.

F. Identification Tags
1. Description: Heat-shrinkable radiation crosslinked, thermally stabilized, flame-retarded modified polyolefin sleeves. Markers shall be recognized to UL Standard 224.
2. Sleeves tags shall be smear resistant prior to shrinking and achieve mark permanency when shrunk without need for permatalizing equipment. Sleeves shall achieve mark permanency when standard ball-point pens or high-carbon content fabric ribbons are used. The markers shall be flattened and mounted on a carrier suitable for use with typewriters or printers. Markers shall be resistant to common industrial fluids including Freon TF, isopropyl alcohol, and Ethylene Glycol.
3. Markers shall be compatible with an integrated hardware and software system allowing high speed, automated, set or batch, wire list printing. System shall allow external data to be imported from mainframe computers. System shall be compatible with panel and wraparound markers as specified in this Section.

G. Cable Application
1. Signal Power Express Cables
   a. The Contractor shall size the signal power express cables (including tap conductors) in accordance with the criteria specified herein.
2. Signal Power Branch Circuits
   a. Signal power branch circuits shall be two, single conductor No. 6 AWG, as specified herein.
3. Auxiliary Wiring
   a. Auxiliary wiring for lighting, receptacles and heating/air conditioning/ventilating combination units shall be in accordance with the NEC for the duty and service indicated. Sizes shall be adequate for 125 percent of the maximum load of indicated equipment but not less than No. 12 AWG. All wiring shall be installed in conduit. Conduit size shall also be in accordance with the NEC.
2.3 FUNCTIONAL REQUIREMENTS

A. General

1. Material and workmanship shall be of the highest quality assuring durability for minimum life expectancy of 40 years. Cables shall be suitable for use in the environment to be encountered on a transit or railroad signal system. Cables shall be certified for continuous operation at 90 degree C (194 degrees F) in wet or dry locations with no conductor failing in continuity or with loss of insulation to cross or ground less than 1 meg-ohm per 1,000 feet.

PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 DELIVERY, STORAGE AND HANDLING

A. The Contractor shall provide required special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions such as vibration or sharp corners on equipment. The Contractor shall be responsible for replacing, at no additional cost to the Authority, any cable installed which is subsequently damaged prior to acceptance as a result of failure to provide such special protection.

3.3 INSTALLATION

A. Installation of power cable shall conform to applicable sections of the NEC and the requirements as specified herein.

B. The Contractor shall give the Authority 24 hours notice prior to installing cables.

C. In certain types of installation where cable cannot be constrained, ample cable slack shall be provided for additional flexibility due to vibration of such equipment.

D. Cables shall not be bent to a radius less than eight times the diameter of cable during installation or as finally installed.

E. All cables shall be tagged at their termination points. All cables shall be tagged within Traction Power Substations (TPSS), Signal Power Distribution Center (SPDC), manholes, handholes, housings, cases and on each side of any barrier cable passes through. Cables shall also be tagged at aerial exits from conduit risers.

F. All cable entrance openings shall be sealed with a compression type fitting or pliable sealing compound after the cable is in place. Sealing compound shall be used to seal the area around cable where cable emerges from the end of a conduit. All spare conduits shall be sealed or plugged in an Authority approved manner. Cable openings within substation floors and/or walls shall be sealed with an Authority approved fire sealant.

G. Where cables leave conduits, the ends of conduit shall be fitted with end bells to prevent damage to the cable.

H. The Contractor shall arrange cables to allow free access to all existing cables for maintenance.

I. Cable connections and splices shall be made in accordance with manufacturer's instructions.

J. Installation in Conduit

1. Reels shall be stripped of all nails in outside edges of reel heads before pulling of cable. Reels shall be conveniently located for feeding cable into conduit without excessive bending or possible injury to cable by abrasion on sides of pull boxes where pull boxes are required. Reels shall be jacked to clear ground level by at least 6 inches before pulling of cable.

2. Cable reels shall be carefully handled to avoid injury to persons or cables. Movement of reels on loading skids or sloping grades shall be controlled by use of a snub line or wedge. Reels shall always be blocked after positioning.

3. Cable shall be pulled into conduits with the use of an Authority approved pulling eye. Pulling ropes shall be attached to the pulling eye with ball-bearing swivels to prevent twisting of cable during pulling.

4. Personnel shall be stationed between the reel and the conduit entrance during pulling operations to inspect, control and direct the passage of cable. Conduit mouth shall be equipped with conduit shields to prevent chafing cable.

5. During pulling operations, cables shall be lubricated with an Authority approved material in accordance with the manufacturer's recommendation.

6. Cable shall not be allowed to chafe on the ground, in manholes or handhole edges, or any sharp surfaces during pulling. Flexible cable pulling tubes shall be provided to guide and protect the cable.

7. All cut ends of cable shall have a watertight seal installed immediately after installation, until the cable is spliced or terminated.

8. Cables shall be installed with freedom of horizontal movement to accommodate expansion and contraction of cables in the conduits.
K. Splices

1. The Authority shall approve all power cable splices prior to installation by the Contractor.

2. Splices can only be made in manhole or hand hole locations. Splices in the middle of conduit or trough shall be prohibited.

3. Splices shall be indicated on the final As-built drawings and detailed on a splice location schedule, by cable size, manhole number and station location.

3.4 TESTING

A. General

1. The Contractor shall provide all instruments, materials and labor required for tests specified herein.

2. Tests conducted at the factory shall include:
   a. Manufacturer's standard tests
   b. Tests relevant to NEMA WC 7/ICEA S-66-524 standards not included in the manufacturer's standard tests. These tests include, but are not limited to:
      1) NEMA 6.4 - Test Samples and Specimens for Physical and Aging Tests
      2) NEMA 6.6 - Accelerated Water Absorption Tests
      3) NEMA 6.11 - Tests for Discharge Resistance
      4) NEMA 6.12 - Volume Resistivity
      5) NEMA 6.14 - Voltage Tests
      6) NEMA 6.15 - Insulation Resistance

3. Tests and checkouts in the field shall include:
   a. Continuity Test
   b. Insulation Resistance Test

B. Conditions for Tests

1. Prior to performing any cable testing, the following conditions shall be fulfilled by the Contractor:
   a. The Contractor shall submit cable testing procedures for the Authority's approval at least 45 days in advance of testing. No testing shall be performed unless the Contractor has obtained Authority approved test procedures.
   b. For factory tests, a four weeks advance notification shall be given to the Authority on the schedule date of tests to enable the Authority to witness the tests.
   c. Field tests shall be scheduled in consultation with the Authority.

C. Witness Tests

1. The Contractor shall ensure that the Authority has the opportunity to witness complete testing on all cable installation.

D. Field Tests

1. General. All AC power cables shall be subjected to Acceptance Tests as specified below to ascertain that the dielectric strength of cable insulation shall not impaired during installation, that connections and splices are properly made and to confirm the integrity of the cable system prior to energization. Tests shall include continuity and insulation resistance tests.

2. Acceptance Tests. Tests shall be conducted before cables are terminated at the electrical equipment. After installation of the entire length of a cable, the Contractor shall perform the tests listed below on each cable.
   a. Continuity Test
      1) This test shall be performed to prove the continuity of the conductor.
   b. Insulation Resistance Test
      1) This test shall be performed to determine cable insulation resistance to ground.
      2) Tests shall be conducted with a motor-driven megger. Test voltage shall be applied between the conductor and ground and be held until the reading reaches a constant value for five minutes. Insulation resistance values obtained by the megger tests shall not be less than two megohms. The Contractor shall advise the Authority when the results of similar tests having unequal readings with variations of 25 percent or more.
3) The Contractor shall record the temperature, humidity, and duration of each test.

3. Defective Cables
   a. Any cable installed under this Contract and found defective during testing shall be replaced with new cables at no additional cost to the Contract.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
   A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT
   A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”
ENGINEERING REPORT

INTRODUCTION

Certain railroad specifications call for rather specific qualification tests on the insulation. These tests involve long-term voltage aging, moisture resistance and thermal aging. ________________ insulation used in railroad signal cable was tested according to these qualifications. Standard factory production cables were used as samples.

SUMMARY & CONCLUSIONS

______________ insulation tested in accord with the procedures below meets the requirements of the railroad specifications.
**DETAILS**

**Thermal Aging** - The specification reads as follows: "The insulation shall be tested in a circulating air oven on 80 mil thick slabs and shall have an elongation not less than 50% after a minimum aging time of 25 hours at 136°C (276.8°F) and 100 hours at 121°C (249.8°F)". The insulation tested as above gave the following results:

- Elongation at Break - Initial: ______________________ %
- Elongation after 25 hours @ 136°C (276.8°F): ______________________ %
- Elongation after 100 hours @ 121°C (249.8°F): ______________________ %

**Moisture Resistance** - The specification reads: "A single conductor No. 14 AWG or larger size with 80 mils or thicker insulation wall, shall have at least 10 feet immersed in water at room temperature. The insulation conductor without any coverings over the insulation shall be continuously energized as follows:

<table>
<thead>
<tr>
<th>DC Voltage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/Mil</td>
<td></td>
</tr>
<tr>
<td>325</td>
<td>2 months, or</td>
</tr>
<tr>
<td>280</td>
<td>3 months, or</td>
</tr>
<tr>
<td>240</td>
<td>4 months, or</td>
</tr>
<tr>
<td>200</td>
<td>6 months,</td>
</tr>
</tbody>
</table>

DART – October 2005
No insulation failure shall occur within the test period. The bare ________________ insulation 80 mils thick on a ________________ tinned copper conductor of ________________ length was placed in tap water at room temperature for ___________ months at a stress of ________________ v/mil. No failure occurred during the test period.

**Voltage Aging**

The dielectric strength stability shall have been demonstrated by voltage aging, a test sample of a single conductor No. 14 AWG or larger size wire with 80-mil or thicker insulation, shielded with the shield grounded. The cable shall be tested in free air with a minimum of ten feet between terminals. One of the following voltage stresses shall have been applied to voltage age the sample.

<table>
<thead>
<tr>
<th>Test Voltage</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 - Hz AC</td>
<td>Age Duration</td>
</tr>
<tr>
<td>Voltage/Mils</td>
<td>Duration</td>
</tr>
<tr>
<td>490</td>
<td>for 6 months, or</td>
</tr>
<tr>
<td>315</td>
<td>for 1 year, or</td>
</tr>
<tr>
<td>225</td>
<td>for 2 years, or</td>
</tr>
<tr>
<td>180</td>
<td>for 3 years, or</td>
</tr>
<tr>
<td>135</td>
<td>for 5 years</td>
</tr>
</tbody>
</table>

No insulation failure shall occur within the test period. The shielded ________________ insulation 80 mils thick on a ________________ tinned copper conductor of ________________ length was placed in free air at room temperature for ___________ months at a stress of ________________ V/mil time for a duration of ________________.

No failure occurred during the test period.
ATTACHMENT B

QUALITY ASSURANCE FORM

This statement will certify that ____________________________________________ (Name of Company) will manufacture and test the cable under the control of a quality assurance program which meets the requirements of Section 10CFR50, Appendix 8, of the Federal Register and ANSI N45.2.

____________________________
Inquiry No. _____________________________
Notary                                                                   Cable Co. Representative

END OF SECTION 16909
PART 1 - GENERAL

1.1 DESCRIPTION
A. The Work consists of providing and installing 110 volt Direct Current (DC) dual control power switch-and-lock movement layouts for each interlocked track switch at locations as shown on the Contract Drawings. A symbol form, shown on the Contract Drawings, is used to indicate various locations where power switch-and-lock movement layouts are to be provided and installed.

1.2 REFERENCED STANDARDS
A. American Railway Engineering and Maintenance-of-Way Association (AREMA)
   1. Communications and Signals Manual of Recommended Practice (C&S Manual)

1.3 SUBMITTALS
A. Contractor shall submit for Authority approval, drawings for assembly of each type of power switch-and-lock movement layouts together with a bill-of-materials, and name and type of graphite lubricant proposed for switch tie plate lubrication.

B. Contractor shall submit installation drawings showing tie straps and mounting details of the power switch-and-lock movement layouts including connections to the track switch points. Circuit drawings shall be submitted for each switch. Typical drawings with connection charts shall not be accepted.

C. Contractor shall submit Test Procedures and Results.

D. Contractor shall provide manuals describing operation and maintenance (O&M) of power switch-and-lock movements.

1.4 QUALITY ASSURANCE
A. Power switch-and-lock movements shall meet the requirements established by AREMA C&S Manual, Part 12.2.1 and in accordance with these Specifications, where the requirements of the AREMA specification do not conflict with any requirement specified in these Specifications.

B. Each switch-and-lock movement shall be pretested before shipping. This factory testing shall be conducted in accordance with the Contractor's Factory Test Procedure for power switch-and-lock movements as approved by the Authority.

C. Contractor shall inspect each power switch-and-lock movement layout after it has been installed and correct any deficiencies noted. This inspection shall be conducted in conformance with the requirements of the Contractor's Installation Inspection Procedure as Authority approved.

D. Final operational tests of switch-and-lock movements shall be conducted as described in accordance with the requirements of these Specifications

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Prior to shipment, all parts of the layout that are not painted, or made of non-corroding material, shall be coated with an Authority approved grease to prevent corrosion. All unused threaded outlets shall be suitably plugged or capped.

B. Switch-and-lock movements and their component layout parts shall be protected against damage during handling and shipment, and be secured against loss during storage.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL
Not Used

2.2 CONTRACTOR FURNISHED MATERIALS
A. Power Switch-and-Lock Movements
   1. Power switch-and-lock movements shall be as manufactured by US&S Co., Style M-23A; or Authority approved equal. Lock rods and detector rods shall be the double adjustable type.

   2. Any proposal for an equivalent switch-and-lock movement shall be submitted in writing for Authority approval. Proposal Authority approval will be based on such evidence and tests as the Authority may require. Contractor shall bear all proposal, certification, testing, and other incidental costs and no additional cost to the Contract shall result for any such proposal.

   3. Fifteen watt internal heaters shall be provided in the contact compartment and motor compartment of each power switch-and-lock movement. Wiring for these heaters shall be terminated on the mechanism terminal board.
4. Heater type, location and mounting details shall be included as part of the drawing submittal.

5. Each power switch-and-lock movement shall be provided with an internal wiring diagram protected by a plastic laminate and fastened to the underside of the mechanism cover.

6. Wire terminal binding posts shall be numbered using stencils or other Authority approved devices.

7. Switches that include a latch-out shall be circuited so that the latch-out is activated when the switch is trailed. The latch-out shall prevent control of the switch until the latchout has been reset.

B. Rods and Hardware

1. Should the power switch-and-lock movement layouts, as submitted by the Contractor, require offsets in the track connecting rods, such offsets shall be made during manufacture of the rods.

2. Ample threaded area shall be provided on each rod to accommodate wide latitude in operating adjustments.

3. All front rods shall be of the swivel type, insulated and adjustable.

4. Two malleable cast metal letters, "N" and "R", at least 3 inches high, painted white, shall be provided to denote the switch point normal and reverse position for each layout. Each letter shall have 4 holes drilled to receive:
   a. No. 12 brass wood screws suitable for securing letters to wood ties.
   b. Fasteners suitable for securing letters to concrete ties or direct fixation structure.

5. For each letter the following shall be provided:
   a. Four, 1-1/2 inch, No. 12 brass, flathead wood screws.
   b. Four fasteners, suitable to affix letters to concrete.

6. Each power switch-and-lock movement mechanism shall be provided with identification letter-numbers not less than 3 inches high, made of malleable cast metal, painted white or embossed or engraved on a metal plate and securely fastened to the outside of the movement cover. Where more than one switch mechanism is operated by one control, the switch number shall be supplemented by letter "A", "B", "C", centered on the mechanism cover.

C. Junction Box: Each power switch-and-lock movement layout shall include a junction box in accordance with requirements of these Specifications.

D. Stranded Wire: Contractor shall provide insulated No. 14 AWG, 19-strand wire (minimum) between junction box and the power switch-and-lock movement.

E. Electrical Fittings: Contractor shall provide all connectors and electrical fittings as required for each power switch-and-lock movement layout.

F. Hose: Metallic Flexible Conduit shall be Type UA, or Authority approved equal. Metallic conduit shall be used with switch-and-lock movements and electric locks.

G. Connectors

1. Hose connectors shall be a watertight and oil tight compression fitting furnished with a locknut and sealing ring.

2. Hose connectors shall provide insulation between hose and junction box; and hose and switch machine housing.

3. The material shall be zinc-plated steel.

H. Factory Painting: All equipment described in PART 2 - PRODUCTS of these Specifications shall be painted in accordance with instructions in Paragraphs 29 and 30 of the AREMA C&S Manual, Part 2.4.30. The finish shall be applied in the factory and the color shall be black.

I. Security

1. Provisions shall be made for the use of padlocks as follows:
   a. A signal padlock to restrict entry to inside of the power switch-and-lock movement.
   b. A signal padlock to restrict entry to inside of the motor compartment.
   c. A signal padlock to restrict entry to inside of the hand crank selector lever, where applicable.
   d. Switch padlocks to secure the selector lever and hand-throw lever.

2. Padlocks shall be provided and installed in accordance with the requirements of these Specifications.
2.3 FUNCTIONAL REQUIREMENTS

A. Power switch-and-lock movement motors shall be suitable for continuous normal operation at 90 to 130 volts DC and shall not be damaged when operated intermittently at 130 to 150 volts DC. Each switch-and-lock movement shall sustain a 150-volt factory test operation without damage to diodes or other components.

B. Power switch-and-lock movements shall complete a full stroke, within the time specified on the Switch Operating Time vs. Voltage Curve, while driving a load meeting the requirements shown in AREMA C&S Manual, Part 12.2.5.

C. Switch-overload circuit shall remove energy from a switch-and-lock movement if the operating current rises above the desired maximum due to a stalled switch or other overload. One overload circuit shall be provided for each power switch machine. If an over current condition develops, the overload stick relay shall energize. The overload circuit shall remain in force until the switch operating control is canceled or reversed. While overload circuit is in force, energy shall be removed from the affected switch machine. Time for pick-up of the overload circuit shall be manufacturer’s recommendation, but shall not exceed 5 seconds.

PART 3 - EXECUTION

3.1 PRODUCTION

A. Each installed switch-and-lock movement shall bear an Identification number corresponding to the number as indicated on the Contract Drawings. Where additional switch-and-lock movements are required for double-slip track switches and crossover and operated by one auxiliary lever, the number of the switch shall be supplemented by the letter "A", "B", "C", centered below the switch number as shown on Contract Drawings.

3.2 INSTALLATION

A. Contractor shall mechanically couple the power switch-and-lock movement to the track switch points and mount the movement on the ties, using the Contract Drawing switch-and-lock movement layouts that include an electric switch-and-lock movement, pedestal mounted or direct fixation junction box, throw rod and basket, insulated swivel front rod, point lug, lock rod, detector rod, gauge plate extensions, shims, identification numbers and letters, all required screws, nuts, washers, pins, grease fittings, cotter keys, plates, adjusting brackets and all other required hardware.

B. Contractor shall mount and adjust the complete power switch-and-lock movement layout as specified in these Specifications and as shown on the Contract Drawings.

C. Contractor shall provide and install tie straps for each power switch-and-lock movement layout as shown on the Contract Drawings.

D. American standards shall apply to threaded layout parts that require periodic adjustments or maintenance, such as: throw rods, lock rods, detector rods, mounting bolts, and other parts. American standards shall also apply to threaded conduit outlets. All adjustable parts shall be centered to provide maximum adjustment capabilities.

E. Contractor shall verify that the track switch layout is in accordance with dimensions indicated on the Contract Drawings and as shown on Authority approved installation drawings prior to commencement of installation Work. Contractor shall provide personnel and resources as required to ensure that the switch layout is adjusted properly.

F. Prior to mounting the power switch-and-lock movement, the Contractor shall verify that switch headlock ties (T1 and T2) are at right angles to the straight stock rail in accordance with the Authority approved installation drawing and condition the switch points to move without binding. Should the switch ties require adjustment, the Contractor shall perform all Work as required in connection with tie adjustment without cost to the Authority. Contractor shall install tie straps as indicated on Contract Drawings and in accordance with the Authority approved installation drawing.

G. Tie Preparation

1. For wooden tie installation, the Contractor shall dap and drill ties to meet the requirements of these Specifications. Whenever the Contractor drills, adzes or daps ties, the cut surfaces shall be thoroughly saturated with copper napthanate, or other type of Authority approved wood preservative. Cutting or dapping shall not exceed 2 inches.

2. For concrete tie installation, switch machines shall be mounted on ties using bolts which protrude through the tie as shown on the Contract drawings.

3. Concrete ties shall be manufactured so that the switch machine is mounted at right angles to the tie at the proper elevation. All mounting holes required in the tie shall be factory installed using a non-conductive sleeve.

4. The tie manufacturer shall coordinate with the switch machine manufacturer for switch machine mounting requirements.
H. Contractor shall be responsible for removing any stone ballast required for installation of each power switch-and-lock movement layout and for replacing and tamping the ballast after installation has been completed. Excess ballast shall be spread evenly between ties in vicinity of the power switch-and-lock movement layout.

I. Contractor shall be responsible for any costs incurred by the Authority in restoring track alignment and surface occasioned by the Contractor's Work on track switches.

J. Contractor shall make a preliminary adjustment of the power switch-and-lock layout at the time of installation and a final adjustment when placing in service. This shall result in the adjusting nuts being centered on the threads, plus or minus 30 percent of thread length.

K. Adjustment shall be such that when the switch point is obstructed 1/4 inch or more and switch and lock movement is manually or electrically operated, the obstruction will prevent the switch-and-lock movement to lock up. Contractor shall also verify that power switch-and-lock movement circuit controller contacts will be made when the switch point is within 1/8 inch closed. Measurements shall be made over No. 1 switch rod for both Normal and Reverse positions of the switch points.

L. Underground cables terminating in the switch junction box shall be dressed in accordance with the requirements of these Specifications. Individual conductors shall be fanned, tagged and terminated. Wiring between the switch junction box and power switch-and-lock movement shall be accomplished using insulated flex wire, No. 6 and No. 14 AWG, 19 strand, minimum. All wires shall be tagged and terminated. Wires between the switch junction box and power switch mechanism shall be installed in a required length of Authority approved flexible watertight conduit. The flexible conduit shall be fastened to the switch junction box and switch mechanism with two, 3-inch stainless steel conduit clamps in accordance with the requirements of these Specifications. Maximum length of the flexible conduit shall not exceed 21 inches unless otherwise Authority approved.

M. During storage and after installation, power switch-and-lock movement layouts shall be properly lubricated and maintained by the Contractor on a regular timed program until accepted by the Authority.

N. Contractor shall exercise care that switches, including switch tie plates, are thoroughly lubricated at all lubricating points, that all machined surfaces susceptible to rusting, both external and internal, are thoroughly coated with an Authority approved grease and threaded portions of switch rods and nuts are similarly coated and protected.

O. Switch tie plates shall be lubricated with an Authority approved graphite lubricant. Tie plates shall be thoroughly steam cleaned to remove all oil or grease prior to application of graphite. Contractor shall periodically renew the protective coating until such time as the Authority assumes responsibility for maintenance of the equipment.

P. Contractor shall install, for each layout, the letters "N" and "R" for the purpose of identifying the position of the switch points. The "N" shall be placed on the normally closed point side as shown on the Contract Drawings.

Q. Field Painting: After installation, the Contractor shall inspect each switch machine and repair all scratches and blemishes in the paint finish of the switch machine. If surface rust is evident, it shall be removed prior to preparation of the surface for touch-up painting. The surface shall be smoothed, cleaned and completely dried prior to application of paint. The same brand and shade of paint applied in the factory shall be used in field painting. Finish color shall be black.

3.3 TESTING

A. Contractor shall test all functions of each power switch-and-lock movement layout in accordance with these Specifications.

B. Field testing shall include the following procedures:

1. Continuity check field wires to switch-and-lock movements to verify proper nomenclature in junction boxes and switch circuit controllers.

2. Adjust throw bar so that proper tension is placed on switch points in both positions.

3. Manually throw switch machine normal and adjust lock rods and point detector rods to allow switch machine to lockup with no obstruction. Repeat above for switch machine in reverse position.

4. Turn on switch machine power and request switch machine normal and observe in field that switch machine corresponds to position called and observe in wayside instrument housing that proper switch correspondence relay is energized.

5. With switch machine normal, check openings of circuit controller contacts to see that they meet equipment specifications. Operate machine reverse and repeat procedure.

6. Open each contact in switch circuit controller and observe that proper switch correspondence relay is de-energized. Repeat this procedure for both switch positions.
7. Place ammeter in series with motor control energy and adjust clutch such that it causes overload relay to energized in less than 10 seconds with 1/4 inch obstruction in switch point. Record current reading. Repeat for opposite position.

8. Throw selector level to HAND and observe switch mechanism cannot be operated by power. Restore lever and verify that switch mechanism can be powered.

9. Operate switch, then place shunt in switch detector track circuits and observe that switch machine is stopped in middle of stroke and does not complete movement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 "Signal System Basic Technical Requirements."

END OF SECTION 16911
SECTION 16915
MOTOR CONTROL CENTERS AND STARTERS

PART 1 - GENERAL

1.1 DESCRIPTION
A. This section specifies furnishing and installing motor control centers, motor control starter unit compartments, individually mounted AC motor starters, and supporting devices, as shown.

B. Work Allocation:
1. Individual starters (and their enclosures) to be used with equipment specified under Division 15, "MECHANICAL", shall be supplied under Division 15, "MECHANICAL". Refer to Section 15040, "Electrical Requirements for Mechanical Work". They shall be installed and wired under Division 16, "ELECTRICAL".

2. Starters other than those in Paragraph 1.1.B.1, including those in motor control centers, shall be supplied, installed and wired under Division 16, "ELECTRICAL".

1.2 REFERENCE STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
   1. ASTM B187 - Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes

B. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC)

C. Underwriters Laboratories, Inc. (UL):
   1. UL 845 - UL Standard for Safety Motor Control Centers
   2. UL 489 - UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

1.3 SUBMITTALS
A. Product Data.

B. Certification: Submit certified copies of field test reports.

C. Shop Drawings: Provide to scale to show all elements clearly legible.

D. Field Testing: Submit a detailed plan of the proposed methods of scheduling of testing the motor control centers and motors at least 30 calendar days prior to initiating the testing program.

E. Operations and Maintenance Manuals, and Training: In accordance with Section 16001, "Electrical Systems - General".

F. Manufacturer’s Data:
   1. At least two weeks before start of any shop coating paint work submit to the Contracting Officer for approval three each of the following:
      a. Complete Paint Data Sheets with surface preparation, recommendations, and the coating paint materials to be used, identified by the manufacturer, brand name, and product number.

1.4 QUALITY ASSURANCE
A. Experience:
   1. Manufacturer: Select a firm regularly engaged in the manufacture of motor control centers and motor starting equipment, of the type and sizes specified herein.

   2. Incorporate equipment into this work which essentially duplicates equipment that has been in satisfactory use for a period of five years prior to the Bid Opening of this Project.

1.5 EXTRA MATERIALS
A. Accessories and Spare Parts:
   1. Accessories: Provide special tools or other devices normally furnished or required for installation, care, and maintenance of equipment.

   2. Spare Parts: In addition to the recommended spares by the manufacturer, include the following:
      a. One spare circuit breaker for each 10 or less circuit breakers of given type, frame size, and trip rating.
      b. One spare contactor (motor starter) for each 10 or less contactors (motor starters) of given size.
      c. One set of spare overload heater elements for each 2 or less sets of specific size.
d. 10 percent spare fuses (minimum of two of each type and rating) for both primary and secondary of control power transformers.

e. 100 percent replacement of indicating lamps.

f. 50 percent replacement of indicating lamp lenses.

**PART 2 - PRODUCTS**

**2.1 GENERAL REQUIREMENTS FOR MOTOR STARTERS**

A. Interchangeable: Provide equipment of same type, rating and size and of functional characteristics and make to be interchangeable.

B. Provide for continuous current rating suitable for associated motor as shown.

**2.2 MANUAL MOTOR STARTERS**

A. Provide quick-make, quick-break, toggle switch type, or push button, with thermal alloy type overload protection. Use manual motor starters for single-phase motors rated less than 1/2 horsepower.

B. Toggle Switch Operator: Provide operator guarded and equipped with a red indicating light to show when the switch is in the closed position.

C. Provide manual motor starters with the following additional requirements: For starters located remote from motors provide thermal type.

**2.3 MAGNETIC MOTOR STARTERS**

A. Provide full voltage, across-the-line or reduced voltage start, reversing or non-reversing type as required, rated for design load requirements, sized to conform with standard NEMA ratings for given horsepower. Provide minimum size of NEMA size 1, and design for use on nominal 480 volts; 3-phase, 60 Hertz service unless otherwise indicated; with 120 volts control circuits; minimum three thermal type ambient compensated as indicated, manual reset, overload relays for motor protection; two convertible auxiliary contacts with provision for field mounting of minimum two future auxiliary contacts; red, green, and amber indicating lights; start-stop pushbuttons as indicated; and hands-off-automatic switch where automatically controlled, as indicated. Additionally, provide indicating lights, pushbuttons, and selector switches with legend plates.

B. Provide overload relays selected, and sized, based on actual full load amperes of particular motor. Additionally, install heaters in conformity with NFPA 70 and manufacturer's recommendations.

C. Provide control transformers for magnetic starters. Provide two fuses in the primary circuit and one in the secondary.

D. Furnish all magnetic starters with three ambient compensated overload relays. Select and size overload heaters based on the actual full load amperes of the particular motor. Install heaters in conformity with NFPA 70 (NEC) and the manufacturer's recommendations. For fans to be used for emergency ventilation, provide magnetic starters sensitive to fault current only.

**2.4 REVERSING STARTERS**

A. Provide such starters as shown, equipped with minimum three overloads. Additionally, interlock starters electrically and mechanically.

**2.5 TWO-SPEED REVERSING MOTOR STARTERS**

A. Provide starters for two-speed, single or two-winding, constant or variable torque motors, as shown, with automatic sequence accelerating relay which will start motor on low speed first at all times.

**2.6 CONTROL UNITS**

A. For control units for power and lighting feeders, provide circuit breakers only. For control units for motors, provide an across-the-line starter, either reversing or non-reversing as required, and a circuit breaker. Provide circuit breakers with molded case, 3-pole thermal magnetic type, with frame size and trip rating as indicated. Provide minimum interrupting capacity of 14,000 amperes RMS symmetrical or as indicated.

B. Mount units on a unit support pan or in a bucket type housing. Provide units of the draw-out type utilizing rails in order that rearrangement or relocation of individual units can be readily accomplished.

C. Securely mount starter and feeder unit doors with rugged hinges which allow the door to swing open for ease of unit maintenance. Fasten unit doors to the stationary structure so they can be closed to cover the unit space when the unit has been temporarily removed. Provide closed doors with captive type knurled or screw driver operable screws designed to help keep doors closed under fault conditions and to discourage unauthorized opening of the doors.

D. Provide combination motor starter unit doors, in addition to an overload reset button, oil tight pilot
lights and push button stations or selector switches as required or specified.

E. Provide units with an integral circuit breaker handle, color coded to indicate ON, OFF or TRIPPED position. Interlock the operating handle with the unit door so that the circuit protector cannot be switched to the ON position unless the unit door is closed. Provide the interlock to prevent opening the unit door unless the circuit protector is in the OFF position. Provide an override feature so that qualified personnel can gain access to the unit without interrupting service. Make provisions that all unit door operating handles can be locked in the ON or OFF position with a minimum of three padlocks.

F. Assemble control units with control leads for all starters and motor leads to fully shielded terminal boards with disconnecting type terminal blocks located with the unit cell. Provide a minimum of 20 percent spare terminals. Load terminal blocks for branch circuit breakers are not required. Furnish individual unit drawings as required, for NEMA Class 1, Type B wiring.

2.7 MOTOR CIRCUIT PROTECTORS (MCP)

A. Provide motor circuit protectors with the following characteristics:

1. UL 489 molded-case, quick-make/quick-break, mechanically trip-free, switching mechanism with adjustable magnetic trip for instantaneous short-circuit protection.

2. Rating:
   a. Continuous current rating: As shown but not less than full load current of motor.
   b. Voltage: 480 volts, 3-phase, 60 Hertz.
   c. Interrupting rating: As shown.
   d. Trip range: As necessary to provide maximum motor protection.

3. Where shown or necessary, individually removable current limiter, internally mounted on load side of MCP, with the following additional requirements:
   a. Limiter current rating and time-current limiting characteristics coordinated with time-current characteristics of motor circuit protector (MCP) to provide the following:
      1) Interruption by MCP under fault-current level up to interrupting capacity of MCP.
      2) Interruption by current limiter in conjunction with the MCP of fault-current level above interrupting capacity of MCP.
      3) Where necessary to protect associated motor starter, limit fault current below withstand capability of the starter.
   b. Current limiter housing interlocked with MCP tripping mechanism so that breaker will trip upon removal of cover.
   c. Equipped with common trip mechanism for tripping poles simultaneously on blowing of current limiter to prevent single phasing.
   d. Capable of interrupting minimum fault-current up to 100,000 RMS symmetrical amperes at 480 volts AC.

2.8 AUTO TRANSFORMER STARTER

A. Where shown on drawings, provide motors with closed transition transformer starter operable on 480 volts, 3-phase, 60 Hertz supply and having the following additional features:

1. Reversing or nonreversing closed transition type, as shown.
2. NEMA size as indicated on the drawings.
3. Adjustable taps for 50, 65, and 80 percent of line voltage.
4. 480 volts primary to 120 volts secondary control transformer with fuses in both legs of the circuit.
5. Manual reset, overload relay, one per phase:
   a. In starter for motors in fan shafts: magnetic type sensitive to fault current only.
   b. In starters for motors in remote locations: thermal type.

6. One pneumatic adjustable timing relay.

7. Two NO contacts with provision for addition of two NO or NC contacts.

8. Nonreversing type: START/STOP push button mounted on door.

9. Reversing type: FORWARD/REVERSE/STOP push button mounted on door.

10. HAND/OFF/AUTO selector switch provided where specified.

2.9 MOTOR CONTROL CENTERS

A. Provide motor control centers complying with NEMA ICS, Class 1, Type B, rated 480 volts, 3-phase, 60 Hertz, totally enclosed, deadfront, free standing, modular assembly with vertical and horizontal buses, wireways, compartments equipped with circuit breakers, MCP, and starters as shown.

B. Enclosure: Reinforced with adequate steel framework to form a rigid structure with smooth outer surface free of burrs, ridges, and other blemishes. Modular assembly to allow a maximum of six compartment units in one vertical assembly and units layout in any combination without structural interference, with the following additional requirements:

   1. NEMA type as described in 2.11 of this section.

   2. Main Incoming Lug Compartments: Provide a front accessible main lug compartment with suitable main lugs. Locate the compartment in the top most or bottom most unit space of the section to accommodate the user's cables entering the Motor Control Center. Provide cover with a hinged door, on the main incoming lug compartment for maintenance access. Provide captive type screws to keep this door closed and to discourage unauthorized access. Provide a unit door padlock attachment to lock the door in the closed position with one 5/16 inch diameter shackle padlock. Fabricate attachment to accept a meter type seal.

   3. Horizontal Wireways: Provide horizontal wireways in the top and bottom of each vertical section and arranged to provide full length continuity throughout the entire assembly. Provide the top horizontal wireway having a cross sectional area of not less than 20 square inches with openings between sections of not less than 11-1/2 square inches. Extend the bottom horizontal wireway through the length and depth of the vertical sections and provide with openings of not less than 11-1/2 square inches to allow for full length continuity throughout the entire assembly. The bottom horizontal height shall be minimum 9-1/4 inches. Provide covers with captive type screws for all wireways to prevent loss of hardware during installation. Isolate all wireways from the bus bars.

   4. Vertical Wireways: Locate a vertical wireway on the right hand side of each vertical section and extend from the top horizontal wireway to the bottom of the available unit mounting space. Provide each vertical wireway with a cross sectional area of not less than 19 square inches and isolated from the bus bars to guard against accidental contact. Provide a separately hinged door with captive type screws covering the vertical wireway for easy access to control wiring without disturbing control units.

   5. Wiring:
      a. For internal wiring in the motor control center use stranded copper with Type TEW 105 deg. C insulation.
      b. Power wiring minimum size No. 12 AWG.
      c. Control wiring minimum size No. 16 AWG.

C. Auxiliary Devices:

   1. Each combination motor starter unit: Provide a control transformer to handle the starter coil burden plus two pilot lights. In addition, size each control transformer to carry 100 VA more capacity than required.

   2. Control transformers: Provide two dual element primary fuses sized at approximately 125 percent of the transformer full load amperes. In addition, provide a single secondary dual element fuse and size to protect against transformer overload. Ground the coil side of the
transformer secondary to the unit support or back pan.

3. Indicating instruments:
   a. 4-1/4 inch square concentric scale type, with white background scales, black scale graduations and black pointer at indicator.
   b. Design for mounting on steel panels.
   c. The accuracy classification: three percent.
   d. The scale: Approximately 6-3/4 inches in length with a spread of not less than 250 deg. F of the instrument face.

2.10 MATERIALS

A. Vertical sections support the horizontal and vertical buses, combination starter units, covers, and doors, and designed to allow for easy rearrangement of units. Provide vertical sections with structural supporting members formed of a minimum of 13 gauge USSG hot-rolled steel. Provide all finished surfaces blemish-free. Where needed, provide reinforcement structural parts of 10 gauge USSG steel for a strong, rigid assembly. Provide each section 90 inches high and with 3 inch high removable lifting angle. Divide complete control center line-ups into shipping splits no wider than approximately 60 inches. Provide the lifting angle on the top of each shipping split extending the entire width of the shipping split. Provide lifting angles designed to support the entire weight of the MCC section. Provide base channels with holes to permit bolting the Motor Control Center(s) to the floor. Construct and package the entire assembly to withstand all stresses induced in transit and during installation.

B. Design Motor Control Centers so that matching vertical sections of the same current rating and manufacture can be added later at either end of the line-up without use of transition sections and without difficulty or undue expense. Provide removable end closing plates to close off openings on the end of the Motor Control Center line-up. Provide a removable top plate on each vertical section of one piece construction for added convenience in cutting conduit holes. In the design, allow use of the standard conduit entrance area without significant sag or deformation of the top plate.

2.11 ENCLOSURE

A. Select motor controller and switch enclosures suitable for the environment in which they are to be used, as follows:
   1. Enclosures for indoors and in dry, dust-free areas: NEMA Type 1.
   2. Enclosures for outdoor locations or where moisture is present: Use NEMA Type 3R, Type 4, or Type 4X, weatherproof as indicated.
   3. Enclosures for areas where dust and dirt are likely to be present: NEMA 12 industrial type.

2.12 PAINTING

A. Factory degrease and provide phosphate coating, after fabrication, to surfaces which are to be painted. Apply undercoat of rust-resistant paint such as zinc chromate over the phosphate coating (except for stainless steel). Apply finish painting of baked enamel, gray.

2.13 HORIZONTAL AND VERTICAL BUSES

A. Main horizontal buses provided at top of structure. Vertical buses for feeding power to each compartment provided in each vertical assembly and securely bolted to main buses.
   2. Each horizontal and vertical bus rated for a minimum of 600 amperes and 300 amperes respectively to meet ANSI temperature of 50 deg. C rise unless otherwise shown.
   3. Hold each bus rigidly by bus supports which have high dielectric qualities, are moisture-resistant, noncarbonizing and nontracking and have vertical creepage surfaces to prevent faults due to buildup of conductive dirt.
   4. Provide bus assembly braced to withstand short circuit rating of 22,000 symmetrical amperes, RMS or available short circuit determined by short circuit calculations, whichever is greater.
   5. Provide unit guides in unit compartment for aligning starter stubs.
   6. Provide continuous bare copper ground bus, 1/4 inch by 2 inch cross section throughout length of control.
7. Motor Starters: As specified under motor starters general requirements.

2.14 CIRCUIT BREAKER
A. Main circuit breaker (if used): One 480 volts, 3-pole, rating as indicated with ammeter and ammeter switch, voltmeter and voltmeter switch; and ground fault protection if required by NFPA 70 (NEC).
B. Branch circuit breaker: One 480 volts, 3-pole for each unit compartment.

2.15 UNIT SPACE HEATERS
A. Provide space heaters in all motor control centers located outdoors or in unheated spaces (only).
B. Provide heaters of required rating to prevent condensation for each vertical section of motor control centers. Additionally, locate heaters such that components in same vertical section are uniformly heated.
C. Provide space heater bus rated 120 volts, 60 Hertz supplied from stepdown transformers connected to the motor control center buses.
D. Do not load each space heater circuit more than 10 amperes, and additionally provide each circuit with one set of fused disconnect, adjustable thermostat and bypass switch in common.

2.16 ACCESSORIES AND SPARE PARTS
A. Furnish special tools or other devices normally furnished or required for installation, care and maintenance of the equipment.
B. Specifically include the items listed in Paragraph 1.5 of this section.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Provide concrete housekeeping pad in accordance with Section 16001, “Electrical Systems - General”.
B. Embed iron sills for anchoring motor control center flush with raised concrete pad as shown.
C. Install motor starters and control centers as shown in accordance with manufacturer’s recommendations and as approved by the Contracting Officer.
D. Install conduit in accordance with Section 16111, "Conduits".
E. Connect power cable and control wire as recommended by manufacturers and as follows:
   1. Make power cable and control cable connections to manual starters, across-the-line magnetic starters and autotransformer starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16120, "Wires and Cables".
F. Ground motor starters and complete motor control center in accordance with Section 16450, "Grounding and Bonding".
G. Apply touch-up paint as necessary.
H. Level motor control centers on the foundations, and place non-shrink grout between cabinet bases and the foundations.
I. Mount individual starters 5 feet above floor unless noted otherwise.

3.2 TESTING START-UP
A. Refer to Section 16030, "Testing of Electrical Systems".
B. Furnish necessary equipment and perform the following tests:
   1. Test circuits for connections in accordance with wiring diagram.
   2. Test to ensure that insulation resistance to ground of nongrounded conductor is in accordance with the grounding and bonding section.
   3. Test equipment enclosures for continuity to grounding system.
   4. Test operation of circuits and controls.
   5. Submit certified field test reports in accordance with Section 16030, "Testing of Electrical Systems".

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. In accordance with Section 16001, “Electrical Systems - General”

END OF SECTION 16915
PART 1 - GENERAL

1.1 DESCRIPTION
A. The Work to be done under this Section consists of designing, providing and installing color light type signal and indicator layouts. Except where otherwise noted, standard railroad signals shall be used for indicators. Indicators for embedded switch machines in unsignaled areas shall be in accordance with these Specifications. Herein, the term "signal" is used to refer to all indicating devices. A symbol form shown on the Contract Drawings is used to indicate the approximate locations where signal layouts are required.

1.2 REFERENCED STANDARDS
A. American Railway Engineering and Maintenance-of-Way Association (AREMA):
1. AREMA - Communications & Signals Manual Of Recommended Practice (C&S Manual)

1.3 SUBMITTALS
A. Submittals shall be in accordance with the requirements of these Specifications.
1. Contractor shall submit for approval, complete drawings for each type of signal layout proposed, including all mounting and wiring details. For 110V circuits, the drawings shall also show the transformer type to be provided and the manner of mounting. A key-numbered parts list and complete material ordering reference numbers shall be included for each type of layout.
2. Contractor shall submit installation drawings that include signal foundation and signal mounting details. Circuit drawings shall be submitted for each signal.
3. Contractor shall submit in conjunction with the factory test of the first Central Instrument House (CIH), an operating test. The operating test shall be performed in the factory with all controlling equipment. Lamp driver and lightout operations shall be verified through the entire range of operating voltages.
4. Contractor shall provide manuals describing operation and maintenance of each type of wayside signal.

1.4 QUALITY ASSURANCE
A. Each lamp unit shall be inspected prior to shipment. Inspection shall conform to the Contractor's Factory Inspection Procedure as Authority approved.
B. Signals shall meet the requirements of the AREMA C&S Manual, Section 7.1.1.
C. Each layout shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as Authority approved. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.
D. Final operating tests to determine acceptability of each complete layout shall be performed.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Layouts and their component parts shall be properly crated to prevent damage throughout delivery, storage and handling.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS
Not Used

2.2 CONTRACTOR FURNISHED MATERIALS
A. Maintenance Materials: Provide 2 complete layouts of every indicator used within the system, including hardware required for installation.
B. Each signal layout shall be provided with lenses, lamps, lamp receptacles, phankill, tapped transformers if required, terminal boards, wiring, number plates, backgrounds, hoods, padlocks and mounting hardware.
C. Each signal layout shall be provided with split-base junction boxes, signal mast and ladder.
D. Signals shall be internally wired at the factory.
E. Each signal shall contain colored lenses as shown on Contract Drawings. Each head shall be wired complete and cable conductors shall be terminated at the junction box and CIH terminal board. Where an aspect is not required by the design, the lamps shall not be installed, and test links shall not be installed on the CIH terminal board for the circuit.
F. Lenses and Hoods

1. If lenses are necessary for the provided LED lighting unit, they shall be doublet type and the inner lens diameter shall not be less than 5-1/2 inches and the outer lens diameter shall not be less than 8-3/8 inches. The outer lens shall be manufactured from high impact resistant LEXAN as Authority approved.

2. Lenses shall be uniform in shade and density for each respective color. Lenses shall be secured to the signal head in a manner such that their removal shall not affect adjustment of lamp receptacles. Lenses shall be provided with neoprene gaskets to provide a weatherproof and dust-proof seal between lenses and signal housing.

3. Contractor shall provide all equipment and material, including shims or special tools required to properly focus and align signals both horizontally and vertically to obtain the proper sighting distance.

4. Each lens unit shall be equipped with a hood and the hood shall be not less than 9 inches in length.

5. To prevent occurrence of phantom aspects, each lens shall be equipped with a phankill device.

G. Lamp Compartments

1. Signal housings shall be made of cast aluminum and shall have individual lamp compartments. Lamp compartments shall be separated from each other by partitions that prevent the passage of light between the compartments and, also, provide a means to pass wiring between units.

2. Each housing shall have a hinged removable door manufactured from cast aluminum. The doors shall be provided with ventilating openings, covered with fine mesh stainless steel, copper, or brass screen on the inside, and protected with hoods to keep precipitation out. Doors shall have gaskets as specified in the AREMA C&S Manual, Section 15.2.10. Ventilation openings in the housing are an acceptable alternative.

3. Doors shall have a provision for padlocks and padlocks shall be keyed in accordance with the Authority signal equipment standard. Contractor shall obtain keying information from the Authority to ensure that Contractor provided keying is identical to existing system keying. Door locking arrangement shall be so arranged that the door cannot be locked until fully closed. All lamp compartment doors shall have a stop that will prevent them from swinging where they may be struck by a passing train. The design shall permit opening of a single compartment door without opening the others. Contractor shall provide a means of locking all doors with a single device such as a lockable rod that fits though all door hasps. As an alternative, the Contractor shall provide a lock for each door.

4. Each lamp compartment shall be of proper size to provide ample space for lamps, lamp receptacles, terminals and such adjusting devices as required.

H. LED Lighting Units

1. LED lighting units shall be installed in lamp compartments.

2. Lighting units shall operate properly and be clearly visible when operated between 8 and 20 volts.

3. LED unit chromacity shall meet the requirements of AREMA C&S Manual, Section 7.1.10. Beam pattern shall meet requirements of AREMA C&S Manual, Section 3.2.37.

4. The LED unit shall withstand either 130 VAC or 54 VDC for 80 milliseconds without damage.

I. Painting

1. The lamp compartment interior shall be painted to the manufacturers’ standard.

2. Each layout shall have 1 primer coat of rust-preventive paint and 1 finish coat of paint at the point of assembly prior to shipment. The lamp compartment housing exterior paint finish coat shall be dull black. The finish coat of paint for the mast, ladder and base casting shall be black.

J. Signal Number Plates

1. Signal number plate shall be placed under the lowest signal lens in the layout and shall be fastened by 4 brass screws.

2. Each number plate shall meet the requirements of the AREMA C&S Manual, Section 14.6.1.

3. Characters and numbers for the number plates shall be 3 inches high round type, black letters on a white reflective background.
K. Mounting, Mast Mounting

1. Mast mounted signals shall be provided for locations as shown on the Contract Drawings. A mast shall consist of a 5 inch aluminum pipe post suitably equipped at the top to accommodate the signal unit(s) and provided at the bottom with an approved base.

2. Base shall be a split base junction box type with AREMA approved terminals as shown on Contract Drawings. The terminals are to be made accessible by a cover or door, with provisions for padlocking, without removing any other part of the signal assembly. Bolt hole center dimensions in this base shall be 11-11/16 inches by 11-11/16 inches.

L. Ladders

1. Ladders shall be provided by the Contractor to provide access to all signal layouts. Ladders shall be complete with cast iron ladder base for layouts in ballasted at-grade construction, with all required bolts, nuts, washers and associated mounting hardware.

2. Ladders shall be provided with all required bolts, nuts, washers and associated mounting hardware for installation of ladder for signals on above grade structures.

3. Ladders shall be equipped with rungs along the full length of the ladder and shall not impede access to any lamp compartment. The top rung shall be no more than 4 feet from the top of the ladder.

M. Where signals are mounted back-to-back, installation shall not create unsafe or restricted working conditions.

N. Contractor shall provide elevated bases for conduit entrance for signals installed on above grade structures.

O. Contractor shall provide mounting brackets for all layouts to allow for adjusting vertical, horizontal, left, and right.

P. Signal layouts shall not be mounted as to require personnel lifting equipment of any type for access.

PART 3 - EXECUTION

3.1 INSTALLATION

A. In areas where mainline signals cannot be installed due to space restriction or where indicated on the Contract Drawings, transit LED color light signals shall be used with the Authority approval.

B. All layouts shall be installed at locations as shown on Contract Drawings and in accordance with approved installation drawings.

C. Layouts shall be properly installed, aligned, and focused, both horizontally and vertically, in order to ensure that each lens configuration is distinctive when viewed from a height of 9 feet above the top of rail.

D. After installation and prior to Contract completion and acceptance, the Contractor shall touch up the exterior of each layout as required to cover all scratches, chips, and blemishes in the painted surface. Touch up paint shall be of the same quality, texture, and appearance as manufacturer’s finish coat.

E. Ladders shall be installed in accordance with approved installation drawings.

F. Contractor shall provide foundations of sufficient depth to ensure stability. In areas where the grade slopes, the Contractor shall build up the earth around the signal installation and, if required to maintain the build-up, shall construct retention structures of treated lumber such as railroad ties.

3.2 TESTING

A. Field testing shall be performed on all signal layouts. These tests shall include:

1. Continuity check of field wires and verification of all nomenclature.

2. Application of energy to signal lighting circuits and adjustment of all lamp voltages to 10 percent less than the lamp rating.

3. Break down of signal clearing relay contacts and observation that proper signal aspect is displayed.

4. Sighting of signals for maximum visibility.

5. Checking of light-out feature, where used.

6. Verification of approach lighting.

B. Contractor shall support the Authority’s System Integration testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.
4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16917
PART 1 - GENERAL

1.1 DESCRIPTION
A. The Work to be done under this Section consists of designing, providing and installing audio frequency (AF) track circuits for train detection. AF overlay track circuits shall not be used for long range train detection.

B. Main line AF track circuits shall provide broken rail detection for both rails.

C. AF track circuit equipment shall detect the failure of insulated joint and protect against it causing any unsafe condition or shall be arranged so that failure of an insulated joint shall not cause an unsafe condition.

D. Selected frequencies of AF track circuits for main line detection and for highway crossing island circuits shall not interfere with the cab signal functions and shall operate properly when coupled with the cab signal frequency.

E. Track circuit shall be compatible with the traction power negative return and not be affected by traction power return current imbalances.

F. Restoration of power after a power failure shall automatically restore the track circuits to normal operation.

G. Reset of de-energized track circuit shall not be based on adjacent track circuit occupancy.

H. Track circuit shall function properly in an uncontrolled temperature environment from negative 40 degrees F to 160 degrees F.

I. AF track circuits shall be protected from lightning and power surges.

1.2 REFERENCED STANDARDS
A. American Railway Engineering And Maintenance-of-Way Association (AREMA):
   1. AREMA – Communications and Signals Manual of Recommended Practice (C&S Manual)

1.3 SUBMITTALS
A. Submittals shall be in accordance with the requirements of these Specifications.
   1. Contractor shall submit drawings showing the physical characteristics, ratings and operating characteristics for the proposed track feed transformers, adjustable resistors and track fuses.

   2. Contractor shall submit the following for Authority approval:
      a. Drawings for AF track circuits together with a bill of materials.
      b. Complete performance data of each type of track circuit to be provided for this Contract.
      c. Test report of lightning and surge protection.

   3. Contractor shall submit installation drawings showing tie straps and mounting details of the AF track circuits including rail connections. Circuit drawings shall be submitted for each track circuit.

   4. Contractor shall submit Test Procedures and Results in accordance with these Specifications.

   5. Contractor shall provide manuals describing operation and maintenance of each type of AF track circuits

1.4 QUALITY ASSURANCE
A. Each AF track circuit component shall be inspected prior to shipment. Inspection shall conform to the Contractor's Factory Inspection Procedure as approved by the Authority.

B. AF track circuits shall meet the requirements of the AREMA C&S Manual, Sections 8.2.1 and 8.6.10.

C. Each AF track circuit shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

D. AF track circuits shall be tested according to Authority approved test procedures.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Where AF track circuits drive a relay, the relays shall be delivered, stored and handled as required in these Specifications.
PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. Maintenance Materials: Two complete sets of AF track circuit equipment, both the transmitting and receiving ends, including coupling unit and tuning devices and any other equipment needed for installation for each frequency used within the system.

B. Keys, Special Tools, and Test Equipment: Contractor shall provide C&S1 test stand for AF track circuit PC cards. The test stand shall allow shop test and troubleshooting of each type PC card used in the track circuit equipment.

C. In interlockings, power frequency (PF) track circuits shall be provided through crossovers. Equipment for PF track circuits shall be in accordance with these Specifications.

D. Track circuit lengths shall match Authority approved block design.

E. Each AF track circuit shall consist of the following basic components and characteristics:

1. A device for generating proper vehicle/train detection frequency signals (Track Module).

2. A device for receiving the proper detection frequency and driving a vital, biased neutral track relay or interfacing to a vital processor’s input when this frequency is received (Receiver Module).

3. Built-in diagnostics with test points and Light Emitting Diode (LED) indicators on modules.

4. AF track circuit modules shall fit in standard 19 inch instrument racks. Means shall be provided to easily and independently adjust both track circuits transmitting energy and receiving sensitivity.

5. Power to each track and receiver module shall be individually fused. A fused buss shall not be permitted.

F. Frequency selection, modulating techniques and signal strengths shall not cause interference and be immune to interference from traction power or conducted and induced emissions generated by light rail vehicles (LRV).

G. AF track circuits shall be immune to improper operation due to crossed or grounded wires or any other influences such as capacitive and inductive coupling or stray currents.

H. No combination of frequencies and/or code rates shall produce an output signal that may improperly energize a track circuit.

I. Detection signal shall be modulated carrier signal to distinguish the presence of a legitimate signal from any noise.

J. AF track circuit receiver shall verify the carrier and coding of the detection frequency in order to energize the track circuit.

K. AF track circuits shall operate satisfactorily under the environmental conditions present on the system.

L. If a track relay is used, it shall be a vital DC biased relay as required in these Specifications.

M. Cable and wiring for AF track circuits shall be as required in these Specifications.

N. Other track circuit system components shall comply with applicable portions of these Specifications.

2.3 FUNCTIONAL REQUIREMENTS

A. AF track circuits shall detect a shunt anywhere within the track circuit boundaries. Shunting sensitivity for AF track circuits shall be 0.25 ohm impedance with rail-to-rail leakage impedance of 3 ohms minimum per 1000 feet of track at the operating frequency and shall be under the following conditions:

1. Train moving or stopped.

2. Traction power on or off.

3. Rail condition for prevalent operation for any track.

B. Failure of track circuit component shall not permit the shunting sensitivity to fall below that specified after the track circuit has been properly adjusted.

C. AF track circuit equipment shall consist of a transmitter, a receiver, and vital track logic. AF track circuits shall be vital and fail-safe. In cab signaled territory, AF track circuit frequencies shall be selected so that the proper operation of the track circuit is not affected by the cab signal frequency. The selected track circuit frequencies shall not cause interference or improper operation of the cab signal system.

D. Reliability of AF track circuits shall comply with the requirements of these Specifications.
E. Insulated Joints (IJ) shall not be required except at interlocking areas.

F. Boundary definitions shall be no more than actual boundary within plus or minus 16 feet at each end at all locations except adjacent to IJs, where the boundary shall be within plus or minus 0 feet.

G. Lightning Protection

1. Contractor shall provide lightning protection and surge protection which are effective in protecting all signal circuits and equipment from damage and operational malfunction. This shall be accomplished by providing as many applicable types and stages of protection as required to protect each type of circuit and equipment involved.

2. Primary surge arrestors shall have the ability to shunt relatively high current surges to ground with relatively little overshoot.

3. Secondary surge suppressers shall have the ability to shunt-to-ground any surge overshoot from the primary arrester devices.

4. Protection devices shall be wired, mounted and located so that triggering or fault of the device shall not damage the facility or other equipment. If required, protection devices shall be fused to prevent damage.

H. Electromagnetic Interference Requirements

1. AF track circuits shall be compatible with Electromagnetic Interference (EMI) generated by the vehicle, the traction electrification system (TES), the communications system, local power lines, rail system environment and any other anticipated electromagnetic noise.

2. Track circuit shall be wired with twisted pair on the wayside and whenever possible in the signal bungalows or cases. Track circuit leads on the wayside shall be properly tagged and labeled to indicate the transmitting and receiving ends.

3. Any form of EMI between adjacent track circuits on the same track or track circuits on adjacent tracks shall not affect the safe operation or reliability of the Signal System.

PART 3 - EXECUTION

3.1 PRODUCTION

Not Used
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section consists of designing, providing and installing power frequency (PF) Alternating Current (AC) track circuits for train detection at locations as shown on the Contract Drawings.

B. PF track circuits shall be designed to operate on 100 Hz and employ two-element vane type induction relays.

C. Single rail PF track circuits shall be provided in crossovers and turnouts.

D. Track circuit shall be compatible with the traction power negative return and not be affected by traction power return current imbalances.

E. Restoration of power after a power failure shall automatically restore the track circuits to normal operation.

F. Reset of de-energized track circuit shall not be based on adjacent track circuit occupancy.

G. Track circuit shall function properly in an uncontrolled temperature environment from negative 40 degrees F to 160 degrees F.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. Communications and Signals Manual of Recommended Practice (C&S Manual)

1.3 SUBMITTALS

A. Submittals shall be in accordance with the requirements of these Specifications.

B. Contractor shall submit drawings showing the physical characteristics, ratings and operating characteristics for the proposed track feed transformers, relay pickup transformers, adjustable resistors and track fuses.

C. Contractor shall submit the following for approval:

1. Drawings for PF track circuits together with a bill-of-materials.

2. Complete performance data of each type of track circuit to be provided for this Contract.

3. Test report of lightning and surge protection.

D. Contractor shall submit installation drawings showing tie straps and mounting details of the PF track circuits including rail connections. Circuit drawings shall be submitted for each track circuit.

E. Contractor shall submit Test Procedures and Results in accordance with these Specifications.

F. Prior to Field Testing of the first PF track circuit, the Contractor shall provide 15 manuals describing operation and maintenance of each type of PF track circuits.

1.4 QUALITY ASSURANCE

A. Each PF track circuit component shall be inspected prior to shipment. Inspection shall conform to the Contractor's Factory Inspection Procedure as approved by the Authority.

B. Each PF track circuit shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

C. PF track circuits shall be tested according to Authority approved test procedures.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Track relays shall be delivered, stored and handled as described in these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. General

1. PF track circuits shall meet the requirements of the AREMA C&S Manual, Section 8.4.

2. Adjustable resistors shall be as specified in these Specifications, and as described herein:

   a. Resistor in the feed end shall have a minimum continuous capacity of 200 watts. It shall handle a current of 10 amperes without damage. The resistor shall be of the variable sliding type and shall allow adjustment in the entire range of
allowed resistance for PF track circuits on the System.

b. Resistor at the relay end shall be adjustable with a continuous capacity of 100 watts. The resistor shall be of the sliding variable type and shall allow adjustment in the entire range of allowed resistance for PF track circuits on the System.

c. Terminals on adjustable resistors shall be standard binding posts that conform to the AREMA requirements.

3. Track fuses shall be as specified in these Specifications and as described herein:
   a. Fuse in the feed end of track circuit shall be 600 volts, 8 amperes minimum.
   b. Fuse in the relay end of track circuit shall be 600 volts, 2 amperes minimum.

4. Track relay shall be vital AC relay as specified in these Specifications.

5. Cable and wiring for PF track circuits shall be in accordance with these Specifications.

6. Other track circuit system components shall comply with applicable portions of these Specifications.

B. Lightning Protection

1. Contractor shall provide lightning protection and surge protection, which are effective in protecting all signal circuits and equipment from damage and operational malfunction. This shall be accomplished by providing as many applicable types and stages of protection as required to protect each type of circuit and equipment involved.

2. Primary surge arrestors shall have the ability to shunt relatively high current surges to ground with relatively little overshoot.

3. Secondary surge suppressers shall have the ability to shunt-to-ground any surge overshoot from the primary arrester devices.

4. Single rail track circuits shall not be provided with lightning arrestors on the track leads.

2.3 FUNCTIONAL REQUIREMENTS

A. PF track circuits shall be relay based, 100 Hz, and of the matching transformer type. Feed voltage shall be adjusted through a transformer and resistor network. Receiving end shall route the 100 Hz current from the track through a transformer and filter to an AC vane type relay where it will be compared to a reference voltage for relay pickup.

B. Design of the track circuit system shall be compatible with Audio Frequency (AF) track circuits.

C. PF track circuit shall detect a shunt anywhere within the track circuit boundaries. Shunting sensitivity for PF track circuits shall be 0.25 ohm impedance with rail-to-rail leakage impedance of 3 ohms minimum per 1000 feet of track at the operating frequency and shall be under the following conditions:

1. Train moving or stopped.
2. Traction power on or off.
3. Rail condition for prevalent operation for any track, i.e., mainline (continuous use), crossover (any type from seldom used to continuous use).

D. Failure of track circuit component shall not permit the shunting sensitivity to fall below that specified after the track circuit has been properly adjusted.

E. Electromagnetic Interference (EMI) Requirements

1. Track circuit shall be compatible with EMI generated by the vehicle, the traction electrification system (TES), the communications system, local power lines, rail system environment and any other anticipated electromagnetic noise.

2. Track circuit shall be wired with twisted pair on the wayside and whenever possible in the signal bungalows or cases. Track circuit leads on the wayside shall be properly tagged and labeled to indicate the transmitting and receiving ends.

3. Any form of EMI between adjacent track circuits on the same track or track circuits on adjacent tracks shall not affect the safe operation or reliability of the Signal System.

PART 3 - EXECUTION

3.1 PRODUCTION

Not Used
3.2 INSTALLATION
A. Track circuits shall be installed at all locations indicated on the Contract Drawings and in a manner as shown on approved installation drawings and described within the approved Installation and Inspection Procedure.
B. PF track circuits shall be installed using 2 single conductors as specified in these Specifications.
C. Any track circuit jumpers in excess of 50 feet shall be installed in conduit and/or cable trough.

3.3 TESTING
A. Tests shall be made in accordance with approved test procedures and in accordance with requirements of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT
A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16919
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section consists of designing, providing and installing a Train-to-Wayside solid-state digital Communication (TWC) link between train and wayside.

1.2 REFERENCE STANDARDS

A. American Railway Engineering And Maintenance-of-Way Association (AREMA)

1.3 SUBMITTALS

A. Submittals shall be in accordance with the requirements of these Specifications.

1. The Contractor shall submit drawings showing the physical characteristics, ratings and operating characteristics for the proposed train-to-wayside communications equipment.

2. The Contractor shall submit the following for approval:

a. A typical layout showing wayside antennas including cable connections, antenna mounting hardware and case location.

b. Typical circuit details.

3. The Contractor shall submit installation drawings showing mounting details of the TWC equipment including rail connections. Circuit drawings shall be submitted for each TWC installation.

4. The Contractor shall submit Test Procedures and Results in accordance with these Specifications.

5. The Contractor shall provide manuals describing operation and maintenance of each type of TWC unit.

1.4 QUALITY ASSURANCE

A. Each TWC component shall be inspected prior to shipment. Inspection shall conform to the Contractor's Factory Inspection Procedure as approved by the Authority.

B. TWC components shall meet the requirements of the AREMA Signal Manual.

C. Each TWC component shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

D. TWC components shall be tested according to Authority approved test procedures.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. TWC system shall be compatible with existing Meister Electronics Vehicle Tagging (Vetag) on-board equipment.

B. The interrogation frequency shall be 100 Khz.

C. Current to the loop shall be adjustable between 100 and 440 ma.

D. Duration of the interrogation pulse shall be 2 ms.

E. The Interrogator shall sample and compare successive messages. Messages shall be validated when two consecutive messages are identical.

F. The Interrogator shall have the capability to decode up to 99 different messages.

G. TWC unit shall have an internal event recorder capable of storing 5000 events. Data entry shall be replaced on first-in-first-out occurrence.

H. The Contractor shall provide all required hardware for installation of the TWC system.

I. TWC system shall be capable of interfacing via modem.

J. TWC system shall be capable of interfacing with a lap top computer using Windows-based software.

K. The Contractor shall provide a TWC layout for locations as shown on the Contract Drawings.

2.3 FUNCTIONAL REQUIREMENTS

A. TWC provided by the Contractor shall be functionally compatible with the existing TWC system. It shall have capability to interface with existing vehicle equipment and other subsystems to provide a continuous flow of information between the train and specified wayside equipment. Vehicle borne TWC equipment is not included in this Contract.

B. The TWC system shall be capable of being utilized as an integral part of a centralized traffic control system to provide the following data functions: vehicle identification, automatic routing, data transmission,
sign display, train tracking, with a minimum of ten percent spare bits.

C. The Contractor shall provide a CANCEL command available via TWC for route requests and “Ready to Depart” controls that are initiated by the same TWC loop.

2.4 DELIVERY, STORAGE AND HANDLING

A. Not Used

PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 INSTALLATION

A. Wayside layouts shall be installed as shown on Contract Drawings. TWC loop placement in station areas shall be coordinated with the installation of berthing markers.

3.3 TESTING

A. Factory and field testing shall be in accordance with approved test procedures.

1. A test train shall be used to test all function at each TWC location.

2. At the TWC loop under test activate a TWC function and verify that the proper TWC function relay is energized in the Central Instrument House (CIH) or equipment case.

B. The Contractor shall support the Authority’s System Integration testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16920
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications to provide and install wayside Automatic Train Protection (ATP) signal transmission and B-point loops.

1.2 REFERENCE STANDARDS

A. American Railway Engineering And Maintenance-of-Way Association (AREMA)

1.3 SUBMITTALS

A. Submittals shall be in accordance with the requirements of these Specifications.

B. The Contractor shall submit manufacturer’s product literature and specifications for ATP signal transmission loops components for Authority approval.

C. The Contractor shall submit manufacturer’s product literature and specifications for B-point loops components for Authority approval.

D. The Contractor shall submit Test Procedures and Results in accordance with these Specifications.

E. The Contractor shall provide manuals describing operation and maintenance (O&M) of ATP loop and B-point loop circuit components.

1.4 QUALITY ASSURANCE

A. Each ATP loop and B-point loop circuit component shall be inspected prior to shipment. Inspection shall conform to the Contractor’s Factory Inspection Procedure as approved by the Authority.

B. ATP loop and B-point loop circuit components shall meet the requirements of the AREMA Signal Manual.

C. Each ATP loop and B-point loop circuit component shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor’s Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority’s satisfaction.

D. ATP loop and B-point loop circuit components shall be tested according to Authority approved test procedures.

E. Field inspect and test ATP and B-point signal transmission loops in accordance with Authority approved procedures and these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. Cab Signal Transmission Loops

1. ATP signal transmission loops shall be provided to transmit continuous ATP signaling speed commands within an interlocking where power frequency track circuits are used.

2. Contractor shall determine the exact layout of the loop or loops through the special track work so as to provide continuous ATP signaling speed commands. Loop layout shall be submitted for Authority approval.

3. Loops shall be transposed to minimize coupling to the rails. Loop feeds shall be twisted to minimize radiation.

B. B-Point Loops

1. Independent track frequency “receive-only” B-point layouts consist of a track loop, matching transformer, a receiver, and an input to the vital track logic. Connection to the rails at these locations shall be without an impedance bond. These receivers may use current coupling pick-up coils in lieu of or in addition to rail connections. Receive point locations shall have a shunting definition not to exceed 10 feet from the point where rail connections or pick-up coils are installed.

2. Contractor shall differentiate between B-points and complete track circuits for event recorder inputs. Failure of a receive point shall not result in a false “occupied” indication of a track circuit.

3. B-points may be used to define the limits of all or a portion of highway crossing warning approaches, highway crossing extended approaches, highway crossing island circuits, indication and release of civil speed restrictions, and for enforcement of speed reductions upon approaching a red home signal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Cab Signal Transmission Loops

1. ATP signaling transmission loops shall be installed at locations designated in the
Contract Drawings in accordance with Authority approved installation drawings.

2. Contractor shall provide and install No. 6 AWG minimum, stranded, insulated and jacketed wire, rail clips and all equipment required for a complete operation and testing of cab signal transmission loops as specified herein.

B. B-Point Layouts

1. Receive Point Loops shall be installed at locations designated in the Contract Drawings in accordance with Authority approved installation drawings.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16922
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section consists of designing, providing and installing impedance bonds or functionally equivalent devices.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):

1.3 SUBMITTALS

A. Submittals shall be in accordance with these Specifications.

1. The Contractor shall submit drawings showing the physical characteristics, ratings and operating characteristics for the proposed impedance bonds.

2. The Contractor shall submit drawings of a typical layout showing impedance bond, including cable and track connections and conductive flux to be used for connections to impedance bond plugs.

3. The Contractor shall submit installation drawings showing mounting details of impedance bonds including rail connections.

4. The Contractor shall submit Test procedures and results in accordance with these Specifications.

5. The Contractor shall provide manuals describing operation and maintenance of each type of impedance bond.

1.4 QUALITY ASSURANCE

A. Each Impedance bond shall be inspected prior to shipment. Inspection shall conform to the Contractor’s Factory Inspection Procedure as approved by the Authority.

B. Impedance bonds shall meet the requirements of AREMA Signal Manual, Part 8.4.5.

C. Each Impedance bond shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor’s Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority’s satisfaction.

D. Impedance bonds shall be tested according to Authority approved test procedures.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Maintenance Materials:

1. The Contractor shall supply two of each type of impedance bond used for the Contract where up to 100 bonds are provided. An additional spare shall be provided for every 50 bonds or portion thereof, above 100 installed bonds.

2. The Contractor shall supply four of each type of tuning unit installed for the Contract.

B. Impedance bonds shall be provided with all mounting hardware, connectors, cables and required appurtenances.

C. Two track winding terminal lugs shall be provided on each impedance bond. Each track winding lug shall accept two 535 KCMIL cables. Center tap on impedance bond shall be required to terminate cross-bonding cables; neutral cables to another impedance bond on the same track at insulated joints and for terminating DC negative returns. Where the center tap lug size does not permit termination of the required conductors, a copper plate shall be provided of sufficient size to accommodate all terminations required and for maximum current to be encountered.

D. Impedance bonds shall be arranged for mounting as shown in the Contract drawings.

2.3 FUNCTIONAL REQUIREMENTS

A. The track winding of each impedance bond shall be rated to carry 2000 amperes per rail continuously. The impedance bond shall function properly with a traction current imbalance of up to 12 percent. DC resistance of the impedance bond, from track lug to track lug, shall not exceed 0.00005 ohms.

B. Impedance bonds in cab signaled territory shall have provisions for three parallel resonant tuned circuits, tuned for the cab signal frequency, track circuit transmitter frequency and receiver frequency of the adjacent track circuit. Basic impedance bonds shall be identical, with capability of either selecting track circuit frequencies within the bond or by interchangeable tuning units. Impedance bonds shall be provided with removable identification plates that identify the frequencies of the tuned circuits.

2.4 DELIVERY, STORAGE AND HANDLING

A. Impedance bonds shall be properly crated to prevent damage throughout delivery, storage, and handling.
PART 3 - EXECUTION

3.1 PRODUCTION
A. Not Used

3.2 INSTALLATION
A. Impedance bond layouts shall be installed at locations as shown on Contract Drawings in accordance with approved installation drawings.
B. Cable interconnections shall be installed in accordance with these Specifications.
C. The Contractor shall coordinate with Traction Power Substation (TPSS) Contractor for crossbond and negative return locations, termination schedule and temporary bond removal requirements.
D. The Contractor shall be responsible for any required adjustment of tie spacing and for removing any stone ballast required for installation of each impedance bond layout and for replacing and tamping ballast after installation has been completed. Excess ballast shall be spread evenly between ties in the vicinity of the impedance bond layout.
E. The Contractor shall be responsible for any costs incurred by the Authority in restoring track alignment occasioned by the Contractor's Work.
F. All cable connecting lugs shall be insulated in such a manner that the lugs shall not short out the insulated floating running rail return current to the casing of the impedance bond. If multiple cables are installed on a single connection, insulators shall be installed between the cable lug and the impedance bond casing.

3.3 TESTING
A. The Contractor shall test the impedance bond layout as per the approved Field Test Procedure.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT
A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16923
SECTION 16930
RAIL BONDING - SIGNAL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION
A. Work to be done under this Section consists of designing, providing and installing all required material to bond the track rails for traction negative return and signal track circuits.

1.2 REFERENCE STANDARDS
A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1.3 SUBMITTALS
A. The Contractor shall submit the following for approval:
   1. Material composition, electrical and mechanical characteristics for power bonds, signal bonds and track circuit connectors.
   2. Mechanical and operating data for the compression tool required for installation of track circuit connections.
   3. Field installation procedures for welded signal and power bonds.
   4. Descriptions of all mechanical devices for securing and protecting rail bonding.
   5. Exothermic weld material.
   6. Installation drawings indicating details of design to show methods of ensuring that bonding is protected from damage, theft or vandalism. Installation drawings shall indicate locations and types of all bonds.

B. The Contractor shall submit for approval, a plan showing detailed typical designs for bonding of special trackwork to assure all pieces of special trackwork are properly connected electrically.

C. The Contractor shall show bonding detail on installation drawings.

D. The Contractor shall submit Test Procedures and Results in accordance with these Specifications.

1.4 QUALITY ASSURANCE
A. The Contractor shall install each welded bond and mechanical rail connector in accordance with requirements of these Specifications.

B. Rail bonds shall meet the requirements of the AREMA Signal Manual, Parts 8.1.20

C. Each Rail bond shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor’s Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority’s satisfaction.

D. The Contractor shall test each welded bond in accordance with the requirements of these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS
A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS
A. Power Bonds
   1. All non-insulated joints in track circuit territory, including guardrail joints, shall use 250 KCMil size, two for each joint, as manufactured by Cembre, Inc., or Authority approved equal.
   2. Power bonds for frog and switch fouling connections and expansion joints shall be two 535 KCMil Locomotive Cables as shown on the Contract Drawings and specified in these Specifications.

B. Restraining Rail Bonds and Signal Rail Bonds
   1. Signal rail bonds shall be rail web type manufactured bonds. The bonds shall be two 250 KCMil extra flexible of required length as described on the Contract Drawings, two for each joint, as manufactured by Cembre, Inc., or Authority approved equal.
   2. Restraining rail bonds shall be rail web type manufactured bonds. The bonds shall be 250 KCMil extra flexible of required length, as manufactured by Cembre, Inc., or Authority approved equal. Bonds shall be installed in accordance with Authority approved drawings.
   3. When space constraints prevent mechanical bonds, then bonds shall be manufacturer's bonds prepared for welding by the exothermic process, Cadweld or Authority approved equal. Installation drawings shall indicate locations where welded bonds are to be used and require Authority approval. Bonds, bonding materials and types of molds shall be Authority approved.
   4. Cable for frog and switch jumpers and end of storage track crossbonds shall be 535 KCMil Locomotive Cable, as shown on Contract Drawings and in these Specifications.

2.3 DELIVERY, STORAGE AND HANDLING
A. Not Used
PART 3 - EXECUTION

3.1 PRODUCTION
A. Not Used

3.2 INSTALLATION
A. Power bonds shall be installed at all non-insulated rail joints.
B. Where restraining rails and guard rails are installed, bonds shall be installed in accordance with the Authority’s requirements.
C. Frog, switch jumper, and crossbonding shall be installed at locations shown on Contract Drawings, and as required by these Specifications. All special trackwork shall be bonded in accordance with Authority approved installation drawings to establish electrical continuity and conductive capacity for traction power return and signal track circuits.
D. For all welded connections to the rails, surface of the rails where bond is to be applied shall be ground clean with a reinforced grinding wheel, of a type recommended by the bonding material manufacturer. After grinding, surface shall be cleaned with an Authority approved non-toxic solvent to remove all traces of grease and dirt.
E. After the surface has been ground and cleaned, it shall be heated to drive out any moisture. The cable bond shall then be welded by the exothermic process in such a manner as to ensure a thorough mechanical and electrical connection.
F. Welding material shall consist of a copper exothermic mixture suitable for connection to load bearing rail, as manufactured by Cadweld (F-80), or Authority approved equal, and shall meet the requirements of the AREMA Communications & Signals Manual, Part 8.1.34.
G. Each rail connection shall be thoroughly welded to the rail web. To ensure quality, the Authority reserves the right to test each weld by hammer and striker or in any other manner which in the opinion of the Authority is reasonable.
H. The Contractor shall install temporary bonds around insulated joints installed as shown in the Contract Drawings.

3.3 TESTING
A. The Contractor shall demonstrate that bonding is in accordance with the requirements of these Specifications and as shown on Contract Drawings, and as specified in the AREMA Signal Manual, Part 8.1.20, Part 8.1.31 and Part 8.1.33.
B. Any bond, weld, or connection installed by the Contractor which is found to be defective prior to acceptance, shall be removed and a new bond installed at no additional cost to the Authority.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT
A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16930
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes specifications for designing, providing and installing automatic highway crossing warning system layouts as specified herein and shown on the Contract Drawings.

B. The Contractor shall visit each crossing with state and local regulatory bodies to review the layout of each crossing.

C. The Contractor shall provide gate malfunction indication for each Automatic Highway Crossing Warning (AHCW) to the Train Control Center (TCC) for display as approved by the Authority.

D. Where required to achieve sufficient warning time, cab signals shall be held to a lower speed until the crossing warning system has provided indication that the crossing gates are horizontal.

E. At near-side stations, speed commands shall ensure that each train stops at the platform. Detection of a train in the platform of a near-side station shall initiate a crossing warning timer. The timer value shall ensure that the crossing warning devices are activated so that sufficient warning time is given. An additional dwell timer shall be used to restore required speed commands to the train at the end of a nominal dwell time. TWC loops in the station shall be provided to permit the operator to cancel or restart the sequence.

1.2 REFERENCE STANDARDS

A. American Railway Engineering And Maintenance-of-Way Association (AREMA):

1. AREMA – Communications and Signals Manual, Section 3 – Highway-Rail Grade Crossing Warning System

2. AREMA - Communications and Signals Manual, Section 7 – Signals

3. AREMA - Communications and Signals Manual, Section 10 – Wire and Cable

4. AREMA - Communications and Signals Manual, Section 11 – Circuit Protection

5. AREMA - Communications and Signals Manual, Section 14 – Electrical Devices, Foundation, Hardware

6. AREMA - Communications and Signals Manual, Section 15 - Materials

B. Texas Manual on Uniform Traffic Control Devices (MUTCD):

1. Texas MUTCD - Chapter 8 – Traffic Control for Rail Road and Light Rail Transit Grade Crossings

C. Texas Department of Transportation (TXDOT)

1. TXDOT – Standard Plans RCPM-96

D. State of Texas Health and Safety Code

1.3 SUBMITTALS

A. The Contractor shall submit the following for approval:

1. Shop drawings for each of the signs to be installed at the crossing.

2. Shop drawings for the assembly of AHCW layouts shall include bills of material.

B. The Contractor shall submit for Authority approval:

1. Final circuits and detail wiring plans showing control of specified equipment for each location.

2. Detailed installation drawings for each layout.

C. The Contractor shall submit manuals describing maintenance and operation of AHCW layouts provided under this Contract.

D. The Contractor shall submit Test Procedures and Results in accordance with these Specifications.

1.4 QUALITY ASSURANCE

A. Each AHCW layout component shall be inspected prior to shipment. Inspection shall conform to the Contractor’s Factory Inspection Procedure as approved by the Authority.

B. The AHCW layout shall meet the requirements of the AREMA Communications & Signals Manual.

C. AHCW systems shall meet applicable requirements of Texas MUTCD.

D. Each AHCW layout shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor’s Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority’s satisfaction.
E. The AHCW layout shall be tested according to Authority approved test procedures.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Prior to shipment, all parts of automatic gate crossing mechanism that are not painted and not made of non-corrosive material shall be coated with an approved grease to prevent corrosion. All unused threaded outlets shall be plugged or capped.

B. Relays shall be delivered, stored and handled as described in these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY PROVIDED MATERIAL

Not Used

2.2 CONTRACTOR PROVIDED MATERIAL

A. Maintenance Materials:

1. Gate Arms: Two of each length used within the system including all installation hardware.

2. Flashing Light Signals: One complete LED flasher unit for every 25 LED flasher units installed or portion thereof, including all installation hardware.

3. Gate Mechanisms: Two complete layouts including installation hardware.

4. Gate Keepers: Two complete layouts including installation hardware.

5. Solid State Crossing Controller: One complete unit of each size used within the system.

B. General

1. Highway crossing warning equipment shall be in accordance with applicable sections of AREMA Communications & Signals, Section 3.3.1 and 3.1.15.

2. Highway crossing warning equipment and associated power supply equipment shall be housed in wayside instrument cases. Crossing controllers, event recorders and any other electronic equipment shall be mounted in the upper portion of the case to minimize exposure to weather when the case doors are opened. Electronic devices shall be installed in the air conditioned side of the case.

3. Solid State crossing controllers similar to Safetran Model SSCC-TC or Authority approved equal shall be provided.

4. Main line Audio Frequency (AF) track circuits shall be used to create approach circuits in the nearest Instrument House. Copper line circuits shall be used to send the approach circuits to the nearest AHCW case, CIH or IIH. Where approved, vital timer functions shall be used to adjust the warning time.

5. Audio Frequency Overlay (AFO) track circuits shall be used for crossing island track circuit. The island circuit equipment shall be located in the AHCW.

6. Crossing signs shall be provided in accordance with sections of AREMA Communications & Signals Manual and Texas MUTCD at all highway crossings indicated on the Contract Drawings.

7. Crossings shall be equipped with warning bells in accordance with applicable sections of AREMA Communications & Signals, Part 3.2.60 and Texas MUTCD.

8. Traffic Preemption shall be provided wherever an intersection is within 300 feet of a crossing or as required in the Contract Drawings. Preemption time shall be derived from track circuit occupancy and an adjustable timer. At each crossing requiring preemption, occupancy and timer shall be configured to provide a preemption signal, adjustable from at least 60 seconds to zero seconds prior to the crossing. The Contractor shall supply and install cable to the handhole at the base of the traffic controller pole or to the nearest manhole if a handhole at the traffic controller is not provided. Sufficient cable length shall be provided so that the cable may be pulled from the interface handhole/manhole to the traffic controller and terminated by others.

C. Flashing Light Signals

1. The Contractor shall provide LED flashing light signals to be mounted on masts and cantilever arms as shown on Contract Drawings.

2. Flashing light assemblies shall consist of various configurations of back-to-back and single direction units as indicated on Contract Drawings. Additional side lights may be added as required to assure every approach roadway has a view of at least one pair of lights.
3. Each lamp housing shall be constructed of cast aluminum or other Authority approved material. The housing shall be equipped with a door with front access, hinged at one side with a weatherproof seal. A ventilation opening shall be provided at the bottom of housing and covered with brass or copper wire screening. A side light shall be provided on both sides of lamp housing complete with gasket, lens and retainer.

4. Flashing light assemblies shall house LED lighting units. The LED units shall meet the requirements of AREMA Communications & Signals Section 7.1.10. The LED unit shall operate at a range of 8-20 Volts. Power consumption of a single unit shall be 18 watts at 10 Volts. LED units shall meet or exceed AREMA Communications & Signals requirements for beam pattern in Section 3.2.37 and shall meet or exceed the power surge rating requirements in Section 11.3.3.

5. Each flashing light unit shall be equipped with, or incorporate, a roundel and phankill device in accordance with American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications and Signals Manual. It shall be highway crossing high intensity red polycarbonate, with a two inch center hot spot with a 30 degree horizontal spread and a 15 degree downward deflection except roundels for cantilever flashing light units shall have a 20 degree horizontal spread and a 30 degree downward deflection. The roundel shall be 12 inch diameter.

6. Each flashing light unit shall be equipped with a 20-inch black, high-density plastic background.

7. Each flashing light unit shall be equipped with a black high density visor.

8. Each flashing light shall be focused in accordance with sections of AREMA Communications & Signals, Section 3.3.5.

D. Masts

1. The Contractor shall provide masts for supporting flashing light signals, flashing light signals with gates and pedestrian gates as indicated on the Contract Drawings. Mast shall be five-inch aluminum pipe complete with pinnacle cap and aluminum split base. Length of mast shall be as indicated on Contract Drawings.

2. Junction boxes for flashing light signal masts, flashing light signals with gate mast and pedestrian gate masts shall be in accordance with these Specifications.

3. In any portion of the Work where gate junction box elevations will be below the flood plain, the Contractor shall provide a secondary mast-mounted junction box above highest anticipated flood levels and make cable connections in the secondary junction box. Cables may not be terminated below maximum anticipated flood plain levels.

4. When there is a curb and no sidewalk, a horizontal clearance of at least 2 feet shall be provided from the face of the vertical curb to the closest part of the signal or gate arm in its upright position in accordance with Texas MUTCD Chapter 8D.01 Flashing-Light Signals, Gates, and Traffic Control Signals Section.

5. Where there is a shoulder, but no curb, a horizontal clearance of at least 2 feet from the edge of a paved or surfaced shoulder shall be provided, with a clearance of at least 6 feet from the edge of the traveled way in accordance with Texas MUTCD Chapter 8D.01 Flashing-Light Signals, Gates, and Traffic Control Signals Section.

6. Where there is no curb or shoulder, the minimum horizontal clearance shall be 6 feet from the edge of the traveled way in accordance with Texas MUTCD Chapter 8D.01 Flashing-Light Signals, Gates, and Traffic Control Signals Section.

7. Where there is a curb and sidewalk, a horizontal clearance of at least 7 feet shall be provided from the face of the vertical curb to the centerline of the closest signal or gate mast in accordance with Texas MUTCD Chapter 8 - Traffic Controls For Highway Light Rail Transit Grade Crossings.

8. Warning gates/flashers shall be installed at all highway crossing indicated on the Contract Drawings measured perpendicular from the centerline of near track, maintaining a minimum distance of 12 feet, usual distance is 15 feet in accordance with Texas Department of Transportation – Standard Plans RCPM-96.

E. Cantilevers

1. The Contractor shall provide cantilever mast and arm assemblies in accordance with these Specifications and as shown on Contract Drawings.

2. Cantilever structure shall be an aluminum non-retractable walkout type. Mast shall be constructed from a minimum 10-inch aluminum pipe with a solid base for arms up to 20 feet. The structure shall be a single 12-inch mast for arm lengths of 22 to
24 feet and double 10-inch mast for arms over 24 feet. A pole mounted junction box shall be provided with provisions for terminating signal cable on AAR terminals. Junction box shall be equipped with a gasketed front door with means of padlocking.

3. Cantilever shall be designed to withstand a wind velocity of 100 mph, gusts of 130 mph, with a maximum horizontal deflection of three degrees 15 minutes and capable of supporting a 500 pound load at the end of the arm with all flashing light units and signs installed.

4. Structure shall be equipped with a ladder, ladder guard and walkway. Ladder shall be provided with a lockable cover plate and padlock to prevent unauthorized use. Walkway shall be equipped with handrails on both sides and shall be a minimum of 20 inches wide, constructed of expanded metal to provide good footing and prevent ice buildup. Handrails shall consist of a top rail 30 inches above the walkway and an intermediate handrail 18 inches above the walkway.

5. The minimum clearance from high voltage overhead wires shall be in accordance with the Texas Health and Safety Code (Chapter 752) during and after cantilever installation. Minimum clearance from low voltage lines (less than 600 volts) shall be 10 feet over the walk and 4 feet from the edges of the cantilever structure.

6. Cantilever shall be installed perpendicular to roadway and the tip of the cantilever arm shall extend to the most inside travel lane. The Authority must approve any deviation from perpendicular installation.

7. When there is a curb and no sidewalk, a horizontal clearance of at least 2 feet shall be provided from the face of the vertical curb to the centerline of the closest signal in accordance with Texas MUTCD Chapter 8D.01 Flashing-Light Signals, Gates, and Traffic Control Signals Section.

8. Where there is a shoulder, but no curb, a horizontal clearance of at least 2 feet from the edge of a paved or surfaced shoulder shall be provided, with a clearance of at least 6 feet from the edge of the traveled way in accordance with Texas MUTCD Chapter 8D.01 Flashing-Light Signals, Gates, and Traffic Control Signals Section.

9. Where there is no curb or shoulder, the minimum horizontal clearance shall be 6 feet from the edge of the traveled way in accordance with Texas MUTCD Chapter 8D.01 Flashing-Light Signals, Gates, and Traffic Control Signals Section.

10. Where there is a curb and sidewalk, a horizontal clearance of at least 7 feet shall be provided from the face of the vertical curb to the centerline of the closest signal in accordance with Texas MUTCD Chapter 8. Traffic Controls For Highway Light Rail Transit Grade Crossings

11. Warning signals shall be installed at all highway crossing indicated on the Contract Drawings measured perpendicular from the centerline of near track, maintaining a minimum distance of 12 feet, usual distance is 15 feet in accordance with Texas Department of Transportation – Standard Plans RCPM-96.

F. Gates

1. General

a. The Contractor shall provide automatic highway crossing gates complete with gate mechanism, gate arm, counterweights, gate arm lights, wind guards when gates are 20 feet or longer, and all required mounting hardware as specified herein, in accordance with AREMA Manual, Section 3 and as shown on the Contract Drawings.

b. General design, painting and striping of gate arm shall conform to the AREMA Communications and Signals Manual, Section 3.2.25 or 3.2.26. Striping shall consist of 16-inch alternate reflectorized red and white stripes on both sides of the arm. The arm shall be constructed of fiberglass and be designed to ensure reasonable durability and rigidity to prevent undue sway or whipping. Clearance between the gate arm and any fixed portion of the assembly shall be a minimum of two inches. Gate over 30-feet in length shall be wooden A-frame configuration. Gate arms shall be attached to the gate mechanism with a "break-away" arm utilizing a pivot pin and shear bolts.

c. A gate test push-button, externally mounted on the side of the case nearest the crossing, shall be provided, with provisions for a hasp and lock.
e. Gate malfunction alarm shall be activated when any of the following conditions are met:

1) There is a failure of the solid state crossing controller.
2) A crossing gate is down with the approaches and island circuits vacant.
3) The approach has been occupied with gates down for two minutes.

2. Gate Arm

a. Gate crossing arm similar to EZ Gate with fiberglass first section and telescoping fiberglass second section or Authority approved equal shall be provided.

b. Highway crossing gate arms shall be of sufficient length to extend to within one foot of the extent of the lanes it is intended to warn and provide a minimum clearance of two feet from low voltage (less than 600V) overhead wire and cable.

c. Where gate arms are 6 feet or longer, the Contractor shall provide a gate light within one foot of the gate tip.

d. Where shown on Contract Drawings, the Contractor shall provide auxiliary gate arms complete with auxiliary shafts and required mounting hardware.

e. Where gate arms are provided, the Contractor shall provide fiberglass arms with the same requirements as for main gate arms.

f. Gate arm shall cover adjacent sidewalk.

g. Gate arm counter weights shall not intrude into sidewalk envelope.

h. Ten-volt LED weatherproof, bi-directional gate arm lights similar to EZ GATE system lamps or approved equal shall be provided in accordance with AREMA Communications and Signals Manual, Section 3.2.40 with highway crossing red lenses.

3. Wind Guards: Gate arm lengths of 20 feet or longer shall have wind guards.

4. Gate Mechanism

a. Gate mechanism shall be housed in one enclosure and include a 12 volt DC motor, gear train, control elements, wire terminals and suitable counterweights.

b. Gate mechanism housing shall be weatherproof and of ample size to house the equipment properly without crowding. Housing shall be equipped with a door for convenient and ready access and be designed with at least two hooded ventilation openings with brass or copper wire screens. Housing shall be constructed of cast aluminum.

c. Gate mechanisms shall be provided with an internal wiring diagram protected by a plastic laminate and shall be fastened to the inside of mechanism cover.

d. Mechanism shall be equipped with a hold clear device to hold the mechanism in the clear position with 450 foot-pounds applied to the shaft.

e. A mechanism support shall be provided with each gate mechanism. The mechanism support shall provide a base upon which the gate mechanism rests and support the weight of the mechanism when it is required to swing gate mechanism for repairs.

f. Circuit controller shall be equipped with copper or brass contacts with sufficient mechanical strength, current carrying capacity, and self-clearing design. Contacts shall be accessible and adjustable. Circuit controller shall be equipped with sufficient contacts to accommodate control and indication circuits as shown on Contract Drawings.

g. Relays in the gate operating unit shall be non-vital type in accordance with these Specifications.

h. Gate Keeper similar to General Signals, Inc., part #SK-1000-C or with Authority approved equal shall be provided.
i. Gate mechanism shall be equipped with an on board gate monitoring system that provides protection of the mechanism if any of the existing conditions exist:

1) Rapid descent of the counterweights caused by a gate arm being knocked off.

2) Rapid descent of the gate arm caused by a loss of power (entrance gates).

3) Rapid ascent of the gate arm caused by a loss of power (exit gates).

4) The gate arm pumps.

5) The motor overloads due to an obstructed gate arm.

j. The gate mechanism shall be equipped with (as standard) a power down and test switch that operates the mechanism to the horizontal position without a gate arm in place.

k. Gate mechanisms shall be provided with circuit protection, either by a fuse or a circuit breaker.

l. Gate mechanisms similar to Western-Cullen Hayes model 3597, Invensys Rail model S-60 or Authority approved equal shall be used.

G. Audio Frequency Overlay Track Circuits

1. Audio frequency overlay track circuits shall be provided for the island track circuits.

2. The overlay track circuits shall be audio frequency, compatible with AF track circuit frequencies, with cab signal frequency, and with the traction power negative return system.

3. The AFO track circuit shall be designed to detect occupancy throughout the length of the circuit. Shunting sensitivity shall be 0.25 ohm impedance at the receiving end of the circuit at the operating frequency.

4. The Contractor shall be responsible for assigning frequencies to the audio frequency overlay track circuits that are compatible with each other and shall not falsely energize or interfere with other track circuits, or interfere with cab signals.

5. AFO track circuits shall be set-up in accordance with the manufacturer’s procedures and be protected with lightning arrestors, equalizers and field side fuses.

H. Solid State Crossing Controller

1. A solid-state crossing controller shall be provided for each AHCW location as indicated on the Contract Drawings. The solid-state crossing controller shall meet all requirements of AREMA Communication & Signals Manual, Section 3.1.25 and Section 3.1.15 as Authority approved.

2. The crossing controller shall be fully integrated, vital, solid-state circuitry device, providing lamps, bells and crossing gates.

3. The crossing controller shall provide a voltage adjustment feature. The output voltage, once adjusted shall be constant.

4. The solid-state crossing controller shall be voltage surge protected.

5. The lamp flash rate shall be 45 to 50 flashes per minute.

I. Other Equipment

1. Crossarms for flashing light units shall be in accordance with AREMA Communications & Signals Manual, Section 3.2.51 as Authority approved.

2. Crossarms for flashing light units shall be constructed of cast aluminum in accordance with AREMA Communications and Signals Manual, Section 3.2.50.

3. Bells shall be provided with 12-inch diameter by two-inch-deep gong with a steel faced clapper in a weatherproof housing. Housing shall be constructed of cast aluminum. The door shall be designed with suitable hinges and a gasket. Bell shall conform to AREMA Communications and Signals Manual, Section 3.2.60. Normal operating voltage shall be 10 VDC.

4. Railroad crossing signs shall be white reflex-reflective sheeting on sheet aluminum with the words “RAILROAD CROSSING” in black letters, in accordance with Texas MUTCD, Article 8 B-2.

5. Number-of-track signs shall be constructed of aluminum alloy and be corrosion resistant. Black letters and numbers on a white background shall be of reflex-reflective sheeting on sheet aluminum.
6. Emergency Notification signs I-13, or I-13A shall be in accordance with Texas MUTCD, Chapter 8.

7. The crossing control shall be provided with an “Out of Service” switch for each track crossing the highway. Activation of the switch shall disable the warning system for the associated track. In cab signaled territory, activation of the switch shall set speed commands such that approaching trains on the out-of-service track are stopped prior to arrival at the crossing and run time sufficient to ensure approaching trains have stopped prior to disabling the warning system for the associated track.

8. Batteries and chargers shall be sized to provide proper operating voltages and currents throughout the highway crossing warning cycle.
   a. An additional battery cell shall be provided for grade crossings where activation of the warning system causes the voltage measured at any gate mechanism to drop below 85% of the rated voltage.

9. Binding posts, nuts, washers and insulators shall conform to AREMA Communications and Signals Manual, Section 14.1.11.

10. Enclosures housing AHCW equipment shall be provided with signs on the front and back of the enclosure identifying the street name and milepost number of the crossing.

PART 3 - EXECUTION

3.1 PRODUCTION
Not Used

3.2 INSTALLATION

A. Contractor shall install AHCW layouts including all flashing light signals, gates, signs, masts, junction boxes and interfaces in accordance with these Specifications and approved installation drawings.

B. Flashing Light Signal Installation

1. Flashing light signal mast shall be securely fastened within the split base in a manner such that the distance between the split halves of the base shall be equal. Heads of bolts in the base assembly shall be squared with each other and facing oncoming highway traffic.

2. Base shall be securely fastened to the concrete foundation with hardware provided for that purpose. Mast shall be plumb when base assembly is fastened to foundation. Shims, spacers, or other filler devices shall not be used to level and plumb flashing light signal equipment.

3. A hole shall be factory drilled in the mast for the bottom crossarm. Centerline of the hole shall be located so that, when the crossarm with light units is attached thereto, center of lens of the light unit shall be seven feet-ten inches above the top of foundation. Holes for additional crossarms, when required, shall be located in the field after bottom crossarm has been secured to the mast. Location and drilling of hole shall result in the centerline of additional light units to be 23 inches above centerline of lower light unit.

4. Bell(s) shall be installed on top of mast of flashing light unit. A minimum of one (1) bell per crossing shall be provided. Where gate mechanisms are more than 80 feet apart a second bell shall be provided. Face of bell gong shall be parallel with highway.

5. Underground cables shall be installed within the mast and terminated in crossarm junction box in a manner as required in these Specifications.
   a. Wiring for flashing light units and bell shall be 37 strand, No. 10 AWG (minimum) in accordance with requirements of AREMA Communications and Signals Manual, Section 10.3.11.
   b. Wiring for bells shall go directly from bottom crossarm junction box to the bell.
   c. Terminations for flasher unit and bell wiring shall be solderless compression type terminals as required by these Specifications.

6. With AC power off and standby battery in a fully charged condition, lamp voltage shall be adjusted to 9-1/2 volts (measured at the lamp) by varying resistor for the flasher unit; then, with AC power on, lamp voltage (measured at the lamp) shall be adjusted to the same voltage by varying lighting transformer taps.

7. Front lights of flashing light unit shall be focused to provide maximum visibility for oncoming highway traffic. Backlights of flashing light unit shall be focused to provide close up visibility for oncoming highway traffic from the opposite direction.
C. Cantilever Installation

1. Base of cantilever shall be securely fastened to the concrete foundation with hardware provided for that purpose. Mast shall be plumb when base assembly is fastened to the foundation. Shims, spacers, or other filler devices shall not be used to level and plumb cantilever layouts.

2. Railroad crossing sign for cantilever arm shall be securely fastened with hardware provided for that purpose.

3. Front lights of the main mast and cantilever unit shall be focused to provide maximum visibility for oncoming highway traffic. Back lights of the main mast and cantilever unit shall be focused to provide close up visibility for oncoming highway traffic from the opposite direction.

4. Installation of cantilever shall provide a minimum clearance of 17 feet 6 inches above roadway.

D. Vehicle Warning Gates

1. Base shall be securely fastened to concrete foundation with hardware provided for that purpose.

2. Heads of bolts in base assembly shall be squared with each other and facing oncoming highway traffic.

3. Masts shall be securely fastened within junction box base in a manner such that the distance between split halves of base shall be equal when tightened.

4. Mast shall be plumb when base assembly is fastened to foundation. Shims, spacers, or other fillers shall not be used to level and plumb highway crossing warning gates.

5. Gate operating mechanism, including counter-weight arms, shall be securely fastened to the mast with hardware provided for that purpose.

6. Mechanism shall be located on mast in a position that shall allow for gate arms, when in down position, to be not more than 4 feet-6 inches, or less than 3 feet-6 inches, above roadway crown.

7. Fiberglass gate arms shall be fastened to gate arm mounting assembly with hardware provided for that purpose.

8. Underground cables shall be installed in the split base junction box or auxiliary junction box in flood areas. Cables shall be dressed, tagged and terminated as required by these Specifications.

9. Gate arm counterweights shall be adjusted in accordance with manufacturer's standards for the length of gate arm specified.

10. Gate arm tip light shall be steadily illuminated and other gate arm lights will flash in unison with mast and/or cantilever mounted lights.

11. Gate arm torque shall be adjusted in accordance with manufacturer's standard.

12. Gate mechanism shall employ a drive down feature where descending time can be adjustably controlled to permit gate arm to descend smoothly and evenly from clear to horizontal position within 10 to 15 seconds. Gate arm shall ascend to upright position in not more than 12 seconds.

13. Operation of mechanism shall be such that it will reverse its direction of movement to reflect a change in track occupancy.

14. Gate mechanism shall operate smoothly and complete all movements without rebounding. It shall be securely held in the clear position until conditions require gate to be lowered.

15. Install gate malfunction indication for indication at Train Control Center (TCC) via the Signal Remote Terminal Unit (RTU).

E. Pedestrian Warning Gates

1. Base shall be securely fastened to concrete foundation with hardware provided for that purpose.

2. Heads of bolts in base assembly shall be squared with each other and facing oncoming highway traffic.

3. Masts shall be securely fastened within the junction box base in a manner such that the distance between split halves of base shall be equal when tightened.

4. Mast shall be plumb when base assembly is fastened to foundation. Shims, spacers, or other fillers shall not be used to level and plumb highway crossing warning gates.

5. Gate operating mechanism shall be securely fastened to the mast with hardware provided for that purpose.
6. Mechanism shall be located on the mast in a position that shall allow for gate arms, when in down position, to be not more than 4 feet 6 inches, or less than 3 feet 6 inches, above the sidewalk.

7. Fiberglass gate arms shall be fastened to gate arm mounting assembly with hardware provided.

8. Underground cables shall be installed in the split base junction box or auxiliary box in flood areas. Cables shall be dressed, tagged and terminated as required by these Specifications.

9. Gate arm tip light for arms 6 feet or longer shall be steadily illuminated.

10. Gate arm torque shall be adjusted in accordance with manufacturer's standard.

11. Gate mechanism shall employ a drive down feature where descending time can be adjustably controlled to permit the gate arm to descent smoothly and evenly from clear to the horizontal position within 10 to 15 seconds. Gate arm shall ascend to upright position in not more than 12 seconds.

12. Operation of mechanism shall be such that it will reverse its direction of movement to reflect a change in track occupancy.

13. Gate mechanism shall operate smoothly and complete all movements without rebounding. It shall be securely held in the clear position until conditions require gate to be lowered.

F. Wind Guards: Where gate arm lengths are 20 feet or longer, wind guards shall be mounted on the mast.

3.3 TESTING

A. Automatic highway crossing warning layouts shall be tested in accordance with these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 "Signal System Basic Technical Requirements."
PART 1 - GENERAL

1.1 DESCRIPTION
A. Work to be done under this Section consists of designing, providing and installing signal power distribution and supply systems.

1.2 REFERENCE STANDARDS
A. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (NEC)
B. National Electrical Manufacturers Association (NEMA)
   1. NEMA 4 - NEMA Standards Publication 250-2003 Enclosures for Electrical Equipment (1000 Volts Maximum)
   2. NEMA 12 - NEMA Standards Publication 250-2003 Enclosures for Electrical Equipment (1000 Volts Maximum)
   3. NEMA AB-1 - Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures

1.3 SUBMITTALS
A. The Contractor shall submit the following for Authority approval:
   1. Catalog cuts and descriptive literature for all power system material.
   2. AC and DC power calculations based on the total peak load that will exist at each signal equipment location. Calculations shall include 25 percent spare capacity of total peak load at each location for future expansion.
   3. Voltage drop calculations for 480 VAC single-phase signal power express cables in accordance with these Specifications.
   4. Plans showing layout of a typical signal power distribution center.
   5. The Contractor shall include schematic plans showing energy distribution of signal power equipment at each signal equipment location. These plans shall include ratings of protective devices and transformers, as well as required cable and wire sizes.
   6. Circuit drawings and drawings showing power layout of feeders, transformer switches, fuses, breakers and buses.
   7. Test Procedures and Results in accordance with these Specifications.

1.4 QUALITY ASSURANCE
A. Materials and equipment provided and installed shall conform to the latest edition of the NEC and all applicable state and local ordinances.
B. Each signal power system component shall be inspected prior to shipment. Factory tests and inspections of the signal power system equipment shall be to manufacturer's standard as approved by the Authority.
C. Each signal power system component shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.
D. Performance tests of the equipment and materials provided and installed shall ensure compliance with these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL
A. Not Used

2.2 CONTRACTOR FURNISHED MATERIAL
A. General
   1. Power feed to signal power distribution equipment shall be obtained from traction power substation's 480 VAC 60 Hz provided in the Traction Power Substation (TPSS). The Contractor shall provide and install the circuit breakers in the TPSS.
   2. From the SPDC, the Contractor shall provide and install a signal power distribution system. The system shall consist of a 480 VAC 60 Hz single-phase two wire transmission feeders with wayside signal power taps as required.
   3. Ventilation fans shall be provided in all SPDC and shall be sized to provide adequate cooling with outside air temperatures of 110 degrees Fahrenheit (F) and summer radiant heat levels.
B. Signal Power Distribution Equipment
   1. SPDC equipment shall be mounted in a wayside case or as shown on the Contract Drawings. Case shall comply with the requirements these Specifications.
   2. The SPDC shall include a wireway box to tee cable from TPSS to sectionalizing switches for each power distribution cable. Disconnect
switches shall be manually operated, double pole, single throw, fusible, rated for heavy-duty application intended to sectionalize energized 480 VAC single-phase 60 Hz circuits. Short circuit ratings shall be equal to or greater than the maximum short circuit to which the switch would be subjected. Ampere ratings shall be determined by the Contractor for the projected loads and shall include 25 percent spare capacity for future expansion.

3. The SPDC shall be provided with a 480 volt to 120 volt step-down transformer for SPDC hotel power. A 120 volt breaker panel shall be provided. The panel’s main breaker shall be rated at 40 amps minimum. Individual breakers in the panel shall be provided for the case lights and outlets and for the ventilation system.

4. The ventilation system shall be thermostat controlled. Thermostat shall be initially set to operate the ventilation system at 90 degrees F or above.

5. Each SPDC will be fitted with a Generator plug mounted on the exterior of the case with weatherproof cover. An interlocked disconnect within the SPDC shall allow selection of the generator plug as the power source for the SPDC. The interlocked disconnect shall ensure that the TPSS feed and the generator plug are never simultaneously connected.

C. AC Power Equipment

1. Circuit Breakers
   a. Circuit breakers for power feed to Instrument Houses and wayside signal cases for 480 VAC distribution shall be thermal magnetic, molded case type, two pole, rated at 480 VAC. Ampere ratings shall be determined by the Contractor for projected loads. Loads shall not exceed 80 percent of the circuit breaker ampere rating. Ampere ratings shall include 25 percent spare capacity for future expansion.
   b. Circuit breakers shall provide adequate overcurrent protection for connected equipment. Circuit breakers shall be UL listed conforming to the requirements of NEMA AB 1-1986.
   c. Short circuit rating shall be equal to or greater than the maximum short circuit to which they would be subjected, with a UL listed interrupting rating of not less than 14,000 symmetrical amperes rms.
   d. Molded case circuit breakers shall have toggle type mechanisms, providing quick-make, quick-break operation. Circuit breakers shall be calibrated for operation in an ambient temperature of 40 degrees Celsius (C). Each circuit breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole. Circuit breakers shall have reverse connection capability and be suitable for mounting and operating in any position.
   e. Circuit breakers shall be provided with removable lugs. Lugs shall be UL listed for 90 degrees C. copper wires.
   f. Circuit breaker enclosures shall be NEMA type 12, provided without knockouts. Enclosure shall be fabricated from galvanized steel, with an electrodeposited, gray baked enamel finish. The external operating handle shall be an integral part of the box, not the door. Enclosure shall be UL listed.

2. Signal power isolation transformers shall conform to the requirements of these Specifications.

D. Signal Power Distribution Centers

1. SPDC shall be enclosed in equipment cases and installed near TPSS. The Contractor shall verify specific site assignments as shown on Contract Drawings.

2. Power distribution centers shall consist of a 480 VAC two pole, thermal magnetic, molded case circuit breakers housed in NEMA type 12 enclosures. Ampere ratings shall be determined by the Contractor for the projected loads. Loads shall not exceed 80 percent of the circuit breaker ampere rating. Ampere ratings shall include 25 percent spare capacity for future expansion.

E. Power cables for the distribution of power to signal equipment locations shall be as required in these Specifications.

F. Instrument House Power Equipment

1. Ground Detectors
   a. Each DC ground detector shall be sensitive enough to detect leakage currents from either terminal of the floating supply to ground through leakage paths having resistance as high as 7,000 ohms.
   b. Ground detection scheme shall be immune to transient current flows that may be the result of charging distributed supply-to-ground
capacitances. It shall also be immune to induced power line ripple that may exist between the supply leads and ground.

c. Ground detectors shall have a memory capability to provide an indication of a momentary leakage condition. The memory shall be held until reset by a push button provided for that purpose.

d. Operation of ground detectors shall not interfere with operation of power or signal circuits or equipment.

e. Ground detector circuits shall meet the fail-safe design criteria with respect to open circuits. Furthermore, the shorting and opening of any component part of the ground detector circuits shall be detectable.

f. Made ground in the ground detecting part of circuits shall be checked to validate its presence. This check shall be made in a fail-safe manner.

g. Ground detector repeater relays shall be vital relays and shall be energized when no ground is detected.

h. Ground detector circuits shall operate in a stable condition over the specified temperature range and over the voltage range specified for each power supply being monitored as specified within these Specifications.

i. Each ground detector shall be equipped with a three-position, center off, momentary contact test switch to check the operation of that detector, by providing momentary 7,000 ohm-to-ground leakage paths for the DC buses being monitored.

j. It shall be required to manually reset the ground detectors to their normal operating condition after a ground has been detected and eliminated.

k. Each ground detector shall be equipped with indication lights:

   1) to indicate that both buses are clear of grounds.

   2) to indicate that a ground has occurred on that bus.

l. Each ground detector shall be equipped with one independent isolated contact for remote indication of alarm condition.

2. Storage Batteries

a. Design

   1) Each cell of the battery assembly shall be hermetically sealed.

   2) Battery shall be leak and spill proof. No electrolyte shall be lost when battery is stored or mounted in any position, or if a cell container should become ruptured.

   3) Battery shall not be capable of explosion under any condition, including a short circuit discharge.

b. Operating Characteristics

   1) Battery shall produce the rated capacity when operated in any position.

   2) Battery shall be capable of a minimum of 1000 charge-discharge cycles to 80 percent discharge without loss of capacity.

   3) Battery shall not release gas, fumes, or any toxic substances when operated under normal conditions, or when charged or discharged at a maximum recommended rate.

   4) Battery shall be capable of normal operation and suffer no damage after being frozen and thawed.

   5) Battery shall not require charging voltages of more than 2.25 volts per cell to maintain rated capacity and life.

   6) Battery shall, if totally discharged, be capable of being recharged to rated capacity with charging voltages of no more than 2.30 volts per cell.

c. Maintenance

   1) Battery shall be "maintenance free," meaning that no addition of water will be required and no overcharge will be required.
### Battery size and application

1) The Contractor shall calculate loads based upon the equipment he proposes to furnish. All batteries shall be sized for a minimum 8-hour standby capacity.

### Battery Chargers

a. Battery Charger similar to Cragg Railcharger model ETC-12V or Authority approved equal shall be provided.

b. Charger shall be a panel-chassis combination with a perforated protective cover. The design shall provide natural convection cooling.

c. Front mounting shall be designed to mount in a standard 19-inch rack space with EIA hole spacing.

d. Front panel shall contain one voltage failure light, output ammeter and output voltmeter. Meter accuracy shall be plus or minus two percent with nominal voltage readings at center scale.

e. Terminal binding posts for input, output and alarm circuits shall be provided. Each terminal shall be insulated from the frame of the unit.

f. All chargers shall be clearly and permanently labeled with manufacturer's name, serial number, part or model number and input and output rating.

g. Battery charging equipment shall be designed for continuous operation.

h. Battery charging equipment shall be designed to deliver rated outputs with input voltage of 100 to 130 volts AC, with a 60 or 100 Hz, single phase, two wire input.

i. Battery charging equipment shall have a reserve capacity at least 25 percent above calculated requirements.

j. Each charger shall be provided with independently adjustable float and recharge voltages, current limiting and automatic charge control. The battery charger shall have automatic, electronically controlled temperature compensation for float voltages.

### Lightning and Surge Protection

1. The Contractor shall provide lightning protection and surge protection that is effective in protecting all power equipment and downstream equipment from damage and operational malfunction. The Contractor shall provide as many applicable types and stages of protection as required to protect each type of circuit and equipment involved.

2. Primary surge arrestors shall have the ability to shunt relatively high current surges to ground with relatively little overshoot.

3. Secondary surge suppressers shall have the ability to shunt-to-ground any surge overshoot from the primary arrester devices.

### Inverters

a. Inverters shall operate with DC input voltages of 9.0 to 18.0 volts.

b. Output shall be 100 Hz of sufficient voltage and current to operate a single power frequency track circuit. Alternatively, the inverter may be used to drive a follower to achieve the required output.

### Functional Requirements

A. The Signal Power System shall be designed to provide normal operations for 8 hours using a battery back-up, with the exception of switch machine operation.
B. Switch machine control at junctions and terminal interlockings shall be provided with an alternate source of AC power. Automatic transfer switches shall be provided to switch between the primary and alternate source.

C. Power frequency track circuits shall receive power from 12V/100V 100Hz invertors.

D. Ventilation systems shall be designed to operate on back-up power.

2.4 DELIVERY, STORAGE AND HANDLING

A. All signal power equipment shall be protected from damage during shipping and delivery.

B. Any damage incurred in transit or caused by mishandling or improper storage shall be at the expense of the Contractor.

C. Batteries shall be stored and delivered in a fully charged state. Batteries shall not be stored for more than 90 days. Batteries shall be shipped separately from housings in which they are to be used.

PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 INSTALLATION

A. Source energy, 480VAC 60 Hz, for the signal power distribution systems shall be obtained within the traction power substations. The Contractor shall install a breaker for signal power from the auxiliary transformer in the substation. Power cables shall be installed from the breaker panel through the interface manhole to the SPDC. Unless otherwise approved, the Contractor shall limit the distribution from a single SPDC to 50 KVA for worst-case loading.

B. Each SPDC shall be installed on a precast pillars in accordance with the requirements in these Specifications and the Contract Drawings. SPDC’s shall be installed in the areas shown on the Contract Drawings and not less than 8 feet-6 inches from centerline of tracks at any point. Access shall be provided to the foundation bolts from inside the enclosure.

C. Each SPDC shall be level and plumb. SPDC’s installed on slabs shall be mounted on an Authority approved neoprene pad. Pad shall be installed between the base of the enclosure and the concrete foundation.

D. Each SPDC shall be externally grounded as required by these Specifications.

E. Cables shall enter SPDC by entrance knockouts with fittings and entrance conduits provided. Cables shall be dressed, tagged and terminated as required by these Specifications.

F. Exterior paint of each SPDC shall be inspected after installation and any damage repaired in accordance with the paint manufacturer’s instructions and as Authority approved.

G. Signal Power Equipment

1. Wayside signal power equipment shall be installed in accordance with manufacturer’s recommendation, NEC, and the Authority approved Contractor plans.

2. Circuit Breakers

a. 480 VAC two pole molded case circuit breakers shall be mounted within the TPSS and SPDC using galvanized steel screws and associated hardware.

3. Signal Power Isolation Transformers

a. Signal power isolation transformers shall be installed as required by these Specifications.

4. Disconnect Switches

a. Disconnect switches shall be wall mounted. Disconnect switches shall not be mounted close to entrance door.

b. Disconnect switches shall be mounted level and plumb.

5. 100 Hz. Invertors

a. 100 Hz invertors shall be installed in Central Instrument Houses.

b. Invertors shall be installed in accordance with Authority approved Contractor plans and manufacturer’s installation instructions.

6. Power Cables

a. Install cables from SPDC to TPSS through the interface manhole in conduits and terminate on breakers in the TPSS.

b. All cable entrance to signal equipment housings shall be from the bottom.

c. Cables shall be installed as specified in these Specifications.

7. AC Ground Detectors
a. AC ground detectors shall be mounted on instrument racks in instrument houses.

H. Rectifiers and Battery Chargers

1. The Contractor shall provide all mounting hardware, terminals and terminators, for mounting wall mounted rectifiers and battery charger units in wayside cases and signal instrument houses.

I. Storage Batteries

1. Battery cells are to be arranged in wooden trays which shall be mounted on steel racks of a design and size subject to the Authority approval. Wood trays shall be painted with two coats of paint resistant to the acid in the batteries. Unless otherwise approved, batteries shall be mounted on battery racks having a single tier.

2. Battery posts shall be coated with an approved grease and battery connectors securely fastened to the battery posts.

3.3 TESTING

A. The signal power system shall be tested in accordance with these Specifications.

B. Simulated load tests in accordance with Authority approved signal power system test procedures shall be satisfactory completed prior to final connection of signal facilities at each equipment location.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”
PART 1 - GENERAL

1.1 DESCRIPTION
A. The Work to be done under this Section consists of designing, providing and installing factory wired Central Instrument Houses (CIH) and Intermediate Instrument House (IIH) as described in these Specifications and as shown on Contract Drawings.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus

B. American Railway Engineering And Maintenance-of-Way Association (AREMA)
   1. AREMA - Communications and Signals Manual, Section 14 – Electrical Devices, Foundations, Hardware

1.3 SUBMITTALS
A. The Contractor shall submit for Authority approval, drawings and product detail for each type instrument house required.

B. The Contractor shall include:
   1. Drawings of each instrument house construction showing proposed size, empty and fully equipped weight, rack layout, location layout, method of house mounting, local control panel, vital relays, microprocessors, communications equipment, event recorders, plan rack and plan table. The Authority's approval shall be obtained prior to manufacture of each instrument house.
   2. Foundation and house mounting details.
   3. Drawings of the grounding grid arrangement.
   4. Details for the fire detection system, intrusion detection system, and environmental control equipment for all instrument houses.

C. The Contractor shall submit Test Procedures and Results in accordance with these Specifications.

1.4 QUALITY ASSURANCE
A. The Contractor shall factory test each instrument house and the functioning of equipment contained within each house in accordance with Authority approved Factory Test Procedures.

B. Instrument houses shall meet the requirements of the AREMA Communications and System Manual, Section 14.4.

C. The Contractor shall inspect each instrument house after it has been installed and correct any deficiencies. This inspection shall be conducted in conformance with requirements of Authority approved Installation and Inspection Procedures.

D. Instrument houses shall be tested according to Authority approved test procedures.

1.5 DELIVERY, STORAGE AND HANDLING
A. All equipment shipped within each instrument house shall be properly fastened and braced to prevent damage during transit. Any equipment damaged during transit, installation, testing and before being placed in service shall be replaced at no additional cost to the Authority.

B. Relays shall be delivered, stored and handled in accordance with these Specifications.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL
Not Used

2.2 CONTRACTOR FURNISHED MATERIAL
A. General
   1. Central Instrument Houses (CIH) are to be located near each interlocking, and shall contain all equipment required for the safe and reliable operation of the interlocking. Equipment enclosure designated Intermediate Instrument House (IIH) are located between interlockings where the distance from CIH to adjacent CIH is more than double the manufacturer’s recommendations for maximum distance permitted between the controlling CIH and the track circuit coupling device at the rail. Equipment provided in an Intermediate Instrument Houses shall include power supply and battery, track circuit equipment; code generating equipment; and vital processor for code selection logic and vital communication between adjacent equipment locations.
2. The size of each instrument house shall be determined by the Contractor in accordance with these Specifications and be of adequate size to house all equipment and provide 25 percent spare space as described in these Specifications. Instrument houses shall not exceed the footprint as shown on the Contract Drawings unless Authority approved.

3. Each instrument house shall have adequate space for housing communications interface equipment as shown on Contract Drawings.

4. The Contractor shall secure all required building permits and jurisdictional approvals prior to installation of instrument houses.

B. Design and Fabrication

1. General Requirements for CIH and IIH
   a. Each instrument house shall be of modular construction of 12 gauge minimum sheet steel, unless otherwise Authority approved. Tops and sides of the houses shall be lined with a fire resistant insulating material complying with a flame spread of 0-20 and a fire rating of seven in accordance with ASTM-E-84 and having a minimum insulation rating of R-16.
   b. Exterior doors shall be hinged and employ a gasket that provides a dust proof and weatherproof seal. Doors shall be designed with a two-position latching device. Doors shall be provided with handles, hasps, and a three-point locking device that will ensure door cannot be locked when not fully closed. Panic bars shall be provided to open doors from the inside.
   c. A 1/4 inch by 2-inch by 2-inch angle plate shall be securely fastened on the exterior of all instrument house doors with provisions made for a vandal proof lock to secure the door angle plate to an angle plate securely fastened on the instrument house. This locking arrangement shall be provided in addition to the normal locking mechanism and handle. Hinges shall be separate castings securely fastened to the housing and door. Hinges shall be equipped with bronze hinge pins, pressure-lubricating fittings and lubricated by the manufacturer before the instrument house is shipped.
   d. Instrument house width shall not exceed 10 feet. The length shall vary in 2-foot lengths from 8 feet to a maximum of 48 feet. Interior headroom shall be a minimum of 7 feet. Spacing between instrument racks shall be as required in these Specifications.
   e. Instrument house shall be dust tight and insulated to provide maximum heating and cooling system efficiency.
   f. Instrument houses shall be provided with signage above each door to identify the house. The sign shall have a white, reflective background with three inch black lettering. The signs shall display the location name and either “CIH” or “IIH”, as appropriate for the location.

2. CIH Requirements
   a. There shall be two areas in each instrument house: a large area to accommodate the signal equipment; and a smaller area to accommodate the local control panel (LCP) and communication equipment. An inside door shall separate the two areas and an outside access door shall be provided for each area. The areas shall be separated by steel mesh panel construction. It shall be equipped with a lock arranged for access from the signal equipment side. The operations area shall be large enough to allow at least one foot of clearance on each side of the LCP.
   b. The LCP area shall be equipped with a desk and chair for use while operating the LCP. Desk shall be sized to accommodate a telephone and full size drawings.
   c. In each instrument house, the Contractor shall make provisions for two administrative telephones.

3. IIH Requirements
   a. An area to accommodate the local control panel (LCP) and communication equipment shall be provided.
b. The LCP area shall be equipped with a desk and chair for use while operating the LCP. Desk shall be sized to accommodate a telephone and full size drawings.

C. Cable Entrance Facilities and Utilities

1. Cable entrance knockouts in the floor shall be provided for full flexibility in arrangement of entrance racks such that cables entering from underneath will not require bending for proper termination.

2. A dedicated cable entrance knockout or sleeve access shall be provided for the signal power line cable.

3. In each instrument house, a dedicated cable entrance shall be provided for Communications cable.

4. A minimum of two conduits shall be spare.

D. Cable Trays

1. Cable trays shall be of open ladder type, aluminum, or other material commercially available and providing support spacing and strength of material characteristics equal to or greater than the aluminum.

2. Ladder rung spacing shall be approximately six inches.

3. Each cable tray shall be designed and fabricated with sufficient capacity to provide 50 percent of the cross-sectional area as free air space after the full number of cables and wires are installed. Corners shall have a minimum radius of 6-inches, for either horizontal or vertical turns. Sufficient overhead space shall be available after installation to permit wires and cables to be inspected.

4. Where practicable, the tray shall be constructed in straight sections joined with approved couplers. Electrical continuity of the tray shall be maintained across sections by bonding straps.

5. Using the manufacturer's standard, the tray shall be laid out using a minimum number of sections, but providing maximum continuous runs without gaps.

6. All fittings, supports, and accessories shall be provided in accordance with the manufacturer's recommendations.

7. To prevent damage to wire and cable, no metal edges of any description shall protrude and no sharp corners shall exist in the completed layout.

8. If the Contractor's system requires separation of wires in the cable trays for electrical interference (EMI) protection as required by these Specifications, EMI mitigation barriers shall be provided.

E. House Facilities

1. Interior lighting shall utilize fluorescent lighting ballasts equipped with LED retrofit tubes to provide lighting above aisles, to both sides of the equipment racks, wall shelves and the local control room area. Light fixtures shall be installed higher in the instrument house than the tops of the instrument racks.

2. Exterior lighting shall be LED and utilize E26 standard sockets and either type A19 or A21 LED bulbs. Exterior lighting shall be in compliance with IECC Green Building Code requirements. The light level at the instrument house entrances shall be a minimum of 2 foot-candles.

3. Heating and air conditioning units shall control environment in the instrument house. Thermostat shall have high and low control position settings for automatically regulating heating and air conditioning units which shall be adequate to maintain a temperature range between 65 degrees Fahrenheit (F) and 85 degrees F with all equipment functioning at peak load, plus spare equipment. Air conditioning units shall not be roof mounted.

a. Air conditioning/heat units shall be wall-mount units in galvanized 20 gauge zinc coated steel cabinets finished with a baked-on textured enamel. The units shall be mounted to the external wall of the instrument house with grilled supply and return openings in the wall. The cabinet shall have a sloped top to direct moisture away from the instrument house and shall be installed with a top rain flashing.

b. Air conditioning/heat units shall have a barometric fresh air damper that will allow a mix of up to 25 percent outside air. The barometric damper shall allow manual adjustment from a full-open position to a full-closed position.

c. The units shall be provided with one-inch washable filters.

d. Air conditioning and heater units shall incorporate built-in circuit breakers. Ventilation fans shall be...
multi-speed and a minimum of 18 inches in diameter. Fans motors shall be a minimum of 1/5 hp.

e. Heating capacity shall be at least 16,000 BTUH.

f. The outside of each air conditioner shall be protected with a hinged, heavy gauge, hot-dipped, galvanized vandal-resistant security mesh cage. The cage shall be constructed with a slot on the frame that, when in its closed position, will not pinch the air-conditioner’s condensation drainage tube. The drainage tube shall direct the condensation away from the instrument house and its foundation.

g. The cage shall be constructed of an angle iron frame and be enclosed with 1-1/2 inch by 10-gauge steel expanded metal to form a 5-sided box.

h. The cage shall be hinged to swing horizontally open to allow for 90 degree maintenance access. Provide 2 locking hasps to hold the cage in the closed position. A mechanical device shall be provided for securing the cage in the 90 degree opened position. Cage design shall allow for a single maintenance technician to gain access and perform any maintenance activity on the HVAC unit. An open HVAC cage shall not impede on the right-of-way.

i. The cage shall be attached to the wall using tamper-proof screw/bolts attached to the instrument house to ensure mounting integrity. The cage shall have an oversized width, additional 1-foot minimum, on the hinged right side to accommodate air conditioner maintenance.

j. Thermostat-controlled ventilation systems shall be provided in instrument housings that contain electronic equipment, battery chargers or batteries. The thermostats should have sufficient upper range so that the ventilation is started automatically after an air conditioning system failure. Fans and vents shall be sized such that the interior temperature will not exceed 115 degrees F. Vents shall be closed by dampers while air conditioning is operating.

k. Ventilation systems shall be disabled when the fire detection system alarms.

4. Fire Detection System: Each instrument house shall be equipped with fire alarm systems in accordance with the requirements of Section 16854, “Fire Alarm Subsystem – Communications System”.

5. Contractor shall provide and install event recorders as required by these Specifications.

6. Contractor shall provide a plan rack for storage of plans. The rack shall be of sufficient size to easily hold all circuit and detail plans for the location. The plan rack and a plan-reading table shall be provided in the Signal Portion of the instrument house.

7. Plan rack and plan table shall be provided in each IIH.

8. In each corner of the instrument house, a 3/8-inch high tensile strength, silicon-manganese bronze stud bolt, for externally grounding the housing shall be provided.

9. The Contractor shall paint all instrument houses in accordance with the following:

   a. Exterior surfaces shall be galvannealed and prepared for finish painting with a vinyl wash primer.

   b. Apply electrostatic powder coat using manufacturer’s recommendations for heat application.

   c. The color shall match Sierra Tan, Federal Standard 595b, Color Number 20372 (semi-gloss). The finish shall have passed the Salt Spray Test per ASTM B117, certified by an independent laboratory.

   d. Interior of the instrument house shall be painted in accordance with the manufacturer’s recommendations. The color shall be white.

10. Instrument house foundations shall be provided as show in the Contract Drawings. Unless otherwise specified the Contractor may choose to use the concrete slab or the concrete pier type foundation.
PART 3 - EXECUTION

3.1 PRODUCTION
Not Used

3.2 INSTALLATION

A. Each instrument house shall be mounted on a concrete slab foundation or on drilled piers as required by these Specifications and Contract Drawings.

B. Instrument houses shall be installed not less than 8 feet-6 inches from centerline of tracks at any point. When a door faces the tracks, the minimum distance from track centerline to the instrument house shall be 12 feet. The Contractor shall be responsible for final grade around each instrument house installation. The Contractor shall ensure that the finished grade around the house is level at least 4 feet from the house in all directions. The Contractor shall spread a minimum depth of 6 inches of crushed rock or ballast from the house to 8 feet in each direction. Where the distance from the finished grade to the floor of the installed instrument house is greater than eight inches, the Contractor shall provide concrete step(s) at each personnel entrance.

C. Each instrument house and foundation shall be oriented such that the local control panel area and operator access is on the track side.

D. Where mounted on a slab, each instrument house shall be level and plumb and mounted on an approved neoprene pad. Pad shall be installed between the base of instrument house and the concrete foundation. Access shall be provided to the foundation bolts from inside the instrument house.

E. Each instrument house shall be externally grounded in accordance with these Specifications.

F. The plan rack and plan tables shall be mounted to the wall in the instrument house. The rack shall be a swing-out type and the plan tables shall be a drop-down type to minimize the space required.

G. Cables shall enter instrument houses by entrance knockouts with fittings and entrance conduits provided. Cables shall be dressed, tagged and terminated as specified in accordance with the requirements of these Specifications.

H. Relays shall be installed on plugboards corresponding to the relay nomenclature and securely fastened in place with the hardware provided.

   1. In designing the detail layout of equipment within the housing, the Contractor shall group instruments so similar types of equipment or functions of a similar nature will be together.

   2. Layout of instruments on all racks shall be uniformly structured. Track and control relays shall be mounted in geographical succession in relation to the track arrangement.

   I. Batteries shall be installed in accordance with the requirements of these Specifications.

   J. Exterior paint of each instrument house shall be inspected after installation and any damage shall be repaired in accordance with the paint manufacturer's instructions and as Authority approved.

3.3 TESTING

A. The functioning of equipment contained within the instrument house shall be tested in accordance with these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16938
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work done under this Section consists of designing, providing, and installing junction boxes for use with switch-and-lock movement layouts, electric lock layouts, signal layouts, pushbutton layouts, crossing warning gates, flashers, cantilever signals and other signal equipment as required by these Specifications and Contract Drawings.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)
   1. AREMA - Communications & Signal Manual, Part 7
   2. AREMA - Communications & Signal Manual, Part 15

1.3 SUBMITTALS

A. The Contractor shall submit for Authority approval, drawings and product detail for each type junction box required.

B. The Contractor shall submit drawings of each junction box provided including terminal boards, terminals, wiring, mounting details and any other integral parts.

1.4 QUALITY ASSURANCE

A. The Contractor shall inspect each junction box after it has been installed and wired and correct any deficiencies. Inspection shall be conducted in conformance with the requirements of the Contractor's Installation and Inspection Procedure as Authority approved.

B. Junction boxes shall meet the requirements of the AREMA Signal Manual, Parts 7 and 15.

C. Each junction box shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

PART 2 - PRODUCTS

2.1 AUTHORITY PROVIDED MATERIALS

A. Not Used

2.2 CONTRACTOR PROVIDED MATERIALS

A. All junction boxes shall be provided with gaskets to prevent entrance of moisture and dust, in accordance with the AREMA Communications & Signal Manual, Part 15.2.10.

B. Switch-and-lock movement layout and electric lock layout junction boxes.

1. Junction boxes for switch layouts shall be the manufacturer's standards with adequate space for double post AREMA approved terminals, terminal boards, cable and other associated apparatus.

2. Each switch-and-lock movement and electric lock layout shall include one junction box, designed for use in railroad applications. The box shall have sufficient space for terminals, disconnects and other components as may be necessary. Terminals and components shall be located in the junction box so that they are accessible and that manipulation of a terminal wrench is not hindered by the structure of top of the box.

3. For at-grade installations, junction boxes complete with pedestal shall be provided. Junction box pedestals shall have a cable entrance near the bottom of the riser section. Pedestals shall be of sufficient length that the box can be securely installed without need for foundation.

4. Knockouts shall be provided on the sides of the junction box to accommodate conduits to switch machine.

5. Junction boxes shall have ventilation breathers with fine wire mesh screen covering the breather holes.

6. Junction box shall be provided complete with double post terminals in accordance with the requirements of these Specifications.

C. Mast-mounted Equipment

1. Junction boxes for the bases of masts shall be the split base type junction box with AAR terminals.

2. Junction boxes for masts shall be steel or cast metal and be in accordance with AREMA Communications & Signal Manual, Part 7.2.36A, Part 7.2.36B, Part 7.2.41A and Part 7.2.41B.

D. Painting

1. Exterior and interior finish and painting requirements shall be in accordance with the requirements of these Specifications.
E.  Security

1. Junction boxes shall be equipped with a locking device capable of being secured, upon closure, with the Authority's standard signal padlock, in accordance with the requirements of these Specifications.

2.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Junction boxes shall be protected from damage throughout delivery, storage and handling.

PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 INSTALLATION

A. Switch-and-lock movement, or electric lock layout junction boxes shall be installed to terminate underground cable for the switch layout, as shown on Authority approved installation drawings.

B. Junction boxes for signal and pushbutton layouts shall be installed to terminate signal cables, as shown on Authority approved installation drawings.

3.3 TESTING

A. Not Used

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 "Signal System Basic Technical Requirements."

END OF SECTION 16940
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work done under this Section consists of designing, providing and installing sectional type instrument racks in Instrument Houses.

B. Work to be done under this Section shall include preparation of detail drawings for each instrument rack, the equipment arrangement thereon and associated circuits.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance-of-Way-Association (AREMA):
   1. AREMA – Communications & Signals, Part 6
   2. AREMA – Communications & Signals, Part 14

1.3 SUBMITTALS

A. The Contractor shall submit product data for equipment racks for approval.

B. The Contractor shall provide:
   1. Submittal of detail arrangement of equipment layout on instrument racks.
   2. Drawings showing proposed arrangement of instrument racks, including a drawing to show methods of grounding and mounting and relation to other equipment in the house.

C. The Contractor shall submit test procedures and results in accordance with these Specifications.

1.4 QUALITY ASSURANCE

A. Racks and all equipment mounted thereon shall be assembled, identified, wired and factory tested in accordance with the requirements of these Specifications, prior to shipment.

B. Each instrument rack shall be inspected prior to shipment. Inspection shall conform to the Contractor's Factory Inspection Procedure as approved by the Authority.

C. Instrument racks shall meet the requirements of the AREMA Signal Manual, Parts 6 and 14.

D. Each instrument rack shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Instrument racks shall include relay racks, electronic equipment racks, power racks, rectifier racks and racks containing track circuit equipment.

B. Instrument racks shall be fully equipped with the required numbers and types of power supplies, transformers, relay plugboards, printed circuit boards, plug connectors, buses, terminals and all miscellaneous electrical and mechanical components specified. A terminal and plug connector panel shall be located on the upper portion of the rack for connecting external wires and cables. Spare space and terminals shall be provided as specified. Insulated terminals shall be spaced as specified in AREMA Communications & Signal Manual, Part 14.1.5.

C. Instrument Racks shall be open frame weldments designed to accommodate mounting of standard 19 inch panels. The frame shall be constructed of 14-gauge minimum cold rolled steel. Width shall not exceed 24 inches. Panel-mounting angles shall be constructed with standard EIA hole spacing. The Contractor may propose other rack dimensions for specialty equipment where it can be demonstrated that the arrangement offers more efficient space usage.

D. Racks shall be shock-mounted and secured to 12-gauge minimum cold rolled steel bases. The base shall be the same width as racks, with a height of 3-1/2 inches.

E. Chassis supports or guides shall be provided for support of heavy equipment such as power supplies. Chassis supports shall be made of 11-gauge minimum cold rolled steel, capable of being mounted directly to the panel-mounting angles and shall permit side-to-side guide adjustment. Relay plugboard support bars shall be provided for each row of relays and be of sufficient strength to support the manufacturer's equipment mounted thereon.

F. Terminal, plug connector and power panel shall be located on the upper portion of the rack for connecting wires and cables. Panel material shall be fire-retardant. A minimum of ten percent spare terminals shall be provided on each instrument rack.

G. Rows of racks shall be oriented to have adjacent rows either front-to-front or back-to-back. Row-to-row and row-to-wall spacing shall be a minimum of three feet, measured at the base of racks.

H. Each instrument rack shall be fully equipped with the required numbers and types of power supplies, transformers, relay plugboards, buses, terminals and all...
INSTRUMENT RACKS - SIGNAL SYSTEM

miscellaneous electrical and mechanical components specified. Terminals and resistors for energy buses where required, shall be located on the upper portion of the rack. Vital inter-rack wiring shall be direct from relay to relay. Insulated terminals shall be as specified in Part 14.1.5 of AREMA Communications & Signal Manual.

I. Wire supports which form interior wire raceway on instrument racks shall be fabricated from steel or material of non-flammable composition.

J. Relay and Component Mounting

1. In designing the detail layout of racks and other equipment, the Contractor shall group the rows of racks and instruments therein so similar types of equipment or functions of a similar nature will be together.

2. Relays or components shall not be mounted at a height of more than 6 feet - 6 inches from house floor nor closer than 10” to the floor. Overall rack height shall not exceed 7 feet - 6 inches.

3. A minimum of 20 percent spare space on each group of instrument racks for additional relays and two spare cable plug couplers for each rack equipped with plug couplers shall be provided.

K. Plug Connecting Cables

1. Plug connectors and cable and wire for plug-connecting cables shall be in accordance with these Specifications.

L. Resistors, Capacitors, Electronic Components and Fuses

1. Approved types of resistors, capacitors, electronic components and fuses shall be connected into track, line and power circuits as shown on Contract Drawings. These components shall be of such design and capacity to protect the equipment and provide positive and safe operation.

2. All fuses shall be locally and remotely alarmed or indicated, except main power fuses and power frequency track circuit fuses.

M. Convenience Outlets

1. Convenience outlets shall be mounted on the front of each row of instrument racks, no more than four feet apart. Convenience outlets shall be provided from the utility panel and those inside the signal equipment area shall be grounded.

N. Wiring

1. Wiring of instrument racks shall be as specified in these Specifications.

2. All instrument racks shall be pre-wired at the place of manufacture.

O. Grounding Posts

1. Grounding posts and ground jumpers shall be provided with each rack. These posts shall be bolted type to permit isolation of the rack for testing by removal of ground wire connections.

P. Identification

1. A white identification number shall be stenciled at the top front and rear of the frame of each rack, including approved vertical coordinate numbering from top to bottom.

2. There shall be an identifying nameplate for each component or device mounted on instrument racks. Nameplates shall be front and back where the device or its connections are on both sides.

3. The back of each relay plugboard shall be equipped with a tag or other approved means of identification, to indicate the nomenclature of the relay for which it is wired. It shall not be necessary to remove the nameplate in order to remove wires. Nameplate shall be readable when wires are in place.

4. Contact numbering system shall be uniform for each type of relay used.

5. Wiring to each removable contact shall carry an approved tag indicating the relay contact number and circuit nomenclature assigned to the wire.

6. Signal power racks shall have special high voltage labels at terminals above 120 volts, affixed in color, format and size approved by the Authority.

Q. Painting

1. Instrument racks shall be painted in accordance with the requirements of this Specification. Finish color shall be Gray ANSI-61, or approved equal.

2.3 DELIVERY, STORAGE, AND HANDLING

A. Instrument racks not factory installed in a house shall be properly crated to prevent damage during shipment. Protected inside storage shall be provided in the event racks cannot be mounted in place upon delivery to the site.

B. Vital relays shall be shipped separately but identified for the racks in which they are to be used. Relays shall be stored in a protected area until installed in racks.
PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 INSTALLATION

A. Instrument racks shall be installed as shown on approved installation drawings. Racks, relays and other equipment, plus all required mounting and fastening materials to mount racks, shall be installed as required. All racks shall be supported at top and bottom.

B. Racks shall be electrically insulated from each other and from the supporting framework. Grounding of racks shall be as required by these Specifications.

C. All interconnecting cables, wiring and connections to power sources and entrance racks shall be installed as shown on approved plans, including interconnections to self-contained rack-mounted equipment units.

D. Interconnecting cables from entrance racks and power racks shall be trained in cable trays and be connected on terminal and power panels of each individual instrument rack. Slack shall be provided for each interconnecting cable or wire.

E. Plug-connected interconnecting cables shall be the same cables used in the factory test of instrument racks.

F. Field-installed wire bundles within rack shall be harnessed in a neat manner and tied with nylon tie-wraps.

G. Lighting fixtures, cable ladders, trays or other equipment shall not extend below the top of instrument racks.

3.3 TESTING

A. Instrument racks shall be tested in accordance with requirements of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16953
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PART 1 - GENERAL

1.1 DESCRIPTION

A. Work to be done under this Section consists of designing, furnishing and installing wire and cable in signal instrument houses, wayside cases, relay rooms, control panels and in enclosures where it will not be exposed to the elements. All intra-rack and rack-to-rack wire and cable shall conform to the requirements of this Section.

B. Where there is a difference between the requirements of this Contract Specification Section and other Contract Specification Sections referenced herein, requirements of this Contract Specification Section shall govern.

C. Definitions – As used in this Section, the listed terms shall be defined as follows:

1. Ampacity: The ampacity of a wire is a rating of the steady current in the conductor that causes exposure of the insulation to the design temperature for a particular exposure condition. Ampacity is dependant upon the installation environment of the conductor, e.g. exposed in air (higher ampacity) or buried within a tray with other heat-producing conductors (lower ampacity).

a. The ampacity values given in this Section are estimates determined by the following:

1) Wire sizes AWG 24-20: Per NFPA Panel 16 proposal for NEC Articles 725 and 760, Power Limited Circuits.

2) Wire Sizes AWG 18, 16, and 500 MCM: Per NEC Table 310-16, “Allowable Ampacities of Insulated Conductors rated 0-2000 Volts” with a 35 percent increase due to the use of 150 degrees C rated insulation.

3) Wire Sizes AWG 14-4/0: Per NEC Table 310-18, “Allowable Ampacities of Three Single Insulated Conductors rated 0-2000 Volts Using Type Z (150 degrees C), in Raceway at Ambient Temperature of 40 degrees C.”

2. Cable: Two or more insulated conductors in a common covering, or two or more insulated conductors twisted or molded together without a common covering, or one or more insulated conductors with a common shield with or without an outer covering.

3. Cable Core: The diameter of cabled wires excluding overall shields and/or jackets.

4. Conductor: An uninsulated single strand, or the assembly of two or more uninsulated strands whose primary function is to transmit electrical energy.

5. Conductor Stranding: The construction characteristics of a stranded conductor, categorized as follows:

a. Bunch Stranding (BUN): Composition of any number of wires of the same diameter twisted together without regard to the geometric arrangement of the individual strands. This type of stranding is least likely to be uniform in cross section due to the tendency of the strands to cross over one another and to migrate from one layer to another during the twisting operation. Common constructions are 7, 10, 16, 26, 41, 65, and 105 strands.

b. Concentric Stranding (CON): Composition with a central wire surrounded by one or more layers of helically laid wires, with a reversed direction of lay, and an increased length of lay, for each successive layer.

c. Unilay Stranding: Composition of more than one layer of helically laid wires, with the same direction of lay, the same length of lay, for each successive layer.

d. Rope Stranding: Composition of groups of any of the above strandings combined in a concentric configuration. This construction has greater flexibility and is generally used for conductors 8 AWG and larger. Rope Stranding is generally specified by the number of components in the rope, and the number and size of the wires in each component.

6. Insulation: The layer or layers covering a conductor whose primary function is to act as an electrical barrier.

7. Jacket: An integral covering that is applied over the insulation, core, shield, or armor of a cable and whose primary function is to provide mechanical and/or environmental protection for the components it covers.

8. Lay: The lay of any helical element of a conductor is the axial length of a turn of the helix
of that element, such that, if a single component wire of a conductor is unwound, the lay in inches will be the length measured along the axis of the conductor that is required to make one complete turn about the axis of the conductor. Usually, the number of turns in one foot of a conductor is measured in order to allow for normal manufacturing variations. Lay lengths are expressed as a decimal or a fraction.

9. Manufacturer: The organization that makes the wire and/or cable sold to the Contractor or purchaser.

10. Material Tests: (Intrinsic properties of material.) Tests that must be performed for the original Certification of Quality and every five years thereafter, or as requested by the purchaser.

11. Multi-Conductor Cable: Two or more wires in a common covering, or two or more wires twisted or molded together with or without a common covering.

12. Purchaser: The Contractor’s organization or subcontractor that issues the purchase order for wire and cable.

13. Qualified Manufacturer: A wire and cable manufacturer that has submitted wire and cable, with required data, that has passed all required tests and has been informed by writing by the purchaser that he is a qualified manufacturer.

14. Routine Test: (Properties affected by the manufacture.) Test that must be performed for each purchase order and at other times as requested by the purchaser.

15. Separator: A layer of insulating material that is placed between the conductor and its insulation, between a cable jacket and the components it covers, or between various components of a multi-conductor cable.

16. Shield: A sheet, screen, or braid of metal, usually copper or aluminum placed around or between electric circuits or cables or their components, to contain any unwanted radiation, or to keep out any unwanted interference.

17. Vendor: The recipient of a purchase order from the purchaser or the supplier of wire and cable to the purchaser. The vendor may or may not be the manufacturer.

18. Wire: (An insulated conductor.) The assembly of a conductor and insulation.

1.2 REFERENCE STANDARDS

A. Association of American Railroads (AAR)
   1. AAR STD S-501

B. American Railway Engineering and Maintenance-of-Way-Association (AREMA)
   1. AREMA – Communications & Signal Manual, Part 10

C. American Society for Quality (ASQ)
   1. ASQ Q9001 - Quality Management Systems - Requirements

D. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)
   1. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire
   2. ASTM B5 - Standard Specification for High Conductivity Tough-Pitch Copper Refinery Shapes
   3. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
   4. ASTM B33 - Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
   5. ASTM B170 - Standard Specification for Oxygen-Free Electrolytic Copper-Refinery Shapes
   7. ASTM B286 - Standard Specification for Copper Conductors for Use in Hookup Wire for Electronic Equipment
   8. ASTM B399/B 399M - Standard Specification for Concentric-Lay-Stranded Aluminum-Alloy 6201-T81 Conductors
   10. ASTM D3159 - Standard Specification for Modified ETFE-Fluoropolymer Molding and Extrusion Materials

E. Federal Construction Regulations (FED)
   1. FED STD-228 CHG Notice 5 - Cable and Wire, Insulated; Methods of Testing
F. Insulated Cable Engineering Association (ICEA)
   1. ICEA S-95-658 - Nonshielded Power Cables rated 2000 volt or less for the Distribution of Electrical Energy

G. Institute of Electrical and Electronic Engineers (IEEE)
   1. IEEE 383 - Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations

H. Military Standards (MIL)
   1. MIL-Q-9858 - Quality Program Requirements
   2. MIL-STD-105 - Sampling Procedures and Tables For Inspection By Attributes [Refer to: ARMY MIL-STD-1916]
   3. MIL-STD-202G CHG Notice 1 - Test Method Standard Electronic And Electrical Component Parts
   4. MIL-W-16878 - Wire, Electrical, Insulated, General Specification For
   5. MIL-W-22759E - Wire, Electrical, Fluoropolymer-Insulated Copper Or Copper Alloy

I. National Electric Manufacturing Association (NEMA)
   1. HP100.2-1991 - High Temperature Instrumentation and Control Cables Insulated and Jacketed with ETFE Fluoropolymers
   2. NEMA WC70 - Nonshielded Power Cables rated 2000 volt or less for the Distribution of Electrical Energy

J. National Fire Protection Association (NFPA)
   1. NFPA 70 - National Electrical Code (NEC)
   2. NFPA 258 - Recommended Practice for Determining Smoke Generation of Solid Materials

K. Underwriters’ Laboratories, Inc. (UL)

1.3 SUBMITTALS

A. The Contractor shall submit the following for Authority approval:
   1. List of each cable manufacturer's railway signal installations.

B. The Contractor shall submit product data cut-sheets and a sample specimen of a four foot length for each proposed cable type. Samples shall remain the property of the Authority.

C. The Contractor shall submit certified copies of the following to the Authority for approval:
   1. Cable test reports for all demonstration tests required by the Authority.
   2. Cable test and inspection reports for tests and inspections required by these Specifications.
   3. Test reports of cable tests conducted in the field in accordance with approved testing procedures.
   4. Certification that each cable supplied complies with the requirements of these Specifications.
   5. A complete, signed and notarized standard Wire and Cable Test Report Sheet as part of each cable test report.

D. Test procedures and results in accordance with these Specifications.

1.4 QUALITY ASSURANCE

A. Quality Assurance Provisions shall be followed in the manufacture of wire covered by this Section. The Contractor shall be responsible for witnessing and reporting the results of any and all required qualification tests. The Contractor shall be responsible for monitoring the manufacturer's conformance to quality assurance requirements and the Authority reserves the right to audit conformance in accordance with the Special Provisions.

B. All other Work covered by this Section shall be accomplished in compliance with the latest version of a Quality Assurance Program that meets the intent of the ASQ Q9001.

C. It shall be the Contractor's responsibility to ensure that the Manufacturer adheres to all testing and production requirements.

D. The Contractor shall secure certification of compliance with these Specifications for each production run. The manufacturer shall provide a Certificate of Compliance with each shipment. The Contractor shall keep the Certificates on file and shall make them available at the Authority's request.

E. The Contractor shall ensure that the manufacturer performs the “Material Tests” at least once every five years and submits the resulting data to the Contractor.
Wire to be used for qualification shall be No. 20 AWG rated 0-600 volts and No. 12 AWG rated 0-2000 volts.

F. The Contractor shall ensure that the manufacturer performs “Routine Tests” on each production lot.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Maintenance Materials:

1. The Contractor shall furnish one thousand feet of each type of wire and cable used on this contract.

B. Conductors

1. Stranded Conductors
   a. Conductors shall be tin plated, soft or annealed copper wire for electrical purposes, per the latest revision of ASTM B33 and B-3.
   b. Strands and rope members shall be concentrically stranded using unilay (UNI), concentric (CON), and bunch (BUN) constructions as specified in Table A.

2. Solid Conductors
   a. Conductors shall be tin plated, soft or annealed copper wire for electrical purposes, per the latest revision of ASTM B33 and B-3.
   b. Solid conductors for wire wrap shall be as specified in Table B.

C. Insulation

1. The insulation material for stranded and solid conductor wires shall be modified ethylene tetrafluoroethylene (EFTE) per ASTM D3159-91a, unless otherwise specified.

2. Insulation for Stranded and Solid Wires
   a. All insulation for AWG 12 through AWG 24 shall be Tefzel 200 or equivalent. Tefzel HT-2127, Tefzel 750 or equivalent, may be substituted for Tefzel 200 for enhanced flexibility.
   b. All insulation for AWG 10 through 500 MCM shall be Tefzel 280 or equivalent.
   c. All insulation for solid conductor wire wrap wire shall be Tefzel 750 or equivalent, per UL Subject 758, Style 10125.

D. Wire Constructions

1. The finished wire diameters, weights, and ampacity ratings are shown for 0-150, 0-300, 0-1000, and 0-2000 volt rated stranded wires in Tables C through G.

2. The finished wire diameters and weights for 0-300 volt solid conductor wire are shown in Table H.

E. Insulation Thickness – Stranded and Solid Wire

1. The nominal or average thickness of the insulation shall be as specified in Tables C through G. The minimum thickness at any point shall not be less than 90 percent of the nominal thickness per NEMA HP 100-1991, Section 3.2.

F. Identification

1. Each stranded wire shall be marked with the following information repeated at intervals no greater than 24 inches:
   a. Manufacturer's name
   b. Year in which wire is manufactured
   c. Size of conductor
   d. Type of insulation
   e. Voltage rating

2. Identifying markings shall be permanent and shall be easily readable and understandable. The marking shall withstand 125 cycles (250 strokes) using a scrape abrasion tester with a 250 gm weight, a wire mandrel with a diameter of 25 +/- 2 mils (.635 +/- .051 mm), a stroke length of 0.375 inch (1.905 mm) and a frequency of 60 cycles/minute.

3. Each solid wire surface shall be printed with the UL Style Number, the manufacturer and the conductor gauge. This information shall be repeated at intervals no greater than 24 inches.

G. Color Coding of Wires

1. Stranded Wires
   a. Cables with unpaired wires shall be solid colored in the color sequence per Table I. Where two colors are indicated, the second color shall be achieved using a stripe that is clearly identifiable and permanent.
b. In paired cables, one wire of each pair shall be white and the other wire shall be coded in accordance with the sequence given in Table I of this Section, omitting the solid white.

2. Solid Conductor Wire (Wire Wrap)
   a. Solid colors as specified by the purchaser shall be used.

2.3 PERFORMANCE REQUIREMENTS

A. All wire and cable specified within this Section shall meet or exceed the requirements of the AREMA Signal Manual, Part 10.3.14 and 10.3.24.

B. Internal plug-connected cable assemblies shall be as specified herein and in accordance with these Specifications.

C. The insulation shall be applied directly to the surface of the specified conductors and shall adhere tightly to the surface, but shall be free stripping and shall leave the conductor clean.

2.4 MULTI-CONDUCTOR CABLES

A. Multi-conductor cables shall be made by assembling individual or twisted pairs of stranded wires into a tight cylindrical form using non-hygrosopic, flame and smoke resistant fibers and tape. The jacket material shall fit tightly to form a tight assembly.

1. Individual wires that are used to make up the cables shall be in accordance with Clause 2.2 of this Section.

2. The color sequence for paired and unpaired wires shall be in accordance with this Section.

3. Fillers used to make the cable assembly round shall be able to shape themselves to fill the depressions. Fillers shall be compatible with the other materials in the cable.

4. Cable lay shall be 12 to 16 times the cable core diameter and pair lay (multi-pair cables) shall have 20-25 times the diameter of the individual wire within the pair. Cable marked “High Twist” shall have a nominal pair lay of 12 to 16 times the single wire diameter, with a cable lay of 8 to 10 times the cable core diameter.

5. Binder Tape – Each layer of two or more wires shall have a helically applied tape with a minimum overlap over the layer, to serve as a binder. Tape thickness shall be 0.002 inches minimum. The tape shall be compatible with the other materials in the cable.

6. Separator tapes shall be used between the outer surface of the cable core and the jacket to assist removal of the jacket. The Tapes may be smooth or corrugated with a thickness of 0.002 to 0.005 inch with a 50 percent overlap. The tapes shall be compatible with the other materials in the cable.

7. Shields – Where shielding is required over single wires, component groups or the overall cable core, in any combination, it shall be a metal laminate tape. The tape shall consist of a laminate of polyester, polyamide, aromatic polyamide or ethylene tetrafluorethylene layer with a thickness of 0.9 mil (0.023 mm) and a copper or aluminum foil layer with a thickness of 0.9 mil (0.023 mm). The tape shall be helically wrapped so that the metal side is in contact with the drain wire over the full length of the cable using a 30 percent overlap. The drain wire shall be uninsulated tin plated copper per 2.1 of this Section and shall be the same AWG size as the basic wire conductors in the cable.

8. Jackets shall be smooth and tight over the cable core and shall be easily strippable.
   a. Tefzel 280 ETFE or equivalent shall be used as a jacket material. For jackets over a calculated core diameter of 0.250 inches (6.35 mm) and less, Tefzel 200 ETFE or equivalent resin can be used.
   b. The jacket thickness shall be in accordance with NEMA HP100.2-1991, Normal Duty as shown in Table I(a).
   c. Identification – Individual wires of multi-conductor cables shall be identified by means of solid colors and stripes in accordance with this Section.

1) Multi-conductor cable color-coding shall be durable and recognizable. Color sequence shall be per Table I of this Section.

2) Each cable jacket shall be marked with the following information repeated at intervals no greater than 36 inches.
   a) Manufacturer's name
   b) Year manufactured
   c) Number and size of conductors
   d) Voltage Rating
   e) Jacket material (ETFE)

3) The identifying marking shall meet the requirements of paragraph 2.2.E.2 of this Section.
PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 PACKAGING, SHIPPING AND STORAGE

A. When delivered from manufacturer, stranded wire and cables shall be wound on reels or spools. Each reel or spool shall have a required diameter for the respective wire size. In no case shall the barrel of the reel or spool have a diameter less than 50 times the nominal diameter of the wire for wire sizes AWG 24 through AWG 14; 40 time for AWG 12 and AWG 10; 30 times for AWG 8 and larger, or less than four inches, whichever is larger. For multi-conductor cables, the minimum barrel size of the reel or spool shall be 20 times the finished cable diameter or larger.

B. Reels or spools shall be finished to prevent corrosion under typical storage and handling conditions. The method of attachment of the flanges to the barrels on metal reels or spools shall be structurally equivalent to a full circumferential crimp.

C. Wire on reels or spools shall be closely and tightly wound in layers. All cable ends must be sealed to prevent the entrance of moisture. The cable ends shall be securely fastened so that they do not come loose during transit.

D. Solid conductor wire (wire wrap) shall be packaged on 16 inch computer spools or in barrel pack to reduce wire curl.

E. Purchase orders shall specify the requirements for minimum continuous wire lengths acceptable and the number of continuous wire lengths permitted per reel or spool.

F. Each reel or spool shall be marked with weather resistant tags, identifying the amount of wire per continuous length and the number of lengths. In addition, the following information shall be included on the tags.

1. Purchaser’s specification number
2. Specification sheet number, if applicable
3. Wire size and stranding
4. Date of manufacture
5. Name of manufacturer
6. Cable description, if applicable

3.3 INSTALLATION

A. General

1. Internal wire and cable shall be installed in accordance with applicable requirements of AREMA Signal Manual, Part 10.4.1, and as specified herein.

a. Wires and cables shall be installed in a neat manner. Cables in trays or troughs shall be laid therein and not pulled into it. Cables shall be installed with a minimum amount of cross-over in the trays and troughs and shall not be pulled tightly around bends. All exposed wires and cables entering or leaving equipment racks or housings shall be protected from abrasion or sharp metallic edges.

b. Nylon straps shall be provided and installed for bundling and cabling of conductors where two or more single conductors are exposed in internal rack bundles, cable trays or cable troughs, or whenever wires are to be bundled. Tape shall not be used for this purpose. Straps shall be installed at intervals of two feet or shorter if required to maintain good standards along the cable run. Wires of multi-conductor cables exposed by the stripping of cable jacket for terminations shall be trained in a neat manner and tied approximately every three inches with nylon straps.

c. There shall be no point-to-point redundancy of wires for increased current capacity.

d. Single conductor No. 14 stranded wire shall be used for interconnecting signal junction boxes, lamp compartments and other miscellaneous equipment.

e. Strain relief shall be provided where needed.

f. Wire or cable splices are not permitted.

g. All wires and cables shall be fully protected against any contact with any surface other than that designed specifically to support or protect them.

h. Wires and cables shall be laid in place with sufficient slack at the bends so such wires and cables will clear the inside bend surface of the wireway to prevent crushing of insulation.

i. All wire and cable shall be free of kinks and insulation damage. Wire installation shall not be subject to accumulations of moisture or foreign matter.

j. Wire and cable dress shall allow for sufficient slack to provide for shock and vibration induced movements,
k. Wiring and cabling dress in harness arrangements shall be tied with a high strength approved dielectric tie designed not to damage wire insulation. Wires and cable ties shall be trimmed and located to eliminate damage from sharp edges.

l. All wires and cables shall be clear of metal edges, bolt heads and other interference points and have electrical clearance from covers.

B. Module Wiring

1. Unless otherwise Authority approved, all module and display panel wiring shall be accomplished with solderless connections using solid wire for wire wrap connections, and stranded wire for crimped connections as specified herein. Minimum wire size shall be No. 22 AWG for stranded wire and No. 24 AWG for solid wire.

C. Rack Wiring

1. Unless otherwise Authority approved, all vital rack wiring shall be accomplished with Authority approved solderless connections. Wire for vital rack wiring shall be stranded wire as specified herein, minimum size No. 16 AWG, or multi-conductor cables as specified herein.

2. All nonvital rack wiring shall be accomplished with approved solderless connections. Wire for nonvital rack wiring shall be stranded wire as specified herein, minimum wire size No. 22 AWG or multi-conductor cables as specified herein.

3. Rack wiring shall be neatly tied into compact bundles. Main bundles and branches shall be secured to the racks in a manner that preclude physical damage due to pressure of abrasion and prevent the wire weight from being supported by the wire terminations, connections or plug connection. Arrangement of wire bundles and cables shall be such that they do not interfere with visual inspecting, troubleshooting or repair of rack-mounted equipment.

D. Rack-to-Rack Wiring

1. All rack-to-rack wiring shall be routed via the overhead cable trays with sufficient slack between cable tray and each rack to which the cable or wire is connected.

a. Vital Racks

1) All rack-to-rack wiring for factory wired housings shall be accomplished using single conductors tied into bundles to form unjacketed multi-conductor cables. For relay circuits, unjacketed multi-conductor cables shall consist of individual conductors of size 16 AWG or larger wire and shall have a maximum tie spacing of six inches. Vital microprocessor cables may be made up of 20 AWG wires in terminated in keyed plugs.

b. Nonvital Racks

1) All rack-to-rack wiring for nonvital racks shall be accomplished using multi-conductor cables as specified herein and nonvital plug connectors as specified within these Specifications. All nonvital racks shall have a plug coupler panel to terminate all wiring from the rack.

c. Nonvital Racks to Vital Racks

1) All wiring between nonvital racks and vital racks shall consist of single conductors, tied into bundles, between the nonvital rack plug connector panel and vital rack connection points. These individual conductors shall consist of size 20 AWG or larger wire and have a maximum tie spacing of six inches.

E. Rack to Local Control Panel

1. Made-up cables and multi-conductor cables for the local control panel shall be installed from vital and nonvital instrument racks to plug connectors installed on the local control panel. Made-up cables shall consist of single conductors, No. 20 AWG stranded or larger, with bundle ties spaced a maximum of six inches.

F. Entrance to Instrument Rack Wiring

1. Wiring from entrance racks to instrument racks shall be accomplished using stranded wire, as specified herein, minimum size No. 20 AWG, as approved by the Authority.

G. High Voltage Wiring

1. Internal wire used in circuits directly connected to the rails and internal wire used in circuits that operate at voltages in excess of 600 volts shall meet the requirements of External Cable, as specified herein.

H. Energy Distribution
1. Vital Racks
   a. Unless otherwise approved, all wiring for energy distribution shall be accomplished using single conductor stranded wire as specified herein. Wiring shall be sized for maximum circuit load, but shall not be less than a stranded wire, size No. 16 AWG. Rack-to-rack wiring shall be accomplished with solderless connections.

2. Nonvital Racks
   a. All wiring for energy distribution shall be accomplished using single conductor stranded wire as specified herein. Rack wiring shall be accomplished with solderless connections using stranded wire, minimum size No. 20 AWG. Rack-to-rack wiring shall be accomplished with solderless connections using stranded wire, minimum size No. 14 AWG.

3. Energy loops on vital and nonvital racks shall not exceed two rows.

I. Conductor Sizing
   1. All conductors must be sized per the National Electrical Code, but shall not be smaller than the minimum conductor sizes specified herein.

3.4 TESTING
   A. The following “Routine Tests” shall be performed for each production run.
      1. Impulse dielectric, high frequency, or direct-current spark test 100 percent of the wire using the requirements in Table H(a)
      2. Insulation Strip Force Test
         a. Use a tension testing apparatus suitably equipped to operate in a tensile mode in conjunction with a fixture attached to one jaw of the tensile testing machine. The fixture is a metal plate approximately 0.2 inches (5 mm) thick with a hole 5 percent to 10 percent larger than the conductor diameter.
         b. The test specimens shall be approximately 5 inches (127 mm) long. Test a minimum of three specimens.
         c. Allow the specimen to completely stabilize at room temperature. Prepare the specimen for testing by carefully removing 3.5 inches (90 mm) of the insulation from one end of the specimen. Trim the insulation and conductor flush at the other end, so as to have 1 inch +/- 1/16 (2.54 +/- 1.6 mm) of undamaged insulation left on the conductor. Both the stripped end and the cut end of the insulation should be square to the conductor. Insert the exposed conductor through the fixture hole and clamp in the free jaw of the tensile tester, without applying any force to the insulation test specimen. Leave approximately 0.5 inch (13 mm) of slack between the fixture hole contact point and the insulation piece. Using the tensile tester, pull the conductor through the insulation at a rate of 2.0 inches/minute (50 mm/minute) and record the maximum force indicated.
         d. For stranded conductors, the force required to remove the insulation shall be as follows:
            1) No. 12 AWG or smaller, 2 – 14 lbs.
            2) No. 1 AWG – 10 AWG, 6 – 25 lbs.
            3) No. 1/0 AWG and larger, less than 35 lbs.
            4) For solid conductors, the force required to remove the insulation shall be a minimum of 0.5 pounds and a maximum of five pounds.
   3. Insulation Shrinkage Test
      a. The shrinkage test measures the ability of insulation to be exposed to an elevated temperature without changes in length at the termination of the wire, to ensure that complete coverage of the conductor at a termination is maintained and that the electrical barrier remains intact.
         1) One inch of insulation shall be stripped from each end of a 14 inch specimen of finished wire using razor blade, or equivalent instrument, held perpendicular to the axis of the wire for the insulation removal operation. The length of exposed conductor at each end of the specimen shall be measured to the nearest 0.01 inch. The specimen shall be exposed to 180° C for six hours in an air oven. At the end of the six hours, the specimen shall be removed from the oven and allowed to return to room temperature. The shrinkage of the insulation shall then be measured as the greatest additional distance which any
layer of the insulation has receded from either end of the specimen. The measurement obtained at the end showing the greater shrinkage shall be recorded as the shrinkage of the specimen. Three specimens shall be tested.

2) The maximum allowable shrinkage for wire sizes AWG 30-16 is 0.125 inches; AWG 14-6 is 0.25 inches; and for AWG 4 – 500 MCM is 0.375 inches

4. The insulation must meet the tensile strength, elongation at rupture, heat shock, and cold bend requirements of NEMA HP100.2-1991, Table 2-B.

B. Material Tests

1. The insulation must meet the aging requirements, heat distortion, insulation resistance, and dielectric constant requirements of NEMA HP100.2, Table 2-1 and the additional tests specified herein. These "Material Tests" shall be performed at least once every five years.

a. Flammability and Smoke Evolution Test

1) The testing shall be according to ASTM E 1354, Standard Test Method for Heat and Visible Smoke Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter.

2) Specimens shall be 100 mm in length and placed side by side in a single layer to cover the entire surface of the specimen holder. The apparatus shall be operated at a heat flux of 35 kw/sq. m in the horizontal orientation.

3) The following information shall be reported: (numbers in parenthesis refer to corresponding paragraphs in the test method)

   a) Specimen thickness, or diameter of cable d, in mm. (13.1.6)
   b) Time to sustained flaming, t, in seconds. (13.1.12)
   c) Average heat release rate for the period beginning when 10 percent of the ultimate specimen mass loss has occurred and ending at the time when 90 percent of the sample mass loss has occurred, q", in kw/sq. m. (13.1.14)
   d) Average mass loss per unit area for the same period as above m", in g/sq. m. (13.1.19)
   e) Average specific smoke extinction area o, in sq. m/g. (13.1.20)

4) Requirements

   a) Smoke Evolution Rate – The product of the average mass loss rate, m", and the specific smoke extinction area, o, shall be equal to or less than (16/d) sq. m/s, where d is the cable diameter: (m") (o) ≤ 16/d
   b) Heat Release Rate – The average release rate, q", shall be equal to or less than (1400/d) kw/sq. m, where d is the cable diameter: q" ≤ 1400/d
   c) Tenable Smoke Density – The product of the smoke toxic potency, LC (50), the smoke specific extinction area, o, and the percent of the sample vaporized, f, shall be equal to or greater than 0.2: (LC (50)) (o) (f) ≥ 0.2

b. Smoke Toxicity Test

1) Testing shall be according to the University of Pittsburgh Smoke Toxicity Test Protocol as described in the New York State Flammability regulations.

2) If the insulation has already been tested according to the filing requirements of the New York State Uniform Fire Prevention and Building Code, Article 15, Part 120, the data bank on file is used which applies to the product registration category to which the wire insulation belongs.

3) If the data is not on file with the State of New York, test the wire insulation according to published procedures.
4) Regardless of filing status, the following shall be reported:

a) LC (50), the toxic potency in grams

b) The percent residue, \( p \)

c) The fraction of the sample vaporized, \( f = (100-p)/100 \)

5) Requirement

a) Toxic Gas Production – The toxic gas parameter, \( T \), shall be less than or equal to \( 2100/d \), where \( m' \) is the average mass loss rate, \( f \) is the fraction of smoke vaporized, \( LC(50) \) is the toxic potency, and \( t_{ig} \) is the ignition time at 35kW/m²:

\[
T = \frac{(m')(450 - t_{ig})}{2100/d} \leq \frac{(f)(LC(50))}{d}
\]

b) These tests and requirements replace the IEEE 383 flame propagation tests included in the NEMA HP100-1991 and NEMA HP100.2-1991 standard.

c) The qualification tests under these requirements shall be conducted with 12 AWG and 20 AWG conductors rated at 2000V and 600V respectively.

6) Corrosion Test

a) The copper mirror corrosion test shall detect corrosive materials that may be driven off the insulation material at elevated temperatures, and have a potential for conductor corrosion.

b) Cut a piece of insulation into small pieces and place 0.4 grams of the insulation into each of two test tubes. Use a third test tube as a control. Suspend a copper glass mirror about 0.25 inches wide by 1.0 inch long in each of the test tubes.

Suspend a thermometer six or seven inches above the bottom of one of the test tubes. Fine copper wires attached to a cork may be used to suspend these items. Seal the test tubes with a cork wrapped in aluminum foil.

c) The mirror shall be vacuum deposited copper with a thickness equal to \( 10 \pm 5 \) percent transmission of the normal incident light at 5000A. Use the mirrors only if no oxide film is present and the copper is not visibly damaged.

d) The bottom two inches of the three test tubes shall be immersed in an oil bath at 175°C for 16 hours. Keep the portion of the test tubes containing the mirror at a temperature below 60°C.

e) After cooling, the mirrors shall be examined by placing them against a white background in good light. Any removal of copper from the mirrors will be a sign of corrosion. Disregard any removal of copper from the bottom 0.6 inches of the mirror, since drippings can cause this condition. Do not consider discoloration of the copper film or reduction of its thickness as corrosion. Consider the removal of copper that renders the mirror transparent as the corrosion, and estimate the area of copper removal.

f) Examine the control mirror for corrosive damage and compare with the exposed mirrors. When compared to the control mirrors, the removal of 5 percent or more of the area of either of the test mirrors shall be considered a failure.
C. Multi-Conductor Cable Testing

1. All cables shall meet the requirements of the following "Routine Tests".
   
a. Cables shall be voltage tested, each conductor to all other conductors, in accordance with either 7.4.1.2 or 7.4.1.3 of NEMA HP100-1991 at the following test voltages.

<table>
<thead>
<tr>
<th>Rated Voltages, Volts</th>
<th>Test Voltage, kV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(ac) (dc)</td>
</tr>
<tr>
<td>150 or less</td>
<td>1.0 3.5</td>
</tr>
<tr>
<td>300</td>
<td>1.5 4.5</td>
</tr>
<tr>
<td>600</td>
<td>2.5 7.5</td>
</tr>
<tr>
<td>1000</td>
<td>3.0 9.0</td>
</tr>
<tr>
<td>2000</td>
<td>4.0 12.0</td>
</tr>
</tbody>
</table>

   b. Shielded cables shall be tested with shields grounded. For cables having shields over individual conductors, the test voltage shall be applied between the insulated conductor and the shield.

   c. For multi-conductor cables with non-shielded individual conductors having a shield over the cable assembly, the test voltage shall be applied between each insulated conductor and all other conductors and the grounded shield.

   d. Shrinkage of the jacket shall be determined by using the procedure described in Clause 3.4.A.3 of this section. The maximum allowable shrinkage is 0.375 inches (9.525 mm).

   e. Cable jackets shall be voltage tested according to Clause 3.4.C.1.a of this Section, using the individual conductors under the jacket as ground or the shield directly under the jacket as ground.

   f. Cable jackets shall meet the tensile strength, elongation at rupture, heat shock and cold bend requirements of NEMA HP100.2, Table 2-1.

   g. All cables shall meet the requirements of the following "Material Tests".
      
      1) Cables shall meet the smoke requirements of NFPA 258. The optical density in both the flaming and non-flaming modes must not exceed 300 within four minutes of the start of the test.

      2) Cables shall meet the flame requirements of IEEE-383, 2.51 through 2.5.4.4.4.

   3) Cable jackets shall meet the aging requirements, heat distortion, insulation resistance and dielectric constant requirements of NEMA HP-100.2, Table 2-1

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 "Signal System Basic Technical Requirements."
### Table A - Stranded Conductors

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Stranding (NO/size)</th>
<th>Strand Type</th>
<th>Conductor Nominal Diameter (mils)</th>
<th>Nominal DC Resistance @ 20° C (ohms/1000 ft)</th>
<th>Nominal DC Resistance @ 20° C (ohms/mm)</th>
<th>Nominal DC Resistance @ 20° C (ohms/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>19/36</td>
<td>UNI</td>
<td>23.6</td>
<td>25.700</td>
<td>0.599</td>
<td>84.300</td>
</tr>
<tr>
<td>22</td>
<td>19/34</td>
<td>UNI</td>
<td>29.6</td>
<td>15.800</td>
<td>0.752</td>
<td>51.800</td>
</tr>
<tr>
<td>22</td>
<td>7/30</td>
<td>CON</td>
<td>30.9</td>
<td>16.900</td>
<td>0.785</td>
<td>55.400</td>
</tr>
<tr>
<td>20</td>
<td>19/32</td>
<td>UNI</td>
<td>37.8</td>
<td>9.630</td>
<td>0.960</td>
<td>31.600</td>
</tr>
<tr>
<td>18</td>
<td>19/30</td>
<td>UNI</td>
<td>46.7</td>
<td>6.150</td>
<td>1.190</td>
<td>20.200</td>
</tr>
<tr>
<td>16</td>
<td>19/29</td>
<td>UNI</td>
<td>53.0</td>
<td>4.770</td>
<td>1.350</td>
<td>15.600</td>
</tr>
<tr>
<td>14</td>
<td>19/27</td>
<td>UNI</td>
<td>66.2</td>
<td>3.040</td>
<td>1.680</td>
<td>9.970</td>
</tr>
<tr>
<td>14</td>
<td>37/30</td>
<td>CON*</td>
<td>71.0</td>
<td>1.760</td>
<td>3.050</td>
<td>10.000</td>
</tr>
<tr>
<td>12</td>
<td>37/28</td>
<td>CON*</td>
<td>87.2</td>
<td>2.020</td>
<td>2.190</td>
<td>6.630</td>
</tr>
<tr>
<td>10</td>
<td>37/26</td>
<td>CON*</td>
<td>110.0</td>
<td>4.130</td>
<td>2.800</td>
<td>4.130</td>
</tr>
<tr>
<td>9</td>
<td>37/.0190</td>
<td>CON*</td>
<td>129.0</td>
<td>2.720</td>
<td>3.270</td>
<td>2.720</td>
</tr>
<tr>
<td>9</td>
<td>19x7/.010</td>
<td>UNI/ROPE</td>
<td>148.0</td>
<td>2.890</td>
<td>3.760</td>
<td>2.890</td>
</tr>
<tr>
<td>8</td>
<td>19x7/29</td>
<td>UNI/ROPE</td>
<td>162.0</td>
<td>2.240</td>
<td>4.110</td>
<td>2.240</td>
</tr>
<tr>
<td>6</td>
<td>19x7/27</td>
<td>UNI/ROPE</td>
<td>203.0</td>
<td>1.420</td>
<td>5.160</td>
<td>1.420</td>
</tr>
<tr>
<td>4</td>
<td>19x7/25</td>
<td>UNI/ROPE</td>
<td>257.0</td>
<td>.879</td>
<td>6.530</td>
<td>.879</td>
</tr>
<tr>
<td>2</td>
<td>19x35/30</td>
<td>CON/ROPE</td>
<td>331.0</td>
<td>.568</td>
<td>8.410</td>
<td>.568</td>
</tr>
<tr>
<td>1</td>
<td>19x43/30</td>
<td>CON/ROPE</td>
<td>360.0</td>
<td>.479</td>
<td>9.150</td>
<td>.479</td>
</tr>
<tr>
<td>1/0</td>
<td>19x55/30</td>
<td>CON/ROPE</td>
<td>418.0</td>
<td>.364</td>
<td>10.600</td>
<td>.364</td>
</tr>
<tr>
<td>2/0</td>
<td>19x70/30</td>
<td>CON/ROPE</td>
<td>464.0</td>
<td>.286</td>
<td>11.800</td>
<td>.286</td>
</tr>
<tr>
<td>3/0</td>
<td>37x45/30</td>
<td>CON/ROPE</td>
<td>531.0</td>
<td>.228</td>
<td>13.500</td>
<td>.228</td>
</tr>
<tr>
<td>4/0</td>
<td>37x57/30</td>
<td>CON/ROPE</td>
<td>598.0</td>
<td>.180</td>
<td>15.200</td>
<td>.180</td>
</tr>
<tr>
<td>500 MCM</td>
<td>7x19x38/30</td>
<td>BUN/ROPE</td>
<td>988.0</td>
<td>.072</td>
<td>25.095</td>
<td>.072</td>
</tr>
</tbody>
</table>

* Double Pass Concentric

### Table B - Stranded Conductors

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Conductor Nominal Dia. (mils)</th>
<th>Nominal DC Resistance @ 20° C (ohms/1000 ft)</th>
<th>Nominal DC Resistance @ 20° C (ohms/1000 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>10.3</td>
<td>0.262</td>
<td>114.0</td>
</tr>
<tr>
<td>28</td>
<td>13.0</td>
<td>0.330</td>
<td>70.5</td>
</tr>
<tr>
<td>26</td>
<td>16.4</td>
<td>0.417</td>
<td>44.7</td>
</tr>
<tr>
<td>24</td>
<td>20.7</td>
<td>0.526</td>
<td>27.8</td>
</tr>
<tr>
<td>22</td>
<td>26.1</td>
<td>0.655</td>
<td>17.1</td>
</tr>
<tr>
<td>20</td>
<td>32.9</td>
<td>0.836</td>
<td>10.5</td>
</tr>
</tbody>
</table>
### Table C – Stranded Wires Rated 0-150 Volts

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Nominal Insulation Thickness (mils)</th>
<th>Nominal Wire OD (mm)</th>
<th>Nominal Weight (lbs/M ft)</th>
<th>Ampacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 10</td>
<td>0.254</td>
<td>43.6</td>
<td>2.3</td>
<td>3.43</td>
</tr>
<tr>
<td>22 10</td>
<td>0.254</td>
<td>49.6</td>
<td>3.2</td>
<td>4.77</td>
</tr>
<tr>
<td>22 (7/30) 10</td>
<td>0.254</td>
<td>49.8</td>
<td>3.2</td>
<td>4.77</td>
</tr>
<tr>
<td>20 10</td>
<td>0.254</td>
<td>57.8</td>
<td>4.8</td>
<td>7.15</td>
</tr>
<tr>
<td>18 10</td>
<td>0.254</td>
<td>66.7</td>
<td>7.1</td>
<td>10.58</td>
</tr>
<tr>
<td>16 10</td>
<td>0.254</td>
<td>73.0</td>
<td>8.8</td>
<td>13.11</td>
</tr>
</tbody>
</table>

* Ampacity Rating per definition in 1.1.C.1

### Table D – Stranded Wires Rated 0-300 Volts

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Nominal Insulation Thickness (mils)</th>
<th>Nominal Wire OD (mm)</th>
<th>Nominal Weight (lbs/M ft)</th>
<th>Ampacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 12</td>
<td>0.305</td>
<td>47.6</td>
<td>2.5</td>
<td>3.73</td>
</tr>
<tr>
<td>22 12</td>
<td>0.305</td>
<td>53.6</td>
<td>3.5</td>
<td>5.22</td>
</tr>
<tr>
<td>22 (7/30) 12</td>
<td>0.305</td>
<td>53.8</td>
<td>3.5</td>
<td>5.22</td>
</tr>
<tr>
<td>20 12</td>
<td>0.305</td>
<td>61.8</td>
<td>5.1</td>
<td>7.60</td>
</tr>
<tr>
<td>18 12</td>
<td>0.305</td>
<td>70.7</td>
<td>7.4</td>
<td>11.03</td>
</tr>
<tr>
<td>16 12</td>
<td>0.305</td>
<td>77.0</td>
<td>9.1</td>
<td>13.56</td>
</tr>
<tr>
<td>14 (UNI) 12</td>
<td>0.305</td>
<td>90.2</td>
<td>13.9</td>
<td>20.71</td>
</tr>
<tr>
<td>14 (CON) 12</td>
<td>0.305</td>
<td>95.0</td>
<td>14.6</td>
<td>21.75</td>
</tr>
</tbody>
</table>

* Ampacity Rating per definition in 1.1.C.1
## Table E – Stranded Wires Rated 0-600 Volts

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Nominal Insulation Thickness (mils)</th>
<th>Nominal Wire OD (mm)</th>
<th>Nominal Weight (lbs/M ft)</th>
<th>Ampacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>15</td>
<td>0.381</td>
<td>53.6</td>
<td>1.361</td>
</tr>
<tr>
<td>22</td>
<td>15</td>
<td>0.381</td>
<td>59.6</td>
<td>1.514</td>
</tr>
<tr>
<td>22 (7/30)</td>
<td>15</td>
<td>0.381</td>
<td>59.8</td>
<td>1.514</td>
</tr>
<tr>
<td>20</td>
<td>15</td>
<td>0.381</td>
<td>67.8</td>
<td>1.722</td>
</tr>
<tr>
<td>18</td>
<td>15</td>
<td>0.381</td>
<td>76.7</td>
<td>1.948</td>
</tr>
<tr>
<td>16</td>
<td>15</td>
<td>0.381</td>
<td>83.0</td>
<td>2.108</td>
</tr>
<tr>
<td>14 (UNI)</td>
<td>15</td>
<td>0.381</td>
<td>96.2</td>
<td>2.443</td>
</tr>
<tr>
<td>14 (CON)</td>
<td>15</td>
<td>0.381</td>
<td>101.0</td>
<td>2.565</td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>0.381</td>
<td>117.2</td>
<td>2.974</td>
</tr>
<tr>
<td>10</td>
<td>17</td>
<td>0.432</td>
<td>144.0</td>
<td>3.658</td>
</tr>
<tr>
<td>9 (37/.019)</td>
<td>17</td>
<td>0.432</td>
<td>163.0</td>
<td>4.140</td>
</tr>
<tr>
<td>9 (19x7/.01)</td>
<td>17</td>
<td>0.432</td>
<td>182.0</td>
<td>4.623</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>0.432</td>
<td>196.0</td>
<td>4.978</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>0.508</td>
<td>243.0</td>
<td>6.172</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>0.610</td>
<td>305.0</td>
<td>7.747</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>0.660</td>
<td>383.0</td>
<td>9.728</td>
</tr>
<tr>
<td>1</td>
<td>28</td>
<td>0.711</td>
<td>416.0</td>
<td>10.566</td>
</tr>
<tr>
<td>1/0</td>
<td>30</td>
<td>0.762</td>
<td>478.0</td>
<td>12.141</td>
</tr>
<tr>
<td>2/0</td>
<td>39</td>
<td>0.991</td>
<td>542.0</td>
<td>13.767</td>
</tr>
<tr>
<td>3/0</td>
<td>50</td>
<td>1.270</td>
<td>631.0</td>
<td>16.027</td>
</tr>
<tr>
<td>4/0</td>
<td>50</td>
<td>1.270</td>
<td>698.0</td>
<td>17.729</td>
</tr>
<tr>
<td>500 MCM</td>
<td>50</td>
<td>1.270</td>
<td>1088.0</td>
<td>27.635</td>
</tr>
</tbody>
</table>

* Ampacity Rating per definition in 1.1.C.1
Table F – Stranded Wires Rated 0-1000 Volts

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Nominal Insulation Thickness (mils)</th>
<th>Nominal Wire OD (mils)</th>
<th>Nominal Wire OD (mm)</th>
<th>Nominal Weight (lbs/M ft)</th>
<th>Nominal Weight (kg/km)</th>
<th>Ampacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>18</td>
<td>0.457</td>
<td>82.7</td>
<td>2.101</td>
<td>8.5</td>
<td>12.67</td>
</tr>
<tr>
<td>16</td>
<td>18</td>
<td>0.457</td>
<td>89.0</td>
<td>2.261</td>
<td>10.3</td>
<td>15.35</td>
</tr>
<tr>
<td>14 (UNI)</td>
<td>18</td>
<td>0.457</td>
<td>102.2</td>
<td>2.596</td>
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<td>22.80</td>
</tr>
<tr>
<td>14 (CON)</td>
<td>18</td>
<td>0.457</td>
<td>107.0</td>
<td>2.718</td>
<td>16.0</td>
<td>23.84</td>
</tr>
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<td>12</td>
<td>18</td>
<td>0.457</td>
<td>123.2</td>
<td>3.129</td>
<td>22.5</td>
<td>33.53</td>
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<tr>
<td>10</td>
<td>20</td>
<td>0.508</td>
<td>150.0</td>
<td>3.810</td>
<td>34.7</td>
<td>51.70</td>
</tr>
<tr>
<td>9 (37/.019)</td>
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<td>169.0</td>
<td>4.293</td>
<td>48.3</td>
<td>71.97</td>
</tr>
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<td>9 (19x7/.01)</td>
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<td>0.508</td>
<td>188.0</td>
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<td>48.6</td>
<td>72.41</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
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</tr>
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<td>247.0</td>
<td>6.274</td>
<td>93.7</td>
<td>139.61</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
<td>0.610</td>
<td>305.0</td>
<td>7.747</td>
<td>146.0</td>
<td>217.54</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>0.660</td>
<td>383.0</td>
<td>9.728</td>
<td>226.0</td>
<td>336.74</td>
</tr>
<tr>
<td>1</td>
<td>28</td>
<td>0.711</td>
<td>416.0</td>
<td>10.566</td>
<td>271.0</td>
<td>403.79</td>
</tr>
<tr>
<td>1/0</td>
<td>30</td>
<td>0.762</td>
<td>478.0</td>
<td>12.141</td>
<td>358.0</td>
<td>533.42</td>
</tr>
<tr>
<td>2/0</td>
<td>39</td>
<td>0.991</td>
<td>542.0</td>
<td>13.767</td>
<td>457.0</td>
<td>680.93</td>
</tr>
<tr>
<td>3/0</td>
<td>50</td>
<td>1.270</td>
<td>631.0</td>
<td>16.027</td>
<td>598.0</td>
<td>891.01</td>
</tr>
<tr>
<td>4/0</td>
<td>50</td>
<td>1.270</td>
<td>698.0</td>
<td>17.729</td>
<td>737.0</td>
<td>1098.12</td>
</tr>
<tr>
<td>500 MCM</td>
<td>50</td>
<td>1.270</td>
<td>1088.0</td>
<td>27.635</td>
<td>1770.0</td>
<td>2637.28</td>
</tr>
</tbody>
</table>

* Ampacity Rating per definition in 1.1.C.1
### Table G – Stranded Wires Rated 0-2000 Volts

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Nominal Insulation Thickness (mils)</th>
<th>Nominal Wire OD (mm)</th>
<th>Nominal Weight (lbs/M ft)</th>
<th>Ampacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>20</td>
<td>0.508</td>
<td>93.0</td>
<td>1.609</td>
</tr>
<tr>
<td>14 (UNI)</td>
<td>20</td>
<td>0.508</td>
<td>106.2</td>
<td>15.8</td>
</tr>
<tr>
<td>14 (CON)</td>
<td>20</td>
<td>0.508</td>
<td>110.0</td>
<td>16.6</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>0.508</td>
<td>127.2</td>
<td>23.2</td>
</tr>
<tr>
<td>10</td>
<td>24</td>
<td>0.610</td>
<td>158.0</td>
<td>36.2</td>
</tr>
<tr>
<td>9 (37/.019)</td>
<td>24</td>
<td>0.610</td>
<td>177.0</td>
<td>50.0</td>
</tr>
<tr>
<td>9 (19x7/.01)</td>
<td>24</td>
<td>0.610</td>
<td>196.0</td>
<td>50.5</td>
</tr>
<tr>
<td>8</td>
<td>22</td>
<td>0.610</td>
<td>210.0</td>
<td>62.5</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>0.660</td>
<td>255.0</td>
<td>96.1</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
<td>0.660</td>
<td>309.0</td>
<td>147.7</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>0.711</td>
<td>387.0</td>
<td>227.7</td>
</tr>
<tr>
<td>1</td>
<td>28</td>
<td>0.711</td>
<td>421.0</td>
<td>271.0</td>
</tr>
<tr>
<td>1/0</td>
<td>30</td>
<td>0.762</td>
<td>478.0</td>
<td>358.0</td>
</tr>
<tr>
<td>2/0</td>
<td>39</td>
<td>0.991</td>
<td>542.0</td>
<td>457.0</td>
</tr>
<tr>
<td>3/0</td>
<td>50</td>
<td>1.270</td>
<td>631.0</td>
<td>598.0</td>
</tr>
<tr>
<td>4/0</td>
<td>50</td>
<td>1.270</td>
<td>698.0</td>
<td>737.0</td>
</tr>
<tr>
<td>500 MCM</td>
<td>50</td>
<td>1.270</td>
<td>1088.0</td>
<td>2637.28</td>
</tr>
</tbody>
</table>

*Ampacity Rating per definition in 1.1.C.1

### Table H – Solid Conductor Wire Wrap Rated 0-300 Volts

<table>
<thead>
<tr>
<th>Conductor Size (AWG)</th>
<th>Nominal Insulation Thickness (mils)</th>
<th>Nominal Wire OD (mm)</th>
<th>Nominal Weight (lbs/M ft)</th>
<th>Ampacity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>6</td>
<td>.152</td>
<td>22.3</td>
<td>0.54</td>
</tr>
<tr>
<td>28</td>
<td>6</td>
<td>.152</td>
<td>25.0</td>
<td>0.76</td>
</tr>
<tr>
<td>26</td>
<td>6</td>
<td>.152</td>
<td>28.4</td>
<td>1.10</td>
</tr>
<tr>
<td>24</td>
<td>6</td>
<td>.152</td>
<td>32.7</td>
<td>1.60</td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>.152</td>
<td>37.8</td>
<td>2.40</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
<td>.152</td>
<td>44.9</td>
<td>3.70</td>
</tr>
</tbody>
</table>

*Ampacity Rating not available for low amperage conductors.
### Table H(a) – Wire Test Requirements

<table>
<thead>
<tr>
<th>Wires rated</th>
<th>High Frequency Test Voltage KVAR (Peak)</th>
<th>Impulse (Peak) or DC Spark Test Voltage KVDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-150 V</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>0-300 V</td>
<td>5.0</td>
<td>7.0</td>
</tr>
<tr>
<td>0-600 V</td>
<td>6.5</td>
<td>12.0</td>
</tr>
<tr>
<td>0-1000 V</td>
<td>8.0</td>
<td>16.0</td>
</tr>
<tr>
<td>0-2000 V</td>
<td>10.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

### Table I – Color Code of Individual Wires of Multi-Conductor Cables

1. Black  
2. Brown  
3. Red  
4. Orange  
5. Yellow  
6. Green  
7. Blue  
8. Violet  
9. Gray  
10. White  
11. White/Black  
12. White/Brown  
13. White/Red  
14. White/Orange  
15. White/Yellow  
16. White/Green  
17. White/Blue  
18. White/Violet  
19. White/Gray  
20. Black/Brown  
21. Black/Red  
22. Black/Orange  
23. Black/Yellow  
24. Black/Green  
25. Black/Blue  
26. Black/Violet  
27. Black/Gray  
28. Black/White  
29. Brown/Black  
30. Brown/Red  
31. Brown/Orange  
32. Brown/Yellow  
33. Brown/Green  
34. Brown/Blue  
35. Brown/Violet  
36. Brown/Gray  
37. Brown/White  
38. Red/Black  
39. Red/Brown  
40. Red/Orange  
41. Red/Yellow  
42. Red/Green  
43. Red/Blue  
44. Orange/Black  
45. Red/Gray  
46. Red/White  
47. Orange/Black  
48. Orange/Brown  
49. Orange/Red  
50. Orange/Yellow  

### Table I(a) – Jacket Thickness

<table>
<thead>
<tr>
<th>Calculated Diameter of Cable under Jacket (Inches)</th>
<th>Jacket Thickness (Mils)</th>
<th>(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.150 or less</td>
<td>10</td>
<td>0.25</td>
</tr>
<tr>
<td>0.151 – 0.250</td>
<td>12</td>
<td>0.31</td>
</tr>
<tr>
<td>0.251 – 0.425</td>
<td>15</td>
<td>0.38</td>
</tr>
<tr>
<td>0.426 – 0.700</td>
<td>20</td>
<td>0.51</td>
</tr>
<tr>
<td>0.701 – 1.000</td>
<td>25</td>
<td>0.64</td>
</tr>
<tr>
<td>1.001 – 1.500</td>
<td>30</td>
<td>0.76</td>
</tr>
</tbody>
</table>

END OF SECTION 16955
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work to be done under this Section consists of designing, furnishing and installing multiple position plug connector assemblies required to connect multi-conductor cables or individual wires to internal wiring of control panels, specified plug-connected racks or equipment modules. These assemblies shall hold and insulate individually mated, extractable pin-and-socket contacts which shall be mechanically crimped to individual wires or wire wrap pins.

B. Each plug connector assembly shall meet applicable requirements as listed in paragraphs 1.2.1 through 1.2.5.

C. Documents applicable to solderless pin and socket contacts refer to paragraphs 1.2.6 through 1.2.11.

1.2 REFERENCE STANDARDS

A. American Society of Mechanical Engineers (ASME)

1. ASME B 46.1 - Surface Texture (Surface Roughness, Waviness and Lay)

B. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)


2. ASTM B 19 - Standard Specifications for Cartridge Brass Sheet, Strip, Plate, Bar and Disks.

3. ASTM B 36/B 36M - Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar

4. ASTM B 140/B 140M - Standard Specification for Copper-Zinc-Lead (Red Brass or Hardware Bronze) Rod, Bar, and Shapes

C. Federal Standard (FS)

1. FS QQ-S-766 Steel, Corrosion Resistant

D. Military Standards (MS)

1. MIL-M-14 - Molding Plastics and Molded Plastic Parts; Thermosetting

2. MIL-C-8384B - Connectors; Plug and Receptacle - Electrical Rectangular Type, Molded Body

3. MIL-W-1687D - Wire, Electrical Insulated, Copper

4. MIL-STD-202G - Test Methods for Electronic and Electrical Component Parts

5. MIL-HDBK-454A - General Requirements for Electronic Equipment

6. MIL-G-45204 - Gold Plating; Electrodeposited.

7. MIL-STD-I916 - Sampling Procedures and Tables for Inspection by Attributes

E. Society of Automotive Engineers (SAE)

1. AMS QQ-N-290 - Nickel Plating; Electrodeposited

1.3 SUBMITTALS

A. The Contractor shall submit for approval, product data for each type of plug connector to be used.

B. The Contractor shall submit for approval, complete drawings and sample of each type of plug connector to be used. Drawings shall include complete parts lists and information required to order replacement parts. Drawings shall be required for the following components:

1. Molded plug connector blocks

2. Protective shells for blocks

3. All locking and keying devices

4. Strain-relief clamping devices

5. Extractable pin-and-socket contacts

1.4 QUALITY ASSURANCE

A. Each plug connector shall be inspected prior to shipment. Inspection shall conform to the Contractor’s Factory Inspection Procedure as approved by the Authority.

B. The Contractor shall inspect each plug connector assembly after it has been installed and correct any deficiencies. This inspection shall be conducted in conformance with requirements of Authority approved Installation and Inspection Procedures.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Connector assemblies shall be easily connected and disconnected by hand and be provided with mechanical locking and keying devices.
B. Two basic types of connectors shall be provided, a vital circuit type and nonvital circuit type. Unless otherwise approved, the number of contacts in a vital circuit plug connector shall not exceed 28 contacts and in nonvital circuit plug connector, 50 contacts.

C. Basic Consist

1. Each plug connector assembly shall consist of the following:
   a. A two-part molded plastic connector block equipped to hold an appropriate number of solderless pin-and-socket contacts.
   b. Devices for the mechanical locking and keying of connector block halves.
   c. Protective shells for both connector block halves.
   d. A strain relief device for the external wiring portion of the connector assembly.
   e. Solderless extractable pin-and-socket contacts.
   f. Where required, embedded wire wrap terminals for internal wiring portion of the connector block.

2. Connector Blocks
   a. Connector blocks shall consist of molded dielectric plastic shaped to accept the required number and types of contact pins, contact sockets and locking, keying and mounting devices. The dielectric material shall exhibit a minimum insulation resistance of 100 megohms as measured between adjacent pairs of contacts and between the accessory hardware and the closest contacts in each connector assembly half.
   b. Contact cavities shall be arranged in a rectangular grid configuration. The opening for each contact shall be uniquely identified by a coordinate molded into both the mating and wiring faces of each part of the connector block.
   c. Vital plug connector blocks shall provide a surface leakage distance of not less than 1/4 inch between contacts and between the contacts and any other metallic part of the connector assembly.

3. Locking and Keying
   a. Each plug connector assembly shall include a device for mechanically locking the two mated parts together.
   b. Mechanical devices and facilities shall be provided to allow mating parts of connector assemblies to be keyed in such a manner that they cannot be coupled except when in the correct position relative to each other and cannot be coupled to the mating parts of other coupler assemblies keyed in a different pattern.

4. Protection and Strain Relief
   a. Each half of the plug connector block shall be protected by a metal shield which shall extend beyond the mating surface. These two shields shall overlap when connector halves are coupled.
   b. External wiring portion of each plug connector assembly shall be equipped with a device to grip the external wiring firmly in order to prevent strain on the plug connector contacts.

5. Pin-and-Socket Contacts
   a. Pin-and-socket contacts shall be fabricated from commercial bronze or brass and plated with gold over nickel underplate. Retention springs of the pin-and-socket contacts shall be fabricated from stainless steel.
   b. Contacts shall be fabricated and classified in the required selection of sizes to accept wire sizes 16 through 22, AWG.
   c. Contact current rating and termination resistance shall meet the requirements of the following table with properly sized contacts applied to the wire sizes specified.

<table>
<thead>
<tr>
<th>Wire Size (AWG)</th>
<th>16,18,20,22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Current: Rating (Amperes)</td>
<td>13.0, 10.0, 7.5, 5.0</td>
</tr>
<tr>
<td>Maximum Termination: Resistance (Milliohms)</td>
<td>1.7, 2.0, 2.7, 4.0</td>
</tr>
<tr>
<td>Contact termination resistance shall be measured in accordance with Method 307 of MIL-STD-202G at the rated current specified for each wire size.</td>
<td></td>
</tr>
</tbody>
</table>
2.3 DELIVERY, STORAGE AND HANDLING

A. Not Used

PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 INSTALLATION

A. The 28-way, vital plug connector assembly shall be required where any vital circuits are to be interconnected and the 50-way nonvital plug connector assembly used where nonvital circuits are to be interconnected.

B. When plug connectors are dedicated to single multi-conductor cables, 20 percent of the wires and connector contacts shall be reserved for future working circuits. When a plug connector is used for made up, un-jacketed cables, 20 percent of the connector contacts shall be reserved for future working circuits.

C. When a plug connector is assembled to a multi-conductor cable, strain relief device shall grip the cable outer sheath.

D. When a vital or nonvital plug connector is dedicated to a cable, each wire shall be terminated properly on a connector contact.

E. In each case, a uniform scheme shall be followed in assigning specific cable wires to specific connector contacts.

F. Where a full hand grasp is required to connect or disconnect a plug connector, a minimum of two inches of clear space shall be provided around the connector. A minimum 3/4-inch clear space shall be provided around connectors, which can be connected or disconnected with thumb and fingertips only.

G. Plug connectors shall be located and installed in such a manner that no part of the plug connector or its cable will extend beyond the wire routing as defined by wire supports and in no circumstances shall the connector or its cable be permitted to protrude into an aisle-way.

H. Each plug connector assembly, as finally installed, shall be marked in such a manner that its mating halves be distinctly identified as being related to each other, but to no other plug connector assembly within the immediate area. These identification markings shall be applied in such a manner that they will not be obscured or worn off in normal use.

I. Tools used to apply plug connector contacts to wire and tools used to extract contacts from the plug connector blocks shall be the size and type recommended by manufacturer of the plug connector assemblies. Four of each tool shall be provided to the Authority.

3.3 TESTING

A. Testing of plug connectors shall be in accordance with the requirements of these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16957
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work to be done under this Section consists of designing, providing and installing all required relays for use in wayside house or case applications only.

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. AREMA – Communications and Signals Manual, Section 6 - Relays

1.3 SUBMITTALS

A. Contractor shall submit for Authority approval all relay specifications, any special mounting or supporting arrangements and contact stacking arrangements for all relay types proposed to be provided. Submittal shall include any required arc suppression components.

B. Contractor shall submit for Authority approval the type of relay identification tag, including method of mounting.

1. In the event of excessive long relay nomenclature on relay identification tags, Contractor shall submit for Authority approval its method of identifying such relays.

C. Contractor shall submit for Authority approval, manuals for each relay type. Each relay manual shall give comprehensive descriptions and illustrations of each type of relay to be provided for this Contract, including such items as operation, overhaul, adjustments, part numbers and other pertinent information.

D. Upon approval of relay manuals, Contractor shall provide 15 additional relay manuals and 15 copies of relay specification and calibration sheets for each type of relay provided.

E. Contractor shall submit an applicable Office Record Test Form for each vital relay provided under this Contract as found in the AREMA Communications and Signals Manual. The use of typewritten characters shall be used to fill in all information requested on the form and then verified in the field in its final configuration, for accuracy of relay serial number, location and relay identification. Indexing of form cards shall be by serial number and turned over to the Authority upon final verification.

1.4 QUALITY ASSURANCE

A. Each relay shall be inspected prior to shipment. Inspection shall conform to Contractor's Factory Inspection Procedure as approved by the Authority.

B. Vital relays shall meet the requirements of AREMA Communications and Signals Manual, Section 6.2.1.

C. Non-vital relays shall meet the requirements of AREMA Communications and Signals Manual, Section 6.3.1.

D. Factory testing of each relay shall be in accordance with the manufacturer's standard procedures.

E. Each relay shall be inspected after it has been installed in the field. This inspection shall conform to Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

F. Each relay shall be tested according to Authority approved test procedures.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Vital relays shall be shipped separately from the wired racks in which they are to be used. Relays shall be stored in a protected area until tested and installed.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. General

1. Unless otherwise indicated, relays shall be plug-in type. Relays of each type shall be uniform in design and contact assembly.

2. A sufficient number of contacts for the number of circuits to be controlled plus spare contacts shall be provided. Unless otherwise approved, each relay or relay-repeater combination shall have at least one spare dependent front-back contact or one spare independent front and one spare independent back contact.
3. All relays and equipment specified shall be capable of rated performance through an operating temperature range of minus 40 degrees F to plus 185 degrees F.

4. All relays shall be in dust-proof enclosures. A provision shall be made for ventilation for heat dissipation, where required.

B. Maintenance Materials

1. Provide one percent of each type of relay (vital, non-vital, timer, flasher) used in the system. All quantities shall be rounded up to the next whole number.

2. All units are to include plug boards.

C. Keys, Special Tools, and Test Equipment

1. Contractor shall provide two complete sets of all vital relay adjustment tools, including:
   a. Contact Adjustment Tools
   b. Front and Back Horizontal adjustment Tool
   c. Heel Horizontal Adjustment Tool
   d. Contact Tension Gauge
   e. Permanent Magnet Hold-Down Gauge
   f. Front and Back Test Plugs
   g. All space gauges needed to adjust armature stroke and contacts.

2. Contractor shall provide one manually operated relay test stand. The stand shall accommodate each type vital and non-vital relay supplied under this Contract. Each stand shall include all instruments and equipments completely installed in the test stand, including all applicable relay plugboards and power supplies needed to be operable from normal 120 volts AC power source. Final configuration of relay test stand shall require approval of the Authority.

D. Vital Relays

1. Vital DC relays shall be of plug-in type and rack-mounted. They shall have a transparent dust cover made of a non-flammable composition meeting the requirements of AREMA Communication and Signal Manual, Section 6.2.1.

2. Vital relays, with a nominal operating voltage of 10-16 volts, shall be capable of operating continuously and successfully without resultant damage with a voltage range of 7-21 volts inclusive applied to their operating circuits.

3. Biased neutral vital relays shall be designed so that gravity alone will prevent the armature from picking up if the permanent magnet is de-energized or if no current is applied to the coil due to interruption of the normal magnetic circuit. Biased neutral vital relays shall be designed so that up to at least 50 times working energization applied for two seconds at both normal and reverse polarity will not affect their operating characteristics by more than two percent and will not pick up their armature on reverse polarity.

4. With the exception of special-purpose relays, each vital relay shall have a minimum of four dependent front-back contacts, two independent front contacts, and one independent back contact. All front contacts shall be silver-to-metalized carbon.

5. When three contacts of DC vital relays, suppressed as specified herein, are connected in parallel and operated from their nominal operating voltage, a vital relay front or back contact which breaks this load shall be capable of at least five million operations at this load without the contact resistance, measured with a 10 milliamp current, exceeding five ohms.

6. Arc suppression for vital relays, when required, shall be built into the relay or mounted directly on its plugboard.

7. Contact arrangements shall be identical for similar types of relays except special function relays.

8. All vital plug-in relays, except vital time-element relays and special application relays, shall be equipped with front current testing facilities. Where required by the Authority, facilities shall be provided to enable testing of voltage from the front of relay.

9. Vital relays shall be equipped with a registration plate to prevent relays of the wrong style, contact arrangement or operating characteristics from being inserted into the plugboard.
E. Switch Operating Relays:

1. Vital switch operating relays used for control of switch-and-lock movement shall meet the same requirements as specified for vital biased neutral relays, except that a minimum of two front-back dependent contacts or two independent front contacts and two independent back contacts shall be required.

2. Each contact shall be equipped with a magnetic blow-out feature to effectively interrupt high currents and minimize contact wear. Each contact shall be capable of interrupting the normal switch-and-lock movement operating current 10,000 times without its resistance exceeding ten ohms measured at five amperes. All switch operating relays shall be identical. One normal and one reverse switch-operating relay shall be provided for each switch-and-lock mechanism.

F. Vital Overload Relays

1. Vital overload relays shall meet the requirements of vital relays except as modified and be used to detect a switch over-current condition. One overload relay shall be provided for each switch mechanism as indicated on Contract Drawings.

2. Switch overload relays shall be of the same manufacture as the switch mechanism, unless otherwise approved by the Authority.

3. Each overload relay shall be provided with a sufficient number of contacts to perform the functions as described in these Specifications. This relay shall be equipped with two non-biased coils; one series connected to detect over-current conditions, the other coil used as a stick circuit. Make-before-break contact shall be utilized as indicated on the Contract Drawings.

G. Light-Out Relay

1. Light-out relays shall meet the requirements of vital relays.

2. Rectifiers required for each light-out relay shall be the manufacturer's standard.

H. Slow Acting Relays: Slow acting relays (slow pickup or slow release), shall have their slow acting characteristics provided by the use of copper or aluminum washers or slugs applied to the relay core.

I. Time Element Circuits: Contractor shall provide solid-state vital and non-vital timers where required in Circuit Drawings consistent with AREMA Communications and Signals Manual Section 6.1.20.

J. Flashers: Flasher rates shall be provided by either vital relay or by solid-state flashers. Flashing rate shall be no less than 45 times per minute nor more than 55 times per minute and shall be in accordance with AREMA Communications and Signals Manual, Section 3.2.55.

K. AC Vital Track Relays

1. AC Vital track relays shall be plug-in, two-element, 100 Hz., vane-type induction relays. AC relays shall be capable of operating continuously and successfully without resultant damage, with a minimum voltage range of 100 volts to 135 volts inclusive applied to the local winding and with a minimum voltage range of 0.75 volt to 5.0 volts inclusive applied to control winding.

2. Each vital AC track relay shall have a minimum of two dependent front-back contacts. Each front contact shall be of silver-to-metalized carbon type.

3. Vital AC track relays shall meet the requirements established by AREMA Communications and Signals Manual, Section 6.1.35, with the exception these relays will be plug-in type and not have screened breathers or equipped with binding posts. These relays shall also meet requirements established in Article 7 of AREMA Communications and Signals Manual, Section 6.2.1.

L. Non-vital Relays

1. Stationary contacts shall be bifurcated silver, palladium or approved equal. Movable contacts shall be bifurcated silver, palladium with gold overlay or approved equal.

2. Each non-vital relay shall meet or exceed the following requirements:
   a. Maximum Temperature Rise: 175 degrees F at 30V DC.
   b. Insulation Resistance: $1.5 \times 10^{10}$ ohms
   c. Ambient Operating Temperature: minus 60 degrees F to 160 degrees F.
d. Dielectric Strength: 500 volts RMS, 60 Hz between all mutually insulated parts.

e. Mechanical Life: 100 million cycle operations.

f. Electric Life: 10 million operations (0.5 ampere resistive load at 77 degrees F).

g. Contact Resistance:
   1) Before Life: 100 milliohms max. at 6 VDC, 100 milliamps.
   2) After Life: 200 milliohms max. at 6 VDC, 100 milliamps.

3. Non-vital relays shall be mounted in dust-proof cabinets having transparent front plates that shall not support combustion. Cabinets shall be mounted in racks as specified. As an alternate, non-vital relays may be provided with individual transparent covers that will not support combustion and be rack mounted.

4. Design of individual relay covers and cabinet in which relays are mounted shall permit viewing the relays without disassembly or other mechanical manipulation to determine the status of each relay.

5. Non-vital relays shall be plug-in, DC neutral relays with a nominal operating voltage of 12 volts. Relays shall pick up with 9 volts or more applied to their operating circuit and must drop out when this voltage decreases below two volts. These relays shall be capable of operating continuously up to a maximum of 21 volts applied to their operating circuit. Non-vital relays shall pick up in less than 25 milliseconds when energized with 9 volts and shall drop out when de-energized from 14 volts in less than 50 milliseconds. These times shall be measured as a front contact closure or opening from the instant the switch applying voltage closes or opens.

6. Contact resistance of non-vital relay contacts shall not exceed 5 ohms after 10 million operations when breaking a test load equivalent to three non-vital relays connected in parallel and supervised as required. Operating voltage for this test shall be 12 volts. Contact resistance shall be measured with a 10-milliamp current. All non-vital relays shall be identical by type and class or function.

M. Relay Plugboards

1. Plugboards shall be designed for insertion of removable type contacts. Plugboards shall be designed so the removable contact will have a direct connection with the relay coil and contact prongs. Plugboards shall be in accordance with applicable sections of the AREMA Communications and Signals Manual, Section 6.2.1.

2. Wire and cable conductor identification tags for terminal board mounting shall be in accordance with the requirements of this Specification.

N. Identification

1. There shall be an identifying nameplate for each relay, relay rack and terminal board.

2. Back and front of relay plugboards shall be equipped with a tag, in accordance with the requirements of this Specification. This tag shall indicate the nomenclature of the relay.

3. Contact numbering system shall be uniform for each type of relay used.

4. Wiring to each removable contact shall be identified with a wrap-around tag in accordance with the requirements of this Specification. This tag shall indicate the relay contact number assigned to the wire.

O. Motor Control Relays for Gate Crossing Mechanisms

1. Relays shall be DC neutral relays with a nominal operating voltage of 12 VDC. Input voltage tolerance (DC) shall be 80% to 110% of nominal voltage.

2. Coil nominal power shall be 14VA, 4.4W.

3. Relay contacts shall meet or exceed the following requirements:
   a. Relay configuration shall be 4 double throw pole (4PDT) type and shall be rated for 35A at 277 VAC or 20A at 28VDC.
   b. Stationary and moveable contacts shall be silver alloy or approved equal.
   c. Insulation Resistance: 1000 megohms at 500VAC.
RELAYS - SIGNAL SYSTEM

3.2 TESTING

A. Contractor shall test all relays in accordance with the requirements of these Specifications.

B. All DC vital relays shall be tested for values in accordance with field requirement values stated in Table 1 of AREMA Communications and Signal Manual, Section 6.4.1.

C. All AC vital relays shall be tested for values in accordance with field requirement values stated in Table 1 of AREMA Communications and Signal Manual, Section 6.4.5.

D. Measured values of all vital relays shall be recorded on relay record forms as specified in AREMA Communications and Signal Manual, and turned over to the Authority upon acceptance of this test requirement.

E. Tests shall be performed at housing locations after housing has been set.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16958

PART 3 - EXECUTION

3.1 INSTALLATION

A. Contractor shall ensure that relay operating characteristics are not altered due to damage during shipping.

B. Contractor shall ensure that all DC power buses are open while installing relays and shall not reconnect buses until all relays are installed.

C. Power feeds through switch mechanism control relays shall be closed only during testing, prior to in-service operation.
PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section consists of designing, providing, installing and testing of vital solid-state microprocessors at interlockings and signal locations shown on the Contract Drawings.

B. Referenced Sections

1. Section 01786 – Operations and Maintenance Instructions

1.2 REFERENCED STANDARDS

A. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. AREMA - Communications & Signals, Part 2

B. American Society of Mechanical Engineers

1. ASME B46.1 – Surface Texture (Surface Roughness, Waviness, and Lay)

C. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM)

2. ASTM B 19 - Standard Specification for Cartridge Brass Sheet, Strip, Plate, Bar, and Disks
3. ASTM B 36/B 36M – Standard Specification for Brass Plate, Sheet, Strip, and Rolled Bar
4. ASTM B 140/B 140M - Standard Specification for Copper-Zinc-Lead (Red Brass or Hardware Bronze) Rod, Bar, and Shapes

D. Federal Standard (FS)

1. FS QQ-S-766 - Steel, Stainless and Heat Resisting, Alloys, Plate, Sheet and Strip

E. Military Standard (MS)

1. MIL-G-45204 - Gold Plating; Electrodeposited
2. MIL-STD-202G - Test Methods for Electronic & Electrical Component Parts
3. MIL-STD-1916 - Sampling Procedures and Tables for Inspection by Attributes

F. Society of Automotive Engineers (SAE)

1. AMS QQ-N-290 - Nickel Plating (Electrodeposited)-FSC MFFP

1.3 SUBMITTALS

A. Contractor shall submit for Authority approval:

1. System data flow and software architecture diagrams for all Vital Microprocessor Interlocking System (VMIS) modules and all system interfaces.
2. Circuit drawings specified for all system and subsystem interfaces, including interconnections of all hardware to the system.
3. A manual for a software developmental training program for engineering-design personnel.
4. Where more than one processor is used to control an interlocking, the Contractor shall submit complete control zone drawings showing, on a copy of approved track plan, segments of interlocking plant controlled by each individual vital controller.
5. Power calculations for all power sources energizing vital controllers or controlled, or switched, by vital controllers. Where manufacturer's specific ripple or regulation specifications exist for vital controllers or associated equipment relying upon these power sources, compliance with such ripple or regulation specifications shall be demonstrated to the Authority's satisfaction.

B. Each Final Design Package shall include:

1. Complete power distribution circuit drawings and schematics as required by these Specifications.
2. Complete rack layout and arrangement plans.
3. Complete equipment plans and installation drawings showing all components of the system. Drawings shall include complete keyed parts lists for all components of the system, racks, terminal boards, plug connectors, cable boots, mounting hardware and all other rack mounted equipment and hardware.
4. Wire routing diagrams showing power distribution, hardware interface, serial data link and any other wire and cable associated with the system. Wire routing within instrument racks, between instrument racks.
and from instrument racks to entrance racks, power racks and any other destinations shall be shown in detail.

5. Software listings and ladder logic diagrams for application dependent software.

6. Drawings showing details of interconnecting cables, plug couplers, terminal boards and other interconnecting devices complete with keyed parts lists and cable assembly instructions.

7. Electronic copy of all vital and non-vital application logic for the location.

C. Contractor shall submit for Authority approval, a manual for a maintenance training program for technical maintenance personnel. Contractor shall include in the submittal all maintenance and development hardware and software, and manuals.

1. Each training manual shall include an outline of the course material, details of text materials, syllabus and lesson plan for training.

D. Contractor shall submit for Authority approval a complete set of application, service and development system manuals including manuals covering all software and hardware provided as part of the development system.

E. Contractor shall provide manuals describing operation and maintenance of the vital microprocessor interlocking system.

F. Contractor shall submit Test Procedures and Results in accordance with these Specifications.

1.4 QUALITY ASSURANCE

A. System shall be designed to operate in accordance with all applicable AREMA requirements for control and indication of interlocking safety functions.

B. System design shall comply with Rules and Regulations Governing Railroad Signal and Train Control Systems as issued by the office of Safety, Federal Railroad Administration, effective February 27, 1984 and of any supplements thereto that become effective before this Contract is awarded.

C. The Vital Microprocessor Interlocking System shall be tested according to Authority approved test procedures.

D. Contractor shall provide written certification that the entire vital microprocessor system to be provided has been tested and successfully functioned in an operating light rail system with its characteristic high electromagnetic interference environment.

E. Contractor shall provide written certification that the system has been successfully operated after being exposed to vibration of 2-10 Hz, 0.2-inch displacement, peak-to-peak and 10-500 Hz at 1.0 G as prescribed by MIL STD 810C, method 514.2, category F, and to shock of 3 G as prescribed by MIL STD.810C method 516.2, Sawtooth Procedure I, Transit Drop Procedure I.

F. All system components, shall be capable of continuous operation at temperatures of negative 40 degrees F to 160 degrees F and humidity levels of 5 percent to 95 percent, non-condensing, without the need of any external environment controls. CRT terminals, printers, and data logging units shall be capable of continuous operation at temperatures of 0 degrees F to 105 degrees F and humidity levels of 10 percent to 95 percent.

G. The system shall meet the requirements of an Authority approved reliability assessment program in accordance with these Specifications. Each vital microprocessor interlocking system, or complete zone thereof, shall exceed a minimum 36,000 hour Mean Time Before Failure (MTBF). Failures are defined in these Specifications.

H. Failure of any component of the vital controllers shall not cause the vital interlocking system to fail in a less restrictive mode.

I. Printed circuit board pin and socket contacts shall be in accordance with the following:

1. ASME B-46.1
2. ASTM A-167
3. ASTM B-19
4. ASTM B 36/B 36M
5. ASTM B 140/B 140M
6. AMS QQ-N-290
7. FS QQ-S-766
8. MIL-G-45204
9. MIL-STD-202G
10. MIL-STD-1916 -

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Equipment provided under this Section shall not be shipped until factory test reports have been approved by the Authority.

B. Each item of the VMIS shall be inspected by the Contractor and the Authority for shipping damage prior to installation.
C. Any equipment showing signs of damage shall be repaired or replaced, at the Authority's option, without cost to the Contract.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Vital Microprocessor Interlocking System shall be Microlok II ® or Authority approved equal.

B. Design Requirements

1. System shall be designed to control and indicate all safety and other functions traditionally implemented with vital relays. Software logic shall be developed using ladder logic.

2. Interconnection with non-vital supervisory control equipment and interface with other vital field control systems shall be as shown on Contract Drawings and in these Specifications.

3. Vital Microprocessor Interlocking System (VMIS) shall be designed on the basis of a single microprocessor philosophy using closed loop principles to achieve safety. Use of multiple processor arrangements based upon voting with a vital comparator is an acceptable alternative to the single microprocessor system. Multiple processor systems shall have at least three processors.

4. Each VMIS shall have an identical on-line backup unit. The system shall assume a safe state while any changeover occurs. The back-up unit shall assure that all interlocking signals have run full approach time before restoring routing functions.

5. Where an interlocking cannot be controlled without maximum single event control and indication delays at the communication interface of three seconds, the VMIS shall be designed with multiple processors on an operational zone principle wherein a unit failure in one zone will not disable operation of the entire interlocking. Zones shall be designed by the Contractor and submitted for Authority approval.

6. VMIS design shall be based upon solid-state microprocessor technology and shall not require any off-line storage devices for operation or start up.

7. The operating instructions for the VMIS shall be divided into application (site specific) and executive dependent portions.

a. The application and executive software shall be stored in separate memory devices.

b. The application dependent software shall be stored in Electronically Erasable Programmable Only Memory (EEPROM) devices.

c. The executive dependent software shall be stored in solid state flash Erasable Programmable Only Memory (EPROM) devices.

d. Executive and application software shall be downloadable to the CPU using a laptop or notebook PC connection to the CPU serial board port. Application programming shall not require the extraction or insertion of the EEPROMs.

e. Processors shall perform those entrance-exit functions commonly supplied for a route-setting system. In addition, other functions as specified shall be part of this system.

8. Single processor VMIS shall consist of normal and "warm" standby microprocessor facilities physically located in card files for mounting in 19-inch racks.

9. Instrument Rack Arrangement Plans shall be provided for all instrument racks housing vital controller card files. Placement of all rack mounted components shall be clearly shown. Front, side, and rear views shall be shown on each rack arrangement plan. Only one instrument rack shall appear on each sheet. All rack grounding and component grounding details shall be shown.

10. All rack mounted components and mounting hardware shall be clearly identified on the drawings by a reference number and shown on the Material Reference List/Apparatus Tabulation.

11. All plug connected cables associated with the instrument rack shall be identified by reference numbers and be shown connected to proper plug receptacle.

12. Cable Assembly Drawings shall be provided for all cables employed by the interlocking system. All plug or receptacle pin assignments shall be shown. All wire gauge, wire color-coding and wire lengths shall be shown. Shield grounding arrangements shall be shown. A list of tools
required and instructions for fabrication of
cables shall be provided on the drawings.
All parts or materials required for reordering
shall be shown and identified with a
reference number. Reference number shall
 correspond with a tabulation of material
showing part numbers and quantities
included on cable assembly drawings and
as shown on the Material Reference
List/Apparatus Tabulation.

13. Complete Cable Schematic Drawings shall
be provided for all data communications
cables employed by the system. All plug or
receptacle assignments shall be shown. All
wire color-coding, functional wire
nomenclature and plug, slot and rack or card
file destinations shall be shown.

14. Complete Circuit Drawings shall be
designed and provided. All hardwire input
and output circuit drawings shall be shown
complete with all terminal designations,
terminal board locations, printed circuit
board edge connector or plug connector
designations and functional wire
nomenclature. Card file or rack number and
slot locations of all printed circuit boards
shall be shown.

15. Signal Lighting Circuit Drawings shall
include all wires and termination points from
printed circuit cards to signal lamps on one
sheet.

16. Switch Operating Circuit Drawings shall
include all wires and terminations from
printed circuit boards to switch control relays
on one sheet.

17. Switch Indication Circuit Drawings shall
show all wires and terminations from the
printed circuit boards to the entrance racks.

18. Track Repeater Circuit Drawings shall show
all wires and terminations from printed circuit
boards to track relays.

19. Wire sizes shall be clearly identified on each
circuit drawing.

20. Power distribution schematics shall be
provided showing all transformers, circuit
breakers, fused disconnects, fuses,
rectifiers, power supplies, terminals, cables,
busses, wires and wire sizes for all power
sources energizing the vital controllers or
controlled or switched by the vital
controllers.

21. VMIS application software shall be
developed using ladder logic. Complete
documentation shall be provided, showing
progression of switch control from
supervisory system inputs to switch control
relays, examples of route, time and switch
locking, progression of signal control from
the supervisory system inputs to the signal
lamps and examples of all other logic
executed by vital interlocking system.
Ladder logic shall emulate typical
interlocking circuitry as required by these
Specifications.

22. All data passed from one vital controller to
another vital controller and all data passed
from any vital controller to the supervisory
system shall be identified as well as all
hardwire interfaces. All ladder logic and all
data received by or sent from controllers
shall be identified with standard relay logic
nomenclature as shown in Contract
Drawings. Translation tables will not be
acceptable.

23. Vital Processor Units shall be equipped with
on-board diagnostics. Diagnostics shall
quickly and reliably identify failed printed
 circuit boards. The nature of failure as well
as specific location of failure shall be
indicated.

24. Vital processor systems shall be provided
with external lightning protection and surge
suppression. Protection shall be sufficient to
protect all power and input/output paths.

C. Diagnostics and Data Logging

1. Vital Processor Units shall be equipped with
on-board diagnostics. Diagnostics shall
quickly and reliably identify failed printed
circuit boards. The nature of failure as well
as specific location of failure shall be
indicated.

2. The Vital Processor Unit shall have internal
event recording capabilities. The internal
event recorder shall comply with the
requirements within Specification 16972.

3. Vital Processor Unit’s diagnostics shall allow
immediate retrieval of user data logs, event
logs, and error logs.

4. The Vital Processor Unit shall allow
monitoring of the state of every application
data bit and allow user selection of
information to be stored in the log.

5. The Vital Processor Unit shall display the
application program name, current version
of the application logic, and the current
version of the executive version on the front
panel.

6. The Vital Processor Unit’s diagnostics bit
monitoring shall provide displays for
standard log-type and timing diagram type
monitoring.
D. Vital Controller Software

1. VMIS shall continuously test for a loss of control over state of hardwire outputs, a loss of control over RAM, a loss of vital data communications and a spontaneous change in application dependent software. VMIS shall include a vital watchdog function to control an external device that disables outputs when a Vital Processor Unit is off-line, in stand-by, or has failed.

2. VMIS shall log all vital and non-vital failures and identify faulty printed circuit card or function.

3. VMIS shall supervise a closed loop monitoring system for all hardwire input and output functions.

4. VMIS software shall be stored on an EPROM or EEPROM device.

E. Application Dependent Software

1. Application dependent software shall define operation of VMIS; operation of individual functions shall be as indicated on Contract Drawings and include:
   a. Cab Signal Selection
   b. Route Check (RCSR).
   c. Signal Control (HR, COR)
   d. Signal Lighting (HG, HY, HR, HCO)
   e. Signal Indication (RGPR)
   f. Light Out RELAY (LOR) including vital hot filament and non-vital cold filament light out protection.
   g. Time Locking (ASR, TER, ASPR, POSR)
   h. Route Locking (NSR, SSR)
   i. Switch Locking (LR)
   j. Switch Control (NLPR, RLPR, NWZR, RWZR)
   k. Switch Indication (NWPR, RWPR)
   l. Switch Correspondence (NWCR, RWCR)
   m. Loss of Shunt (TPSR)
   n. Switch and Signal Blocking
   o. Traffic Circuits

2. Software development system shall contain all hardware and software required for the composition, debugging, simulation and EPROM storage of the application dependent software.

3. Development system software prepared by the manufacturer of the vital controller shall be provided.

4. No copy protection schemes, including product or software keys, shall be employed on any of the software.
5. All hardware and software supplied with the development system shall be demonstrated to be completely compatible.

6. One complete development system shall be provided for the Authority’s use and the Contractor shall maintain one complete development system in perfect working order on-site.

7. Contractor shall provide training on the application logic development system hardware and software, including composition and, debugging, of the application logic, simulation, and EPROM storage.

F. Application Dependent Firmware Development System

1. The application dependent firmware development system shall contain all hardware and software required for the composition, debugging, simulation, and electrically erasable programmable read only memory (EEPROM) program storage for the application dependent firmware.

2. The hardware shall consist of an Intel® based laptop or notebook computer with the following minimum requirements:
   a. Processor: Dual-core 1.6 gigahertz (GHz) central processor unit (CPU) and a 512 kilobyte (KB) L2 cache
   b. Operating System: Windows © 7 based (minimum)
   c. Memory: 2GB Synchronous Dynamic Random Access Memory (SDRAM) expandable to 4 GB at 667 megahertz (MHz) input and output bus speed
   d. Storage: 80 GB hard drive at 7200 RPM
   e. Optical Drive: CD-RW/DVD-ROM removable with read speed of 24x (CD)/4x (DVD), write speed of 24x, and rewrite speed of 4x.
   f. Display: 15 inch widescreen WXGA color liquid crystal display capable of 1280 X 800 pixels
   g. Communications: 802.11g wireless, 10/100/1000 Ethernet
   h. Interfaces and Connections: S-video, 15 pin HD D-sub, RS-232, RJ-45, VGA, USB 3.0 (2), SD card slot, SDHC, or SDXC card slots.
   i. Battery life shall be minimum of 6 hours operating time.
   j. Accessories shall include an AC charger and carrying case.

3. Other hardware shall include one EEPROM programmer, compact disc storage case which shall contain up to 50 CD-RW compact discs, minimum 4.7 GB DVD read and write device operating at 16X speed complete with 100 write once, read many DVD media disks, computer table with working area of not less than 16 square feet, power plug strip with surge protection, and all required cables, documentation, software, and interface electronics. The computer system shall be fully assembled and ready for service.

4. The computer shall be equipped with an internal hard disk drive and system random access memory (RAM) required for proper operating and development systems operation. The hard disk drive and system RAM shall be provided such that each has 50 percent unutilized capacity as measured by peak usage for a fully disk resident operating system and application software load including at least 200 percent of RAM as virtual memory and the most extensive software application execution.

5. All hardware shall be readily available over the counter throughout the United States and the system shall be provided with not less than a three-year warranty for each component and the system in its entirety. The choice of the particular hardware items shall be subject to Authority approval.

6. The application dependent firmware source code editor shall be supplied as part of the development system.

7. Development system software prepared by the manufacturer of the vital controller shall be provided.

8. No copy protection scheme, including product or software keys, shall be employed on any of the software supplied as part of the development system.

9. All hardware and software supplied with the development system shall be demonstrated to be completely compatible.

10. One complete development system shall be provided for the Authority’s use and the Contractor shall maintain one complete development system in perfect working order on-site.
G. General Hardware and Operating Requirements

1. VMIS shall consist of Vital Processor Units and associated cables, plugs, wire connectors, terminal boards, data transmission equipment, power conditioning equipment, instrument racks and hardware.

2. Each Vital Processor Unit shall consist of printed circuit boards mounted within cardfiles in one instrument rack. Vital Processor Units shall allow individual removal and insertion of printed circuit boards (PCBs) from the rear.

3. All plug connectors, data transmission equipment, power supplies, power conditioning devices, terminal boards, wire connectors and other equipment required to achieve a complete, stand-alone subsystem shall be mounted within the instrument rack along with associated Vital Processor Units.

4. Each Input, Output and Input/Output printed circuit board shall be equipped with a lighted status indicator on each port. Indicator shall be illuminated when the respective port is energized.

5. Vital Processor Units shall be provided with Double Break Vital Output (DBVO) Printed Circuit Boards and Vital Input (VI) Printed Circuit Boards. A sufficient number of these types of printed circuit boards shall be installed in each Vital Processor Unit to accommodate all vital hardware inputs and outputs.

6. Vital Processor Units shall be provided with Non-Vital Input/Output Printed Circuit Boards (PCBs). A sufficient number of these type printed circuit boards shall be installed in the Vital Processor Units to accommodate all non-vital hardware inputs and outputs.
   a. NVI and NVO PCBs shall have a minimum of 32 isolated inputs and 32 isolated outputs.

7. Hardware interface board shall indicate, with logically grouped lights mounted on the interface boards, the status (Hi or Lo) of each input or output. An approved lamp labeling system shall be provided as part of the unit, visible when viewing the status lamps.

8. Vital Processor Units shall be provided with Vital Output Printed Circuit Boards and Vital Input Printed Circuit Boards. A sufficient number of these types of printed circuit boards shall be installed in each Vital Processor Unit to accommodate all vital hardware inputs and outputs within that Vital Processor Unit’s scope of control. Alternatively, the Vital Processor Unit may incorporate vital outputs to drive lamps directly.

9. Use of external relays as interface devices between the Vital Processor Units and external circuits shall be as required by these Specifications.

10. Vital Processor Units shall have a twenty percent expansion available for storage of application dependent firmware and capability.

11. External apparatus and circuits controlled by the VMIS via hardware interfaces shall include:
   a. Speed command
   b. Powered Switch and Lock Movements
   c. Electric Switch Locks
   d. Signal Lamps
   e. Signal Mechanisms
   f. Traffic and Line Circuits
   g. Event recorders and other miscellaneous functions as specified, or shown on Contract Drawings.

12. External apparatus and circuits passing indications to the VMIS via hardware interfaces shall include:
   a. Track Relays
   b. Electric Switch Locks
   c. Switch Circuit Controllers
   d. Signal Mechanisms
   e. Traffic and Line circuits
   f. Other miscellaneous indications as specified, or shown on Contract Drawings.

13. Provide programmable controller; MICROLOK or approved equal.

14. Each Vital Processor Unit shall be provided with Vital Serial Communication Ports as required by these Specifications. The number of Vital Serial Communication Ports shall be sufficient to allow interconnection of all Vital Processor Units. Communication of data between Vital Processor Units shall be transmitted through these Vital Serial Ports.
15. Each Vital Processor Unit shall also be provided with Non-Vital Serial Communication Ports as required by these Specifications. The number of Non-Vital Serial Communication Ports shall be sufficient to allow interconnection of Non-Vital Processor units, and supervisory control system.

16. All data communications between the supervisory control system and vital controllers shall conform to RS232 or RS423 standards. Each vital controller shall be connected by one cable to the supervisory system. If multiplexing of supervisory communications is employed, required cable junctions and any steering devices shall be located on or near the supervisory system.

17. All data communications between the supervisory control system and vital and non-vital controllers shall utilize the DF-1 protocol via the Ethernet.

18. Each Vital Processor Unit cardfile(s) shall contain printed circuit boards of the types described herein. Additional types of printed circuit boards required for operation of Vital Processor Units shall be provided and installed as required. Combination of functions among board types shall be allowed only as required by theses Specifications.

19. All data communications between vital controllers shall conform to RS232 or RS423 standards.

20. If required, all data communication between vital controllers located within outlying instrument cases and vital controllers located within a central instrument house, shall be via a 20 milliamp current loop or modem. All modems, current loop interfaces and any other data communications equipment shall be located on a data communications rack and conform to all environmental requirements as required by these Specifications.

21. VMIS shall not use any custom or semi-custom integrated circuits.

22. Printed circuit boards shall be housed within a cardfile and be plug-in type. Keys shall be provided on the cardfile to prevent insertion of improper printed circuit board types.

23. Cardfiles shall be factory mounted in standard 19 inch instrument racks. All wire connections to cardfiles shall be via plug connected cables. Forced air ventilation shall not be used.

24. All cables or wiring leaving instrument racks shall be routed through rubber boots at the top of racks and provided with means to be neatly routed and securely fastened with tie straps.

25. All power conditioning including surge protection and noise suppression required on power feeds for rack mounted power supplies shall be located on power distribution racks. All inputs and outputs of microprocessor systems shall be protected from surges and lightning.

26. Hardwire inputs of vital controllers shall not respond to AC of any voltage level. Hardwire inputs shall be biased and shall not, under any failure condition, respond to any voltage of improper polarity.

27. Hardwire outputs of vital controllers shall provide security equal to conventional double-break relay circuits.

28. Plug connectors shall comply with all of the requirements of these Specifications.

29. Power input into the Vital Processor Unit shall be controlled by a circuit breaker.

H. Vital Processor Unit Printed Circuit Boards

1. Each Vital Processor Unit shall be equipped with one Central Processing Unit Printed Circuit Board (CPU PCB). CPU PCBs shall conform to the requirements shown below:

a. CPU PCBs shall contain microprocessor, clock, RAM, Application Dependent Software, data bus, address bus and all other components of the computing portion of the system. Other printed circuit boards comprising the system shall be input-output adapters and interfaces only.

b. CPU PCBs may contain hardware for Vital and Non-vital Data Serial Communication Printed Circuit Boards (VI PCBs, DBVO PCB's and NV PCBs).

c. Wire jumpers and piggyback boards shall not be permitted.

2. Each Vital Processor Unit shall be equipped with one Non-Vital Serial Interface Printed Circuit Board (NVSI PCB). NVSI PCBs throughout the Vital Processor System shall be identical. NVSI PCBs shall conform to the following requirements:

a. NVSI PCBs shall contain two RS232C compatible serial ports.
b. One port shall be configured as a master with the ability to initiate communications with and discretely address an approved number of other serial ports electrically connected to a common serial line. Maximum number of such slave ports shall be the manufacturer's standard.

c. Slave port shall be configured with the ability to select one of an assigned number of address codes. Slave port shall receive and transmit data only when the master port connected to common serial line specifies an address that corresponds to the slave port's address.

d. Data transmission rates for all non-vital serial ports shall be independently adjustable. Method of adjustment, maximum adjustable Bauds per second (BPS), and optimum adjusted BPS shall be as approved by the Authority.

e. Communications protocol for all serial data communications lines shall be compatible with all connected devices.

f. Data communications cables in accordance with the requirements of these Specifications shall be plug connected to the NVSI PCBs. Cable shielding shall be connected to ground on one end only.

3. Each Vital Processor Unit shall be equipped with Vital Input Printed Circuit Boards (VI PCBs) as required by these Specifications.

a. VI PCBs shall be provided and installed in sufficient number to accommodate all vital inputs within the VMIS's scope of control including:

1) Input from each vital track relay front contact.
2) Inputs from switch and lock movements for normal and reverse position indications.
3) Input from each electric switch lock for a normal position indication.
4) Input from each signal lighting control network, indicating the stop position.

b. VI PCBs shall accept inputs without the use of external or board mounted interface relays. Energy for inputs shall flow directly from relay contacts, line circuits or signal equipment.

c. VI PCBs shall have a minimum of 16 inputs.

4. Each Vital Processor Unit shall be equipped with Vital Output Printed Circuit Boards (VO PCBs) as required by these Specifications.

a. VO PCBs shall be provided and installed in sufficient number to accommodate all vital outputs within the Vital Processor Unit's scope of control including:

1) Outputs to each switch and lock movement for normal and reverse controller relays.
2) Outputs from each color light signal control network.
3) Output for each possible polarity of each vital line circuit feed.
4) Outputs for train stops and other miscellaneous functions as required by the Contractor's design.

b. VO PCBs shall output energy directly to relay coils, line circuits or signal equipment.

c. VO PCBs shall have a minimum of 16 outputs.

5. Each Vital Processor Unit shall be equipped with vital timers as required by these Specifications.

a. Vital timers shall be provided in sufficient number to accommodate all vital timing functions within the Vital Processor Unit's scope of control, including:

5) Input from each signal lighting control network, indicating the approach or proceed position.
6) Input for each possible polarity of each vital line circuit.
7) Miscellaneous inputs as required by the Contractor's design.
1) Loss of shunt time for track repeater relays (TPSRs)
2) ASR timers for each signal (TER).

b. Vital timers shall be field adjustable by a means other than by modification of application software designed for the interlocking.

c. Vital timer selection switches shall be covered to insure the integrity of the settings and prevent accidental contact.

6. Each Vital Processor Unit shall be equipped with Vital Lamp Driver Printed Circuit Boards (VLD PCBs).

a. VLD PCBs shall be provided and installed in sufficient number to accommodate all vital signal lamps within the Vital Processors Unit's scope of control.

b. VLD PCBs shall output energy to signal lamps.

c. VLD PCBs shall have a minimum of 16 outputs for non-LED signals and 12 outputs for LED signals.

d. Wattage for VLD PCB outputs shall be adequate to handle designed maximum signal lamp load.

e. Lamp driver modules shall be equipped with light out detection. The Vital Processor Unit shall log light out detection.

f. Detection of a lamp out or replacement of a lamp shall not cause the Vital Processor Unit to reset and/or transfer to the offline Vital Processor Unit.

g. When normal and standby Vital Processor Units are used, and the lamp drivers are connected in parallel between the normal and standby units, the offline unit lamp driver modules shall maintain a positive health status unless a problem is detected. Any offline Vital Processor lamp driver module with a positive health status shall not generate lamp out errors.

I. Identification

1. Card files shall be supplied with printed labels that identify input and output ports on PCB by name assigned in the application firmware.

2. Ports shall be identified by PCB slot number and port number.

3. A method shall be used to mount a printed nametag on a front plate of each rack or cabinet as Authority approved.

J. Redundancy

1. The redundant Vital Processor pair failover shall be automatic from normal to standby to manual and from standby to normal.

2. The redundant Vital Processor pair shall function in warm standby configuration.

3. The failover from the normal Vital Processor Unit to the standby Vital Processor Unit shall cause minimal disruption to the data communication links.

PART 3 - EXECUTION

3.1 PRODUCTION

Not Used

3.2 INSTALLATION

A. Instrument racks shall be arranged and mounted in central instrument houses as indicated on Contract Drawings in accordance with Authority approved installation plans.

B. Cardfiles shall be mounted in standard 19-inch instrument racks. All wire connections to the cardfiles shall be via plug connected cables. Forced air ventilation shall not be used.

C. All cables or wiring leaving instrument racks shall be routed through rubber boots at the top of racks and be neatly routed and securely fastened with tie straps.

D. Mounting of cardfiles and associated equipment shall provide for easy access to all test points, indicators, and adjustments.

E. Normal and standby units, if not on same rack, shall be in the same row on adjacent racks.

F. Mounting of microprocessor equipment within an instrument house or room shall be restricted to an area between 1.5 feet and 5.5 feet above the finished floor.
3.3 TESTING

A. Factory Testing

1. VMIS shall undergo qualification testing in accordance with approved Qualification Test Procedure.

2. VMIS and all subsystems shall be tested in accordance with Authority approved Factory Test Procedure and as required with these Specifications.

3. Entire complement of instrument racks, or cabinets, for a given vital interlocking or interlocking zone shall be set up at the point of assembly, with all equipment installed. Racks or cabinets shall be interconnected with the same plug connector cables as will be shipped to the field, in accordance with Authority approved plans. Contractor shall simulate functions external to signal central instrument house or room, where required. All system functions shall be tested to determine that each function operates as required.

4. Contractor shall make adjustments and correct all defects as required to obtain proper operation.

5. VMIS shall be in compliance with and have means of accessibility to permit all testing as required by the current edition of “Rules and Regulations Governing Railroad Signal and Train Control Systems” as issued by Federal Railroad Administration. If the Contractor's system requires any external equipment to permit making such tests, such equipment shall be provided as part of the system.

6. All design changes required for proper operation shall be submitted for Authority approval.

B. Field Testing

1. VMIS and all subsystems shall be tested in accordance with these Specifications.

2. The latest type unit for testing vital microprocessor interlocking equipment, as recommended by manufacturer, shall be provided to assist diagnosing modules.

3. Contractor's tests of VMIS shall demonstrate that safety logic that is to be implemented by the VMIS is not masked or implemented by non-vital logic during testing. Contractor shall incorporate test functionality into the local control system that bypasses non-vital logic and introduces signal and switch requests directly into the application logic for the purpose of challenging locked routes during testing. Contractor shall demonstrate these requests are shown in the application logic via the laptop connection.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16959
PART 1 - GENERAL

1. DESCRIPTION

A. Work to be done under this Section consists of designing, providing and installing transformers.

1.2 REFERENCE STANDARDS

A. American Railway Engineering And Maintenance-of-Way Association (AREMA):

1. AREMA, Communications & Signal Manual, Part 14

1.3 SUBMITTALS

A. The Contractor shall submit for Authority approval, drawings, wiring diagrams and performance data for all transformers to be provided and installed under these Specifications.

B. The Contractor shall submit for Authority approval, calculated size of transformers required to feed loads created by equipment being provided and installed under this Contract. All transformers shall be rated to carry 125 percent of total load continuously.

C. The Contractor shall provide manuals describing operation and maintenance of each type of transformer.

D. The Contractor shall submit Test Procedures and Results in accordance with these Specifications.

1.4 QUALITY ASSURANCE

A. The Contractor shall inspect and test each transformer prior to shipment. Inspection shall conform to the Contractor's Factory Inspection and Testing Procedure as Authority approved.

B. Each transformer shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

C. Final operating tests to determine acceptability shall conform to the requirements of the Authority approved Field Test Procedure.

D. Transformers shall be in accordance with the AREMA Signal Manual, Part 14.2.10 for Single-Phase Transformers.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Maintenance Materials:

1. Contractor shall furnish one transformer of each rating used in the system.

B. General

1. All transformers shall be air-cooled unless otherwise Authority approved.

2. Transformers shall be provided for signal power, isolation purposes, 100 Hz AC track circuits and general purpose transformers as required in these Specifications or Contract Drawings.

3. Track transformers shall be provided with sufficient primary and secondary voltage taps to adjust for varying feeder voltages between 100 and 125 volts.

4. Transformers shall not emit audible noise in excess of 75 dB, referenced to 0.0002 dynes/cm² at a distance of two feet at rated voltage and current.

5. Primary and secondary taps shall be brought to terminals mounted inside the transformer case. A connection for each secondary tap and at least two connections for the primary winding shall be brought out of the transformer to suitable terminals or bushings. All terminals shall be identified in an Authority approved manner.

6. Track feed transformers required for power frequency track circuits shall be equipped with terminal boards containing terminals for primary and secondary leads.

a. Secondary windings shall be arranged to provide for varying voltage in one-volt steps up to a maximum of 15 volts. Terminal boards shall comply with AREMA Signal Manual requirements.

b. Primary excitation shall be 120 VAC, 100 Hertz. All track feed transformers shall have a volt-ampere rating sufficient to handle the operating load. Track transformers shall not be susceptible to DC saturation by propulsion currents.

7. Transformers for signal power shall be single phase with 480 volt, 60/100 hertz, primary windings and 120 volt, 60/100 hertz, secondary windings. Transformer windings shall contain Class H insulation with four, 2-1/2 percent full capacity taps. Two taps shall be above the nominal voltage and two below nominal voltage. The transformer enclosures shall be of drip-proof construction and provided complete with provisions for wall mounting.
a. Each signal power transformer required for a central instrument house location shall be rated at a minimum of 15 kVA.

b. Each signal power transformer required for a wayside signal case shall be rated a minimum of 5 kVA.

2.3 DELIVERY, STORAGE AND HANDLING

A. Transformers shall be protected from damage throughout delivery, storage and handling.

PART 3 - EXECUTION

3.1 PRODUCTION

A. Not Used

3.2 INSTALLATION

A. Transformers shall be installed as shown on Authority approved installation drawings.

B. Mounting

1. Track transformers shall be rack mounted, except in junction boxes wherein they shall be mounted in accordance with Authority approved plans.

2. Signal power and general power transformers shall be wall mounted.

C. Isolation transformers may be wall mounted.

3.3 TESTING

A. The Contractor shall test each transformer with its associated system in accordance with these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16963
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work to be done under this Section consists of design, provision and installation of circuits, software, and hardware for an operating a computer-based Local Control system at each Central Instrument House (CIH) and Intermediate Instrument House (IIH).

B. Work shall include providing the design required to interface controls and indications with the Train Control Center (TCC). Contractor is responsible for a list of all controls and indications needed for complete operation of the interlocking plant from TCC. All track circuit indications shall be provided at the TCC. Contractor shall provide software and hardware for controls and indications data transfer between TCC and LCP as Authority approved.

1.2 SUBMITTALS

A. Contractor shall submit the product data including computer hardware and software specifications, wiring details, and plug connector details for Authority approval.

B. Contractor shall submit the screen design for Authority approval.

C. Each Design Review Package shall include the Local Control Screen Drawing.

D. Each Final Design Review Package shall include:
   1. A complete software functional description that includes operating instructions and graphical descriptions of all user inputs and local control indications.
   2. Screen display arrangement drawings showing mounting location of all signal equipment. Drawings shall include comparison of operating track direction to panel orientation.
   3. Assembly drawings with a keyed parts list showing ordering numbers for replacement parts for all equipment within the local control and indication panels to be provided under this Contract.

E. Contractor shall submit Test Procedures and Results in accordance with these Specifications.

1.3 QUALITY ASSURANCE

A. Each local control system component shall be new and free of defects.

B. All local control equipment shall be tested before shipping. Factory testing shall be conducted in accordance with the Contractor's Factory Test Procedure as Authority approved. Prior to shipment, a copy of the manufacturer's certification of factory tests performed shall be forwarded to the Authority.

C. All electrical components in these Specifications shall be rated to operate at power, voltage, current and temperature levels 20 percent above the level components shall be subject to in normal service unless otherwise specified.

D. Each local control system shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as Authority approved. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

E. The local control system shall be tested according to Authority approved test procedures.

1.4 DELIVERY, STORAGE AND HANDLING

Not Used

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Local Control Interface Panel. Above the desk in the operations section of each CIH and IIH, the Contractor shall provide a small panel equipped with a reset button, key switch override, audible alarm, and a data connection for a laptop computer
   1. Reset button reboots the LCC
   2. Data connection permits LCC operation with a lap top during an LCC failure

B. Display
   1. Local control panel display shall be LED based screen or other Authority approved solid-state screen. The screen shall be permanently mounted on the wall above the desk in the operations section of each CIH and IIH.
   2. Display shall be sized to comply with the requirements of Mil Standard 1472F.
3. Display Layout
   a. The top portion of the display shall include the track plan. Orientation of the plan shall be so that it is geographically correct, relative to the track and desk location in the CIH.
   b. The bottom portion of the display shall have text boxes to reflect user input and alarm status.

C. Computer: The local control computer (LCC) shall be an industrial grade computer that is rack-mounted in the CIH/IIH equipment section. The computer shall be rated to operate without functional degradation or failure as a result of shock, vibration, and environmental conditions.

1. Memory
   a. The LCC shall be provided with a minimum of 1 gigabyte of RAM and shall also satisfy the requirement that when the application and operating system are loaded and functioning at the peak performance level, 50% of system RAM shall be unallocated.
   b. The LCC shall be provided with a hard drive sized to store the complete and fully installed operating system including its utilities and its support software as well as the local control software. The hard drive shall also be sized such that a 75% spare hard drive capacity shall be available following 180 days of continuous operation.

2. Each LCC shall be provided with keyboard and mouse.

2.3 FUNCTIONAL REQUIREMENTS

A. The display shall provide user controls and indication interface as required to effectively and efficiently operate the interlocking using entrance/exit control.

B. The display shall be ergonomically designed and shall provide logical and unambiguous objects and methods that critically minimized the human man-machine interface interactions required to view indications and perform control functions.

C. Display Objects

1. The track display shall include the following objects;
   a. Interlocking Name (CIH)
   b. Track (CIH and IIH)
   c. Switches (CIH)
   d. Operating Mode (CIH)
   e. Signals (CIH)
   f. Traffic Indication (CIH and IIH)
   g. Track Circuits (CIH)
   h. Grade Crossing (CIH and IIH)
   i. Stations (CIH and IIH)

2. The supervisory portion of the screen shall include;
   a. Execute Button (CIH and IIH)
   b. Cancel Button (CIH and IIH)
   c. Alarm Acknowledge Button (CIH and IIH)
   d. User Input Text Box (CIH and IIH)
   e. Alarm Text Box (CIH and IIH)

D. Indications and Colors (CIH and IIH)

1. Display colors are intended to match those of the OCC display. The colors specified herein are subject to review and may be modified during the preliminary engineering phase. In the Signal System preliminary design review, the Contractor shall submit color scheme for Authority approval.

2. Background: Display background shall be black.

3. Track and Track Circuits
   a. Unoccupied track shall be indicated with a red line.
   b. White perpendicular lines shall indicate the track circuit boundaries. When an interlocking track has a route locked, the associated track display shall expand to approximately four times the normal width and be colored purple. When a track circuit becomes occupied, the track line corresponding to the occupied circuit shall expand in width to approximately four times that of the unoccupied track and shall be colored orange.
c. Track circuit names shall be indicated in white text. Where space permits, track circuit names should appear between the tracks in double-track areas. In interlockings, the names should appear outside of the tracks so that they do not interfere with the switch names.

d. For track circuits in the Cab Signal territory, current speed code shall be displayed next to the track name.

e. The display shall include all interlocking track circuits and all track circuits that are controlled by the CIH/IIH equipment. Where an intermediate house is located between the CIH and next adjacent CIH, a composite indication shall be provided that will indicate occupied if any of the track circuits controlled from the IIH are occupied.

4. Switches
   a. Track segments that correspond to the indicated switch position shall be solid line type. A section of track in the opposite position shall be a dashed line.
   
b. When a switch is requested, the section of track corresponding to the requested position shall become a solid flashing line while the switch is out-of-correspondence. When the switch indicates correspondence, the line in the requested position shall stop flashing and become solid and the opposite section of track shall become dashed.
   
c. When a switch is blocked, the switch shall be outlined by a blue box.

5. CIH / Operating Mode: The location of the CIH shall be indicated on the display by a solid white box. A single text character within the box shall indicate the operating mode, where “L” = Local; “A” = TWC/Auto; and “T” indicates TCC control.

6. Signals
   a. Signal symbols shall consist of a single solid circle with a line indicating the mast and base. The symbol is to be similar to that used on the mosaic panel.
   
b. The circular part of the signal shall be red for signals at STOP. The lines depicting mast and base shall be white.
   
c. When a signal is selected as an entrance, the circular portion of the signal symbol shall turn steady white. All possible exit signal symbols shall flash white. When the signal is cleared, it will turn solid green.
   
d. When a signal has been fleeted, a green box shall outline the signal symbol.
   
e. When a signal exit block has been selected, the signal symbol shall be shown in a solid blue box.
   
f. Signals in time locking shall be indicated by a flashing locking signal symbol.

7. Traffic Indication (CIH and IIH): Traffic shall indicate by arrows centered above areas where traffic locking is applied. A green arrow shall indicate the current unlocked traffic direction. When traffic is locked, the arrow shall be shown red.

8. Stations: Stations shall be indicated by an unfilled yellow box denoting the platform. Center platform stations will be shown with a single box between the tracks. Side platform stations shall be shown by boxes outside of the track. Station names shall be shown in white text inside the yellow box. Box shall be sized to allow two lines of legible text.

E. Controls
   a. Signal and Route Control (CIH):
      1) Prerequisites for route operation:
         a) User must be logged onto the system.
         b) Local control has been requested and surrendered by the control center, or the override key switch has been operated.
         c) There are no conflicting or opposing routes aligned and the desired traffic section is available.
         d) The exit is not blocked.
e) Switches in the route are not blocked out-of-position for the desired route.

2) Right-clicking the mouse button with the cursor over the desired entrance signal shall initiate a drop-down menu with the following commands:

<table>
<thead>
<tr>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>N / X</td>
</tr>
<tr>
<td>Signal Cancel</td>
</tr>
<tr>
<td>Fleet</td>
</tr>
<tr>
<td>Fleet Cancel</td>
</tr>
<tr>
<td>Call On</td>
</tr>
<tr>
<td>Call On Cancel</td>
</tr>
<tr>
<td>Block</td>
</tr>
<tr>
<td>Block Cancel</td>
</tr>
</tbody>
</table>

3) Selection of “N / X” while the cursor is over a signal will designate that signal as an entrance, provided another entrance has not already been selected. With an entrance designated, selecting “N / X” with the cursor over a signal indicating that it is a valid exit will cause the exit to be selected. When an entrance/exit pair has been selected, the route shall be requested. The requested route will flash until the “Execute” button is clicked, at which time the route request will be implemented.

4) Selecting “Signal Cancel” with the cursor over a signal will cause the signal to be canceled if it is clear. Alternatively, the program shall allow multiple signals to be selected by left-clicking on the signal, and then right-clicking over a selected signal and selecting “Signal Cancel” and the “Execute” button.

5) To implement fleeting, the user shall be able to place the cursor over the desired signal, right-click, and select “Fleet” from the drop-down menu and clicking the “Execute” button. Fleeting shall be able to be canceled using the same procedure. Canceling fleeting shall not cancel a clear signal. Fleeting shall be requested or canceled for multiple signals by selecting signals using the left mouse button prior to using the drop-down menu command.

6) Call-on commands shall only be available for the following:

a) One signal at a time and only if the desired route has already been established (or if the track circuit is occupied), no conflicting or opposing routes, and for both the over-the-switch (O/S) and exit track circuits

b) To request a call-on, the user shall be able to place the cursor over the desired signal, right-click, and select “Call-on” from the drop-down menu and clicking the “Execute” button. The user shall be able to cancel call-on signals using the same procedure.

7) Signal Exit Blocks shall be requested and canceled in the same manner.

b. Switch Control.

1) Prerequisites for switch operation:

a) User must be logged onto the system.

b) Local control has been requested and surrendered by the control center, or the override key switch has been operated.

c) There are no conflicting or opposing routes aligned and the desired traffic section is available.

d) The switch is not in the desired position.

e) Switches in the route are not blocked.

f) Switch is not in a locked or occupied route.

2) Right-clicking the mouse button with the cursor over the desired switch shall initiate a drop-down menu with the following commands:

<table>
<thead>
<tr>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set Normal</td>
</tr>
<tr>
<td>Set Reverse</td>
</tr>
<tr>
<td>Block</td>
</tr>
<tr>
<td>Block Cancel</td>
</tr>
</tbody>
</table>

3) The user shall be able to operate switches by placing the cursor over the switch, pressing the right mouse button, selecting the “Set Normal” or “Set Reverse” menu item and
clicking the “Execute” button. The user shall be able to select multiple switches using the left mouse button to make the same request for all selected switches.

4) Switch blocks shall be requested and canceled in the same manner.

c. Operating Mode Selection

1) Prerequisites for setting the operating mode:
   a) User must be logged onto the system.
   b) Communication link between TCC and the CIH is operating, or the Manual Override switch has been operated.

2) Right-clicking the mouse button with the cursor over the CIH symbol switch shall initiate a drop-down menu with the following commands:

3) “Set TCC” shall disable local and automatic control.

4) “Set Auto” shall only be available when in the Local mode and will surrender local control.

5) “Request Local” shall send local control request to the TCC unless the Override key switch is operated, in which case the selection will cause local control to be implemented.

F. Alarms (CIH and IIH)

a. Alarm conditions shall be displayed at the bottom of the screen. New alarms shall be colored red and blink until acknowledged. Each new alarm shall also cause an audible alarm until acknowledged. Alarms conditions shall include the following as applicable:

1) 60 Hz. Power Off
2) 100 Hz. Power Off
3) AC GROUND
4) DC GROUND
5) AC Blown Fuse
6) DC Blown Fuse
7) Data Transmission System Failure
8) Intrusion Alarm
9) Fire Alarm
10) Processor Alarm Non-Vital
11) Processor Alarm Vital
12) Battery Charger Failure

b. Alarms shall retained in the VMIS memory and be accessible from the LCP. The display shall include an alarm summary tab. Right-clicking the mouse button with the cursor over the alarm summary tab shall initiate a drop-down menu with the following commands:

<table>
<thead>
<tr>
<th>View</th>
<th>Acknowledge</th>
<th>Clear</th>
</tr>
</thead>
</table>

G. Terminal Operation

1. At temporary and permanent terminal stations, the local control software shall emulate the terminal panel as shown on the Contract Drawings. Terminal operations shall be on a separate screen from the local control. An on-screen button shall allow the user to switch between the two screens.

2. Terminal control inputs shall only be enabled when interlocking is in local control. When control is set to “Remote” or “Auto” terminal control shall be available at the TCC.

3. The Contractor shall provide three modes of operation for the terminal:

   a. Mode 1 will be set for the trains approaching terminal locations to diverge to the inbound track and depart from there on a straight route. A following train is held at the approach signal until the platform is clear.

   b. Mode 2 will be set for trains to alternate platforms. When both platforms available a train approaching terminal locations to diverge to the inbound track and depart from there on a straight route, next train will go straight and cross over upon departure.
c. Mode 3 will be set for the trains to approach terminal locations on a straight route and cross over upon departure. A following train is held at the approach signal until the platform is clear.

4. Contractor shall provide “Next Train” logic for input to the station sign system. The circuit will indicate from which platform the next train will depart based on first-in/first-out logic.

H. Interlocking Tests: The test functions shall be incorporated into the local control system. Control of test functions must bypass all non-vital local control logic and inject signal and switch request directly into vital logic to challenge the vital logic. The log-in function shall require a separate privilege level to use test functions.

I. Speed code downgrade: Speed code downgrade function shall be provided for each AF track circuit or cab loop. The log-in function shall require a separate privilege level to use Speed code downgrade control.

PART 3 - EXECUTION

3.1 PRODUCTION

Not Used

3.2 INSTALLATION

A. Local control and indication panels shall be located in the central instrument house.

B. Location of panel shall permit convenient use by an operator sitting in front of it.

C. Any damage caused during installation shall be repaired. Restored finish shall be equivalent to factory finish and performed in a manner satisfactory to the Authority.

3.3 TESTING

A. Local control system shall be tested in accordance with these Specifications.

B. Local control equipment tests shall consist of controlling wayside functions. All controls and indications on the respective panel shall be tested.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work to be done under this Section consists of designing, providing, and installing event recorders as described in these Specifications. Event recorders shall be installed at Automatic Highway Crossing Warning (AHCW) system cases and Central Instrument House (CIH) locations.

B. Where the VMIS has event recording capabilities that comply with the requirements herein, the VMIS may be used in lieu of a stand-alone event-recording device. Where event-recording tasks cause processing time to fall below specified limits, additional VMIS processors shall be provided as specified.

1.2 REFERENCED STANDARDS

Not Used

1.3 SUBMITTALS

A. The Contractor shall submit proposed event recorder product data for Authority approval.

B. The Contractor shall submit a detailed equipment layout and a bill of materials for a typical event recorder.

C. Each Final Design Package shall include details of the event recorder circuit design and connections.

D. The Contractor shall provide event recorder manuals that describe installation, operation and maintenance.

1.4 QUALITY ASSURANCE

A. Contractor shall factory test each event recorder with the Authority approved Factory Test Procedure.

B. Contractor shall inspect each event recorder in accordance with the Authority approved Installation and Inspection Procedure. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

C. Event recorders shall be tested according to Authority approved test procedures.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Event recorder components shall be protected from damage throughout delivery, storage and handling.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS

Not Used

2.2 CONTRACTOR FURNISHED MATERIALS

A. Maintenance Materials: Two complete recorder units with all required components for installation.

B. Keys, Special Tools, and Test Equipment: Contractor shall provide 1 laptop computer for downloading the existing memory contents. The computers shall be provided with software, interface hardware, and cables for connection to the event recorder.

1. The computers shall be Pentium processor-based with hard disks of a size sufficient for operating system, application software and downloaded data from the full storage of at least 10 event recorders. The laptop computers shall be provided with Authority approved network cards.

2. Event recorders shall continue to store new events while downloading to the laptop computers.

3. Contractor shall either provide translation software or ensure that the data file format is such that the data may be printed directly from the laptop, or transferred to a database, or spreadsheet application.

C. Contractor shall provide microprocessor based event recorders containing non-volatile solid-state memory for data storage.

D. Event recorders shall be a multi-channel, multi-speed system containing self-test capability and battery backup.

E. Event recorder memory data storage shall function as a circular queue. When memory storage capacity is reached, the oldest event will be erased and replaced with the event containing the newer information.

F. Event recorders that monitor main lines without junctions shall have the capability of retaining all of the data for 340 train moves per day for 7 consecutive days before recycling. Each event will be date and time stamped.
G. Event recorders that monitor junctions shall have the capability of retaining all of the data for 480 train moves per day for 7 consecutive days before recycling. Each event will be date and time stamped.

H. The CIIH event recorder shall record the following information:
   1. Interlocking Track Circuits
   2. Approach Locking Track Circuits
   3. Signal Request
   4. Signal Clear
   5. Switch Request
   6. Switch Position
   7. Switch Locking
   8. Approach Locking
   9. Route Status
   10. Destination Code
   11. Route selection, Train to Wayside Communication (TWC) or Automatic
   12. Control, Train Control Center (TCC), Local Control Panel (LCP), or AUTO Mode.
   13. All Alarms
   14. Speed Command for each Occupied Track Circuit

I. Event recorders in Automatic Highway Crossing Warning cases shall record the following information:
   1. Approach Track Circuits
   2. Island Track Circuits
   3. XR Status
   4. Gate Down
   5. Gate Up
   6. Battery Voltage
   7. All Alarms

J. Contractor shall provide event recorders complete with an Ethernet interface for connectivity to the communications Ethernet switch to allow remote data retrieval via the CTS system.

K. Contractor shall provide to the Authority new and unused equipment and software required to program each event recorder’s data point mnemonics.

L. Event recorder shall be housed in a protected case.

M. Twisted pair inputs cables shall be provided.

N. The Contractor shall provide a barrier strip terminal block of adequate terminals and 10 percent spare terminals to interface with event recorder external circuits.

PART 3 - EXECUTION

3.1 PRODUCTION
Not Used

3.2 INSTALLATION
A. Contractor shall install event recorder in accordance with Authority approved installation drawings.

3.3 TESTING
A. Contractor shall test event recorders in accordance with Authority approved Installation and Inspection Procedures and these Specifications.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT
A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16972
SECTION 16976
GROUNDING OF EQUIPMENT - SIGNAL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION
A. Work to be performed under this Section consists of designing, providing, and installing a grounding system for instrument houses, wayside signals, wayside cases, junction boxes, grade crossing gates and cantilevers, and other wayside equipment described in these Specifications or shown on Contract Drawings.

1.2 REFERENCED STANDARDS
A. ASTM International (Formerly American Society for Testing and Materials) (ASTM)
   1. ASTM B187/ B187M - Standard Specification for Copper, Buss Bar, Rod, and Shapes and General Purpose Rod, Bar and Shapes
B. American Railway Engineering And Maintenance-of-Way Association (AREMA)
   1. Communications and Signals Manual of Recommended Practice (C&S Manual)

1.3 SUBMITTALS
A. Contractor shall submit a grounding plan. The grounding plan shall be based on the enclosure layout and shall show:
   1. Ground rod placement
   2. Primary ground grid location
   3. Location of racks, trays, and other equipment connected to the grid and the path of all ground connectors that complete the plan.
B. Each Final Design Package shall include circuit and schematic drawings showing design and details for each type of grounding system and equipment. Drawings shall form part of an overall equipment layout submittal for instrument racks, entrance racks and cable trays as required by these Specifications.

1.4 QUALITY ASSURANCE
A. Grounding systems shall be inspected and any deficiencies noted shall be corrected in accordance with the Contractor’s Authority approved QC program. The inspection shall be conducted in conformance with requirements of an Authority approved Contractor Installation Inspection Procedure.
B. Grounding systems shall meet the requirements of the AREMA C&S Manual, Section 11, Parts 11.3.4, 11.3.5, 11.4.1, and 11.4.2.
C. Grounding systems shall be tested according to Authority approved test procedures.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIALS
Not Used

2.2 CONTRACTOR FURNISHED MATERIALS
A. Ground rods shall be copper-clad steel, non-rusting type as manufactured by Copperweld Corporation, or Authority approved equal. Rods shall be at least 8 feet in length and at least 0.75 inch in diameter.
B. Ground rod connections shall be established by exothermic welds, cadweld types GR or GT, or Authority approved equal.
C. Internal ground wire, from equipment to ground buss, shall be insulated No. 6 AWG stranded copper wire. Insulated ground wire shall use colored green insulation.
D. A grounding buss of hard drawn pure copper having a minimum conductivity of 98 percent per ASTM B187 shall be provided in each instrument house and wayside instrument case. Minimum buss dimensions shall be 8 inches by 8 inches by 1/2 inch thick. A minimum of 12, 3/8 inch holes shall be drilled and tapped in the buss and twelve, 3/8 inch by 1/2 inch long hex head nickel plated bronze studs with 1 washer each shall be installed.
E. Grounding grid for instrument houses shall consist of ground rods and No. 4 AWG bare copper connecting cable. Instrument cases shall be grounded with a single No. 6 AWG connected to ground rod(s).

PART 3 - EXECUTION

3.1 INSTALLATION
A. General
   1. Ground connection to track rails or use of the neutral conductors of Public Power Utility or AC signal power supply system will not be permitted.
   2. Series grounding arrangements are not permitted.
   3. Ground rods shall not be visible above the finished grade and ground rods shall be installed near the finished grade surface in such a manner as to preclude the creation of a personnel trip hazard.
B. Instrument Houses

1. Each instrument house shall be grounded by means of a copper wire connection from the ground buss mounted on the wall of instrument house to driven ground rods around the foundation perimeter.

2. Ground wire connection shall be No. 6 AWG bare copper wire, which shall be buried at least 18 inches below the finished grade.

3. Resistance between earth ground and instrument house ground buss shall not exceed 5 ohms. Where a lower ground resistance is required for proper operation of the equipment, the Contractor shall provide conductors and ground rods to achieve the Authority approved design grounding parameters.

C. Wayside Equipment: All wayside equipment shall be grounded. Resistance between ground and the signal structure shall not exceed 5 ohms.

D. Junction Boxes, Wayside Cases

1. All junction boxes and wayside cases shall be grounded with a separate ground rod, exothermic weld and ground connection wire connected to 3/8 inch stud bolt provided with the box or case. Resistance to ground shall not exceed 5 ohms.

2. On aerial structures, ground connection shall be made from instrument case ground buss to ground grids installed beneath the structure. Contractor shall provide exothermic welded connection to either the ground conductor or to the handrail within 1 foot of the ground conductor connection to the handrail.

3. All ground rods shall have grounding wire attached to ground rod 4 inches above grade to facilitate maintenance inspection. Ground rod shall be driven in such a location that it does not create a tripping hazard.

4. When electrical resistance between equipment and earth is excessive, additional rods shall be installed until ground connection resistance meets the requirements of these Specifications.

E. Grounding of Inside Equipment

1. Entrance rack and instrument rack grounding shall be accomplished using a ground buss. All racks shall be electrically connected to ground buss by means of No. 6 AWG stranded wire. Means shall be provided to isolate each rack from ground for test purposes. Wire chases shall be isolated from racks and grounded separately.

2. All other individual apparatus not located on racks or herein specified to be grounded shall have individual insulated No. 6 AWG extra flexible ground connections to the ground buss. Connections shall be designed to be of the shortest possible distance.

3. Contractor shall provide any additional special grounding engineering, work, material, and labor required to meet these Specifications.

3.2 TESTING

A. Grounding systems testing shall be in accordance with these Specifications.

B. Should testing indicate that resistance between equipment and earth is excessive, an additional ground rod section shall be added. Additional rods shall be installed in multiple with the first rod until ground connection resistance meets requirements for ground tests. Contractor shall retest and verify proper results after ground rods are installed. Rods connected in multiple shall be spaced a minimum distance of 6 feet apart.

C. Ground Connection Resistance

1. All grounding connections shall be tested using the ratio ground resistance test method to determine that ground resistance is not greater than 5 ohms for CIH and other signal equipment. All ground connections shall be tested.

2. In the event that Authority approved Contractor ground resistance design and installation and testing results in greater than 5 ohms, the Contractor shall provide additional equipment or modifications to grounding to achieve the requirement.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16976
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the requirements for a comprehensive electromagnetic compatibility control (EMC) program that shall be provided in the Signal System design and installation.

B. Definitions – As used in this Section, the listed terms shall be defined as follows:

1. Electromagnetic Compatibility is the ability of equipment and systems to function as designed without degradation or malfunction in the intended operational electromagnetic environment without adversely affecting or being adversely affected by any other equipment or systems.

C. Electromagnetic Environment:

1. The known Authority Light Rail Transit System (LRT) electromagnetic environment includes: frequent close proximity to high voltage transmission lines; close proximity of diathermy equipments; close proximity to radio and television broadcast equipment. Within the LRT system, there will exist harmonics generated by the traction power AC/DC converter system, by the transit vehicle propulsion system, and by the communication system.

1.2 REFERENCE STANDARDS

A. Urban Mass Transit Administration (UMTA), now the FTA


B. Military Standards


C. International Electro technical Commission (IEC)

1. IEC 61000-4-1, Electromagnetic Compatibility Part 4: Testing and Measurement. Techniques; Section 1: Overview of immunity tests

D. Institute for Electrical and Electronic Engineers (IEEE)

1. IEEE Std 1100-1999, Recommended Practice for Powering and Grounding Electronic Equipment

E. American Railway Engineering And Maintenance-of-Way Association (AREMA)

1. AREMA - Communications & Signals, Part 11

1.3 SUBMITTALS

A. The Contractor shall submit the following for Authority approval:

1. The Electromagnetic Interference (EMI) Control Plan

2. The EMI Control Plan Report

3. Grounding Plan

4. Detailed EMC Maintenance Procedures

1.4 QUALITY ASSURANCE

A. The EMI Control Plan shall meet the requirements of all applicable standards.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. The EMI Control Plan shall include the following:

1. The Management Control Plan shall be implemented, enforced, and integrated as part of the overall design and development program. Define specific organizational responsibilities, lines of authority and control, and the implementation plan, including milestones to be used by the Contractor. Define responsibility for associate contractor equipments and subcontractor vendor items.

2. Identify Frequency Management methods for minimizing emission spectrum and receiver bandwidths, controlling oscillator frequencies,
pulse rise times, harmonics, sidebands, and duty cycles.

3. Identify the prediction or analysis techniques to be employed for determining the adequacy of specific aspects of the mechanical, electrical and electronic designs, including electromagnetic site surveys.

4. Employ the prediction or analysis techniques to identify equipment for which existing analyses and data document electromagnetic compatibility in identical or manifestly similar applications. Identify any potential problem areas and outline appropriate measures to be implemented to control EMI. When electromagnetic compatibility is to be certified based on similar applications, submit existing analyses and data.

B. The Contractor shall also consider mechanical design, materials, and construction methods that provide an inherent attenuation to electromagnetic emissions and susceptibilities without compromising other mechanical requirements of the individual equipment specifications. EMI Control Plan shall describe the material and construction used and the criteria for this selection, including:

1. Metals, castings, finishes, and hardware.

2. Fabrication considerations such as compartmenting, filter mounting, isolation, and type and attenuation characteristics of RF gaskets used on all internal and external matting surfaces.

3. Shielding and design practices to be employed for determining shielding effectiveness.

C. Wiring design shall describe the proposed electrical/electronic wiring designs to mitigate EMI. Include the practices to be used with regard to routing and isolation of wires and cables external to factory wired equipment and grouping of signal, logic and control and power cables. Describe installation criteria to be employed with regard to shielding and grounding of cable shields.

D. Electrical/Electronic circuit design shall describe the EMI suppression techniques which are to be applied to all parts and circuitry, whether capable of generating undesirable emanations or suspected of being susceptible to the coupling fields and voltage levels specified. Include the following:

1. Describe the proposed electrical/electronic wiring designs. Include the practices to be used with regard to routing and isolation of wires and cables external to factory wired equipment and grouping of signal, logic and control and power cables. Describe installation criteria to be employed with regard to shielding and grounding of cable shields.

2. Choice of component parts and circuitry, the criteria for use of standard parts and circuitry and bonding and grounding techniques.

3. Justification of selected filter characteristics, including type and attenuation, filter selection criteria and specific circuit applications.

4. Justification of selected filter characteristics, including type and attenuation, filter selection criteria and specific circuit applications.

5. Part location and separation based on orientation of electric and/or magnetic fields for reduction of emissions, susceptibility.

6. Location of critical circuits and decoupling techniques employed for each.

7. Shielding and isolation of critical circuits.

8. Failsafe criteria shall be used in filter design and parts selection for the Signal System.

E. The Contractor shall submit for Authority approval the Report, an analysis of the known electromagnetic environment developed under these Specifications, recommendations for frequency assignment plan, and receiver sensitivity plan. These analyses shall clearly demonstrate that the signal system will perform the intended functions without degradation.

F. Prior to equipment installation, the Contractor shall submit for Authority approval, a grounding plan detailing the installation parameters and criteria to be applied at each location to ensure the following:

1. Resistance from shields to ground is sufficiently low that expected shield effects are provided.

2. Conductive coupling is avoided.

3. Personnel and equipment are protected from hazardous voltages.

4. Other EMI control measures are not degraded.

G. Detailed EMC Maintenance Procedures shall be delivered to the Authority before the delivery of the last Operations and Maintenance Manual. The Contractor shall submit detailed maintenance procedures for all equipment, detailing actions and intervals, required to sustain signal to noise margins and overall EMC.

2.3 FUNCTIONAL REQUIREMENTS

A. Achievement of EMC shall be a joint endeavor of the Contractor, other contractors and site-specific electric utilities working with the Authority.

B. The Signal System Electromagnetic Compatibility Control Program is intended to ensure that equipment will operate in electromagnetic environments without
either causing or suffering harmful interference because of electromagnetic emission or response. The primary objective shall be to develop equipment and installation parameters that shall assure an electromagnetically compatible system. This objective shall be achieved through coordination of Signal System equipment selection and design, and installation design with the electromagnetic environment such as traction power supply, AC power distribution system, vehicle propulsion systems and nearby facilities and through the coordination of the equipment selection and design and installation design for all subsystems with each other.

C. The Contractor shall conduct such field surveys as required to determine the existing electromagnetic environment that may emanate from fixed facilities along the right-of-way that may interfere with the proper functioning of the Signal System equipments.

D. Approach to implementation of EMC shall include control of: conductivity coupled interference; interference coupled through common impedance; and interference coupled through radiated electric and magnetic fields.

E. The Contractor's equipment designs shall be immune to the residual alternating current present in the traction power system.

F. The Contractor's equipment designs shall be immune to the inductive and conductive emissions produced by the tractive effort control system.

G. The Contractor's equipment designs shall be immune to the inductive and conductive interference generated by the incoming power supply network.

H. The Contractor shall certify, through testing if necessary, the electromagnetic compatibility of equipment provided. Existing analyses and data, properly documented and verifiable for equipment and applications that are identical, may be used for this purpose.

I. The Contractor shall establish test requirements, test schedules and facilities; qualifications, both technical and managerial, of company personnel who will be specifically responsible to implement and control the overall EMI Control Program; and duties of any special review boards. The entire effort shall be integrated to assure continuity of effort and the progress of the efforts shall be subjected to continuous review in all the Contractor individual departments and at vendor facilities.

2.4 DELIVERY, STORAGE AND HANDLING
A. Not Used

PART 3 - EXECUTION

3.1 PRODUCTION
A. Not Used

3.2 INSTALLATION
A. In the selection, design, manufacture, and installation of all Signal System equipment, incorporate EMC concepts to minimize potential interference from within the Signal System and from nearby systems.

B. Consider the effect of signal equipment and other equipment sharing facilities.

C. Select train detection signal operating frequencies for overlay track circuits so as not to be affected by harmonics from rectification of traction power and controls of the vehicle propulsion subsystem.

D. Shield circuit wires and use twisted pairs in cables, as necessary, to minimize electrostatic and electromagnetic coupling.

E. Use cable sheath insulation and surge protection that shall withstand voltage transients and voltage spikes generated within the DC traction power system. Voltage variations include those lasting more than 500 microseconds, and voltage spikes include those lasting from 100 to 500 microseconds with amplitudes up to 2,700 volts. Select semiconductors to withstand maximum expected signal voltages without protection of surge suppressors. Assure that surge suppresser action starts above the maximum signal amplitudes but below the inherent breakdown voltages of semiconductors. Consider the effects of corona influence on voltage spikes, which will tend to limit the magnitude of large spikes, both positive and negative.

F. Consider the electromagnetic environment to which the Signal System will be exposed and incorporate techniques to minimize interference with system operation.

3.3 CABLE WIRING AND HARNESSING
A. Undesired proximity coupling among wires and cables interconnecting networks, chassis, and equipment racks is one of the principal causes of EMI. Group and separate wires and cables into similar classes by signal or power type and minimize EMI coupling between groups.

1. Use a wiring classification scheme to group wires and cables as follows:
   a. High-power AC and DC sources (50 volts and above).
   b. Low-power AC and DC sources (50 volts and below).
   c. Pulse and digital sources.
   d. Audio and sensor susceptible circuits.
   e. Video input and output circuits.
2. Power levels in adjacent wires within a common bundle or harness shall not exceed a 30 dB spread as a design goal.

3.4 SHIELDING

A. Shield signal cables and equipment enclosures against sources of electrostatic or electromagnetic interference considering the following items:

1. Make shields electrically continuous.
2. Use jumpers and electrical connector pins between connected sections to maintain uniform electrical continuity of the shield.
3. Clean surfaces to be connected to provide electrical homogeneity in the shield.
4. Use smallest possible openings in shields at connection points.
5. Use materials having high magnetic permeability, such as steel, for shielding low impedance or magnetic interference of low frequency.
6. Use materials having high conductivity such as copper and bronze for shielding high frequency interference.
7. Use metal conduits of high magnetic permeability in equipment rooms to enclose power wires that are a source of EMI to other equipment.
8. Use EMC gaskets made of conducting materials, such as copper or aluminum, where required, to seal removable panels, equipment drawers and doors. Compress all gaskets with sufficient pressure to assure an EMI seal at the point of maximum joint separation. The difference between maximum and minimum compressed heights of a gasket shall be sufficient to accommodate the joint unevenness of the mating surfaces.
9. Use metal barriers and compartments to separate equipment that generates EMI from other equipment.
10. Use metal screen covers over holes and openings in metal barriers and equipment enclosures, where required, to preserve shielding.
11. Minimize the number of joints, seams, inspection plates, adjustment holes, screened ventilation ports, gasket seals and openings.
12. Check equipment enclosures for EMI leaks through meters, switches, indicator lamps, fuse holders, handles and access doors.

3.5 GROUNDING AND BONDING

A. Grounding methods shall be designed to minimize the noise voltage generated by currents from two or more circuits flowing through a common ground impedance and to avoid creating ground loops that are susceptible to magnetic fields and differences in ground potential. Safety considerations also require the chassis or enclosure for electrical equipment be grounded to minimize passenger and Authority personnel shock hazards except in cases where a safety ground may be desirable at a point that would be unsuitable for a signal ground.

B. Design grounding equipment to accomplish the following:

1. Protect personnel and equipment from electrical hazards, including lightning, to the extent practicable.
2. Reduce potentials to grounding equipment neutrals.
3. Reduce or eliminate the effects of EMI and electrostatic interference arising within the Signal System.
4. Provide a single point grounding system for all equipment enclosures, cabinets, drawers, assemblies and chassis and cabinet subassemblies.
5. Isolate signal ground conductors from the equipment ground methods and from all enclosures, trays, conduits and structures.

C. The following guidelines shall be applied to grounding:

1. For all indoor and outdoor equipment requiring grounding, the grounding systems for enclosures, wireway, panels, switch boxes, pull boxes, conduits, terminal boxes, splice cases and similar enclosures to structures shall be designed to provide proper terminations for shielding and to avoid conducted coupling, low impedance ground loops and hazardous operation conditions.
2. All ground wires shall be sized in accordance with NEC requirements to provide an adequate conduction path for all possible fault and interference currents.
3. A single point ground wire shall not carry load currents.
4. Ground equipment racks and cabinets as required in these Specifications.
D. Design and implement bonding to accomplish the following:

1. Prevent static charge accumulation that could produce electromagnetic interference or constitute a personnel shock hazard.
2. Provide a homogeneous and stable ground plane.
   a. Provide a fault current return path.
   b. Prevent spurious development, rectification, and intermodulation of potentials between hardware elements.

E. Bonding shall be implemented through direct metal-to-metal contact. Continuous or multi-point bonding shall be preferred over single contact to reduce the concentration of high current densities at the point of contact.

F. Following guidelines shall be applied to bonding:

1. Clean all bare metal mating surfaces.
2. Where possible, weld all mating surfaces.
3. Where protective films are required, use film material with good conductivity, such as silver or gold plating.
4. Fastening methods shall exert sufficient pressure to hold the surfaces in contact, in the presence of deforming stresses, shock and vibrations associated with the equipment and its environment.
5. Paint shall not be used to establish electrical bonds.
6. Threads of screws or bolts shall not be used to establish bonds.
7. Ohmmeters shall not be used to evaluate RF bonds or RF gaskets.
8. Bonding of dissimilar metals shall be analyzed as to galvanic and electrolytic action.
9. Ground resistance shall be checked at the single point ground in each instrument housing and wayside device location to ensure that resistance to the single point ground does not exceed 0.5 ohm, and that resistance to ground is below 5 ohms.

3.6 TESTING

A. Perform tests, either separately or as part of other tests in accordance with these Specifications to ensure that EMI reduction techniques are effective on installed Signal System equipment.

B. Include the following items in these tests:

1. Susceptibility of equipment to electrical energy appearing on AC and DC power leads.
2. Susceptibility of equipment to spike interference on AC and DC power leads.
3. Susceptibility of equipment to intermodulation of unwanted and rejected signals at the input terminal.
4. Radiated magnetic field emissions from equipment, power cables and interconnecting wiring.
5. Radiated electric field emissions from equipment, power cables and interconnecting wiring.
6. Radiated susceptibility of equipment to short duration magnetic fields or spike interference on the input/output cabling.
7. Radiated susceptibility of equipment to magnetic fields and electric fields.
8. Grounding and Bonding:
   a. Personnel and system safety
   b. Floating grounds
   c. Ground loops
   d. Impedance coupling
   e. Resistance to the single point ground at each instrument housing and wayside device location.

C. When testing is required to document compliance with EMC criteria, submit EMC test plans for approval. Except where tests are to be performed in full accordance with published standards, include for each test, block diagrams depicting the test set-up, test instrumentation to be used, detailed procedures and method for recording data.

D. Submit test reports that are certified by a Licensed Texas Professional Engineer. The reports shall verify and document that EMC requirements have been incorporated into the Signal System design. Include the following items:

1. Test facility description, equipment grounding or bonding method, where required, to simulate actual equipment installation; physical layout and cabling of equipment under test; real or simulated dummy loads, and test instrumentation.
2. Modes of operation and operating frequency for each test, control settings on equipment tested, frequencies at which interference may
be expected and performance checks conducted.

3. Test procedure, including block diagrams depicting test setups, test instrumentation used, frequencies modulation characteristics of interfering signals, test data and test log summaries.

4. Discussion, in brief narrative form, of results and corrective actions initiated or proposed.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16978
PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies the establishment and maintenance of Signal System Reliability and Maintainability (R&M) Program. The Signal System R&M Program shall be applied to obtain a valid assessment of the Mean Time Between Failure (MTBF) and Mean Time to Repair (MTTR) capabilities of all equipment furnished under this Contract.

1.2 REFERENCE STANDARDS

A. American Railway Engineering And Maintenance-of-Way Association (AREMA):

1. AREMA - Communications & Signals, Part 17.

B. Military Standards

1. MIL-HDBK-781 A - Reliability Testing For Engineering Development, Qualification, And Production

2. MIL-HDBK-338 Electronic Reliability Design Handbook. This handbook provides procuring activities and contractors with an understanding of the concepts, principles, and methodologies covering all aspects of electronic systems reliability engineering and cost analysis as they relate to the design, acquisition, and deployment of equipment or systems. Currently a two-volume set, it discusses the entire subject, heavily emphasizing the reasons for the reliability discipline. It includes general information, referenced documents, definitions, reliability theory, component reliability design considerations, application guidelines, specification control during acquisition, logistic support, failure reporting and analysis, reliability and maintainability theory, reliability specification allocation and prediction, reliability engineering design guidelines, reliability data collection and analysis, demonstration and growth, software reliability, systems reliability engineering, production and deployment reliability and maintainability (R&M), and R&M management considerations.

3. MIL-HDBK-H 108 Sampling Procedures and Tables for Life and Reliability Testing

4. MIL-STD-721C, Definition of Terms for reliability and Maintainability

1.3 DEFINITIONS

A. The following definitions apply specifically to terms used in this Section. Meanings of terms not defined herein are in accordance with the definitions in MIL-STD-721 and the latest edition of Quality Control and Reliability Handbook, H-108, as prepared by the Government Printing Office, Washington, D. C.

1. Mean Time Between Failure (MTBF): Average time that equipment will operate without a chargeable failure.

2. Mean Time to Repair (MTTR): Combined average time required to:
   a. Troubleshoot
   b. Repair equipment for operation after report of a failure.
   c. MTTR is measured from the time troubleshooting and repair work begins until restoration is completed.
   d. MTTR is a measure of maintainability of the design and equipment.
   e. Time required to locate and repair dependent (non-chargeable) failures shall be included in the total repair time.

1.4 SUBMITTALS

A. General

1. The Authority may accept, at its sole discretion, Contractor reliability data previously acquired from similar equipment and subsystems.

B. Reliability and Maintainability Program Plan

1. The Contractor shall submit for Authority approval a Reliability Program. The Program shall include:
   a. Key personnel in the Contractor's Reliability and Maintainability programs.
   b. Design, component selection details, and screening processes to be used to meet reliability requirements.
   c. Procedures, details, and formulas employed calculate MTBF and MTTR.
   d. Identification of sources proposed to be used for component reliability data.
   e. Proposed serialized type forms and reports, including preventive maintenance and discrepancy reports specifically for joint use by the Authority and the Contractor during field reliability assessment testing program.
   f. Plan and procedures for ensuring that subcontractors and suppliers comply with the R&M Program requirements.
g. Procedures to evaluate design changes for possible system reliability and maintainability impacts.

h. Provisions for providing calculated design reliabilities.

i. Plan and procedures for field reliability testing.

j. Plan and procedures for continual evaluation of field reliability testing results with accept-reject criteria.

k. Provisions for early fault detection and rapid fault isolation.

l. Provisions for providing a time log showing the actual factory time spent in repairing each piece of defective equipment removed during the course of the R&M Program.

m. Provisions for field repair time analysis.

n. Plan and procedures to track corrective measures and assess R&M impact of field equipment failures.

C. Predicted Reliability and Maintainability Reports

1. The Contractor shall initiate a study and submit to the Authority, a report documenting the Contractor’s predicted reliability for each subsystem. Where areas of common failure appear inherent in the design or equipment specified mode, an alternate design or equipment change shall be proposed for Authority approval.

2. Reports shall include complete methods and calculated R&M values. Actual performance data for a similar system for which reliability records have been maintained for a period of not less than five years, may be used to support or substantiate the submitted predicted R&M calculations.

3. Reports shall be updated and re-issued monthly and shall indicate by subsystem the estimated percent of design completion upon which reliability and maintainability predictions are based.

4. Reports shall include analysis of items for which prediction does not meet requirements or for which prediction has changed significantly from the last report. For items predicted not to meet requirements, proposed corrective action shall be described in the report.

5. During the design process, whenever the Contractor encounters reliability calculations in the design process that are below system design goals, an updated reliability report shall be created and forwarded to the Authority. If these reports indicate a marked decrease in predicted reliability, the Authority may require an alternate design or equipment change to increase calculated reliability to requirements specified in the Table of Reliability Goals.

1.5 QUALITY ASSURANCE

A. The reliability and maintainability assurance program shall meet the requirements of the AREMA Signal Manual, Part 17.4.1.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. Product of this Section consists of documents that establish and verify reliability goals have been met as specified.

2.3 DELIVERY, STORAGE AND HANDLING

A. Not Used

PART 3 - EXECUTION

3.1 PRODUCTION

A. The Contractor shall demonstrate system availability using engineering, analysis, and reliability tools and techniques, and report to the Authority that the Contractor’s design satisfies the specified system availability of not less than 99.5% for a 16-hour operating day under a seven day per week operation.

B. Assessment Program

1. Verification that equipment fulfills the reliability requirements described herein shall be accomplished via a reliability assessment program generally in accordance with MIL-HDBK-781 A.

2. Reliability values and requirements specified herein shall not be interpreted as a relaxation of signal control and interlocking system fail-safe design requirements.

3.2 INSTALLATION

A. Not Used

3.3 TESTING

A. Not Used
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16995
PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies providing and installing Operations and Maintenance Signs for the DART Light Rail Transit System (LRT).

B. Work shall consist of providing and installing Operations and Maintenance Signs including aluminum signs, traffic buttons, painted ties, sign posts, foundations, brackets and hardware; providing final camera-ready artwork for each sign; providing spares; providing all materials and labor required for complete sign and equipment installation in accordance with these specifications, the locations and details are shown in Table 1 below, and as shown on the Contract Drawings.

C. All Work must be coordinated and phased to avoid disruption to ongoing operations and construction.

1.2 REFERENCED STANDARDS

A. The following Codes, Regulations, Reference Standards and Specifications are used as references:

1. Codes and regulations of jurisdictional authorities.

B. All sign legends shall be computer generated and machine cut. Hand-rendered or hand-cut legends are not acceptable.

C. Sign colors, lettering, symbols and borders shall conform to the details shown in the Contract Drawings unless otherwise noted. All the above shall conform to TMUTCD, Standard Highway Sign Design for Texas and Standard Alphabets for Highway Signs and Pavement Markings.

1.3 SUBMITTALS

A. Submit the following for Authority approval and in accordance with these Specifications:

1. Contractor shall submit for Authority approval, manufacturer's technical data for sign materials and designs. Provide installation details and instructions for each type of sign and mounting required.

2. Contractor shall submit for approval:

a. Samples of the color and finish of aluminum materials and accessories required for the signs. The Authority's review of samples will be for color, texture, and materials only. Compliance with all other requirements is the exclusive responsibility of the Contractor. Furnish full-size samples of sign materials, when required by the Authority.

1) Office samples must be of sufficient size and quantity to clearly illustrate characteristics of the product. Include related parts and attachment devices and full range color, texture and pattern.

b. Shop Drawings: Submit shop drawings of all sign panels, components, parts and fittings. Provide installation procedures showing layout, jointing, complete anchoring and support systems for the various applications and mounting details for all signs. Drawings shall clearly show provisions or all performance functions described herein. Submit shop drawings for approval of details, sections, sign panels and signs at full size scale.

3. Final Design Review Packages shall include layout and installation drawings for wayside signs.

1.4 QUALITY ASSURANCE

A. Each sign shall be inspected prior to shipment. Inspection shall conform to the Suppliers inspection procedure.

B. AF track circuits shall meet the requirements of this contract and all applicable local, state and federal codes, reference standards, safety standards.

C. Each sign shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

1.5 QUALIFICATIONS

A. The sign manufacturer shall be an established firm, which is regularly engaged in the fabrication and installation of signs and approved by the Authority.
PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. Maintenance Materials: Contractor shall provide 10 of each sign type used within the system, along with the corresponding mounting hardware.

B. Signs, Posts and Fasteners

1. All sign panels shall be made of aluminum, unless otherwise noted, and be manufactured or provided by the Contractor. All sign panels shall be manufactured by a sole source, and fabricated from material specified below under "Sign Panels".

2. Cut edges or drilled holes shall be deburred and smoothed.

3. Signposts and anchors must be square, 12 gauge galvanized steel Unistrut, or as approved by the Authority with 1/2-inch perforation on 1 inch centers. Signposts shall be 2 inches square. Anchor posts into the ground using a 2-piece breakaway anchor consisting of a 2-1/4 inches square, 3 feet long base, and 2-1/2 inches square, 1-1/2 feet long sleeve. Utilize connecting bolts, fittings and hardware as shown on Contract Drawings.

4. Concrete Grout shall be used for signpost anchor base installed in core-drilled concrete paving. Grout between anchor and concrete paving with concrete grout, fast setting, rapid strength gain 1000+ psi in 8 hours, and 5000+ psi in 24 hours. Grout shall be shrinkage compensating, contain no chloride, and comply with ASTM C1107 Types B and C. Use TXI Zip Crete as provided by Texas Industries (TXI) or approval equal.

5. Framing and Bracing shall use connecting bolts, fittings and hardware as shown on the Contract Drawings.

6. Sign Fastening shall use stainless steel hex-head lag bolts, washers, nuts, and clamps to attach signs to steel posts, braces, brackets, fences, guardrails and gates. Paint all exposed fastenings to match adjacent areas.

7. Special Fasteners shall be Hilti, Authority approved equal, anchor bolts and adhesives to secure signs or sign brackets to walls. Install as shown on the Contract Drawings and in these Specifications.

C. Sign Panels

1. All signs shall be solid one-piece panels.

2. Provide final camera-ready artwork for each sign.

3. Sign face shall not be permanently defaced by steam, acids, aromatics, scratching, inks or paints, and shall readily wipe clean with paint remover and solvents without affecting appearance or legibility of the sign finish or graphics.

4. Sign face shall retain legibility and finished appearance when sprayed with a 10 percent solution of nitric hydrochloric, or sulphuric acid for 30 minutes, or when scrubbed by a brush of medium hardness using common commercial cleaning compounds such as ammonia, detergents, laundry soaps, carbon tetrachloride, or petroleum base solvents.

5. Sign edges shall not be crazed or cracked and edge finish shall be smooth, clean, and neat.

6. Finished sign shall be absolutely flat.

7. All signs must have the holes drilled and sealed per type of installation as noted in the tables and Contract Drawings.

8. All signs shall have rounded corners with a 1-1/4-inch radius.

9. Reflectivity requirements: All sign copy and graphics shall be screen painted over 3M Scotchlite Reflective Sheeting Diamond Grade VIP (Visual Impact Performance) or Authority approved equal.

10. A protective covering shall be placed on and between signs to prevent damage during shipment. Damaged signs shall not be accepted.

11. Minimum standard sign panel thickness shall be 0.125 inches.

12. Sign face shall be warranted for a period of 10 years against chipping, delaminating and fading.

D. Table 1 provides a list and description of signs in this Contract. Each sign shall be fabricated according to the graphics and the specification sheets. Preliminary locations of Operations and Maintenance (O&M) mainline signs are indicated on the single line Contract Drawings.
PART 3 - EXECUTION

3.1 INSPECTION
A. Prior to procurement and shop drawing submittal, the Contractor shall examine the site locations and conditions under which signs are to be installed.
B. Prior to signage installation, the Contractor shall mark each sign location with a flag, paint mark, tape, or survey stick. The Authority's inspector shall approve each sign location prior to installation.
C. Contractor is responsible for location of underground utilities coordination Work.

3.2 ERECTION METHODS DETAILS
A. Install signs as shown in Authority approved Installation Contract Drawings. Installation types and methods include, but are not limited to the following:
   1. Unistrut post installations shall be in ballast, concrete, asphalt, pavers, or soil. Concrete is required when signs are located on pavements or other solid structures.
   2. When installing on painted ties, clean the tie surface before applying paint and apply 2 coats of paint on concrete ties and 4 coats of paint on wooden ties and apply glass beads per manufacturer's direction.
B. Post Erection: For each post, drive an anchor, then a sleeve into the ground with a pneumatic post driver. Install anchor and sleeve plumb. Drive directly into ballast rock, gravel, asphalt, dirt, or other material. On concrete paving, core drill a 3 to 4 inch diameter hole through the concrete, then drive an anchor and sleeve. Apply grout in between anchor sleeve and concrete, making grout flush with existing concrete. All anchors and sleeves shall be exposed from 1 to 2 inches above grade for bolt connections. Post should extend into anchor between 6 and 8 inches. Secure post with 90-degree bend stainless steel anchor bolt and the post must be plumb.
C. Dispose of surplus excavated material.
D. On bridges install posts in accordance with the Authority approved Contract Drawings.

3.3 INSTALLATION
A. Install sign units and components at the locations shown, securely mounted, in accordance with these Specifications.
B. Install signs level, plumb, and at the proper height. Coordinate with other contractors for installation of sign units to finished surface. Repair or replace damaged units as directed by the Authority.

3.4 TEMPORARY COVERS
A. Signs installed prior to their operational or testing function shall be covered to conceal the sign face from view.
B. Coverings shall be of a dark gray or black plastic heavy-duty material acceptable to the Authority, neatly affixed to sign face with matching or concealed fasteners. When coverings are removed, clean the signs and treat faces with antistatic solution.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL
A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT
A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”
# Operations and Maintenance (OM) Signs

<table>
<thead>
<tr>
<th>OM Signs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM-1</td>
<td>Permanent Speed Restriction</td>
</tr>
<tr>
<td>OM-2</td>
<td>Diverge Speed</td>
</tr>
<tr>
<td>OM-3</td>
<td>Whistle</td>
</tr>
<tr>
<td>OM-4</td>
<td>Horn</td>
</tr>
<tr>
<td>OM-5</td>
<td>Begin Auto Block</td>
</tr>
<tr>
<td>OM-6</td>
<td>End Auto Block</td>
</tr>
<tr>
<td>OM-7</td>
<td>Yard Limit</td>
</tr>
<tr>
<td>OM-8</td>
<td>Stop</td>
</tr>
<tr>
<td>OM-9</td>
<td>Safety Stop</td>
</tr>
<tr>
<td>OM-10</td>
<td>Auxiliary Lights On</td>
</tr>
<tr>
<td>OM-11</td>
<td>Auxiliary Lights Off</td>
</tr>
<tr>
<td>OM-12</td>
<td>Temporary Speed</td>
</tr>
<tr>
<td>OM-13</td>
<td>Temporary Resume Speed</td>
</tr>
<tr>
<td>OM-14</td>
<td>Start Block</td>
</tr>
<tr>
<td>OM-15</td>
<td>Intermediate Block</td>
</tr>
<tr>
<td>OM-16</td>
<td>End Block</td>
</tr>
<tr>
<td>OM-17</td>
<td>Time Speed (This Sign Not Used)</td>
</tr>
<tr>
<td>OM-18</td>
<td>No Clearance</td>
</tr>
<tr>
<td>OM-19</td>
<td>Section Insulator</td>
</tr>
<tr>
<td>OM-20</td>
<td>Spring Switch (This Sign Not Used)</td>
</tr>
<tr>
<td>OM-21</td>
<td>Fouling Point Marker</td>
</tr>
<tr>
<td>OM-22</td>
<td>Apply Brake for Crossover</td>
</tr>
<tr>
<td>OM-23</td>
<td>Brake for Station</td>
</tr>
<tr>
<td>OM-24</td>
<td>End of Wire</td>
</tr>
<tr>
<td>OM-25</td>
<td>Berthing Marker</td>
</tr>
<tr>
<td>OM-26</td>
<td>Mile Post Marker</td>
</tr>
<tr>
<td>OM-27</td>
<td>Shop Track Number</td>
</tr>
<tr>
<td>OM-28</td>
<td>Yard Track Number</td>
</tr>
<tr>
<td>OM-28A</td>
<td>Tie-Mounted Yard Track Number</td>
</tr>
<tr>
<td>OM-29</td>
<td>Interlocking, Crossover, Grade Crossing, or Substation Identification</td>
</tr>
<tr>
<td>OM-30</td>
<td>Start Test Zone Marker</td>
</tr>
<tr>
<td>OM-31</td>
<td>End Test Zone Marker</td>
</tr>
<tr>
<td>OM-32</td>
<td>Shop Limit</td>
</tr>
<tr>
<td>OM-33</td>
<td>Chain Marker</td>
</tr>
<tr>
<td>OM-34</td>
<td>Gate Identification</td>
</tr>
<tr>
<td>OM-35</td>
<td>TWC Call</td>
</tr>
<tr>
<td>OM-36</td>
<td>Coast</td>
</tr>
<tr>
<td>OM-37</td>
<td>Power</td>
</tr>
<tr>
<td>OM-38</td>
<td>Begin Cab Signal</td>
</tr>
<tr>
<td>OM-39</td>
<td>End Cab Signal</td>
</tr>
<tr>
<td>OM-40</td>
<td>Emergency Notification</td>
</tr>
<tr>
<td>OM-41</td>
<td>Emergency Notification</td>
</tr>
<tr>
<td>OM-42</td>
<td>Interlocking Limit</td>
</tr>
</tbody>
</table>
# Sign OM-1, Permanent Speed Restriction

## Description

<table>
<thead>
<tr>
<th>Alphanumeric Colors:</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alphanumeric:</th>
<th>Type: Series E *note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
<td>8 inches *note</td>
</tr>
</tbody>
</table>

| Message Position:    | Centered top-to-bottom and left-to-right. |

| Border Width:        | ½ to ¾ inch, or equal but not to exceed stroke width of alphanumeric. |

| Border Placement:    | Set ½ inch from sign edge. |

(drawing not to scale)

## Indication: Reduce/Increase Speed to That Indicated on Sign

Numeral indicates maximum authorized speed.

## Remarks

### Purpose:

To provide operator the speed regulation in accordance with maximum authorized speed for particular segments of the system.

### Criteria:

<table>
<thead>
<tr>
<th>Sign Placement:</th>
<th>To be placed at full service braking distance when approaching lower speed restriction change points or at 3-car train distance in advance of higher speed restriction change points.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Cab Signal Territory, place a sign at block boundary where the maximum authorized speed code changes.</td>
</tr>
</tbody>
</table>

**Vertical:**

Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.

**Horizontal:**

Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.

### Notes:

* Alphanumeric series and size based on two-digit speed restriction.

Signs should be installed adjacent to each track for normal and reverse running.
## Sign OM-2, DIVERGE SPEED

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics Color:</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series E *note</td>
</tr>
<tr>
<td>Size:</td>
<td>6 inches *note</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(drawing not to scale)

### INDICATION: REDUCE SPEED TO THAT INDICATED ON SIGN FOR DIVERGING MOVE

Numeral indicates maximum authorized speed for diverging move through turnout.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify maximum authorized speed for diverging move through turnout.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed adjacent to home signal governing turnout.</td>
</tr>
<tr>
<td>Vertical:</td>
<td>Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Horizontal:</td>
<td>Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Alphanumerics series and size based on 25 m.p.h. speed restriction for diverging movement. Signs should be installed adjacent to each track for normal and reverse running.</td>
</tr>
</tbody>
</table>
WAYSIDE SIGNS - SIGNAL SYSTEM

Sign OM-3, WHISTLE

DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics Color:</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td>Alphanumerics Type:</td>
<td>Series E</td>
</tr>
<tr>
<td>Size:</td>
<td>12 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch in from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

INDICATION: SOUND WHISTLE PER RULES APPROACHING GRADE CROSSING OR DESIGNATED AREA.

REMARKS

Purpose: To identify point prior to grade crossings or other designated areas where train operator is to start sounding whistle.

Criteria: Sign Placement: To be placed at distance where train traveling at maximum allowable speed is ten seconds in approach to crossing or other designated area.

Vertical: Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.

Horizontal: Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.

Notes: Signs should be installed adjacent to each track for normal running only.
<table>
<thead>
<tr>
<th><strong>DESCRIPTION</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alphanumeric</strong></td>
<td><strong>Colors:</strong> BLACK</td>
</tr>
<tr>
<td><strong>Border Color:</strong></td>
<td>BLACK</td>
</tr>
<tr>
<td><strong>Background Color:</strong></td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td><strong>Sign Shape:</strong></td>
<td>SQUARE</td>
</tr>
<tr>
<td><strong>Sign Size:</strong></td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td><strong>Alphanumeric:</strong></td>
<td>Series E</td>
</tr>
<tr>
<td><strong>Type:</strong></td>
<td>12 inches</td>
</tr>
<tr>
<td><strong>Message Position:</strong></td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td><strong>Border Width:</strong></td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumeric</td>
</tr>
<tr>
<td><strong>Border Placement:</strong></td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

**INDICATION:** SOUN D HORN PER RULES APPROACHING DESIGNATED AREA.

<table>
<thead>
<tr>
<th><strong>REMARKS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose:</strong></td>
<td>To identify point where train operator is to start sounding horn.</td>
</tr>
<tr>
<td><strong>Criteria:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sign Placement:</strong></td>
<td>To be placed at distance where train traveling at maximum allowable speed is ten seconds in approach to designated area.</td>
</tr>
<tr>
<td><strong>Vertical:</strong></td>
<td>Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td><strong>Horizontal:</strong></td>
<td>Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td><strong>Notes:</strong></td>
<td>Signs should be installed adjacent to each track for normal running only.</td>
</tr>
</tbody>
</table>
### Sign OM-5, BEGIN AUTO BLOCK

**DESCRIPTION**

<table>
<thead>
<tr>
<th>Alphanumeric</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td>Alphanumeric:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series D</td>
</tr>
<tr>
<td>Size:</td>
<td>3 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge</td>
</tr>
</tbody>
</table>

![Diagram](drawing_not_to_scale)

**INDICATION:** INDICATES BEGINNING OF AUTOMATIC BLOCK SIGNALING TERRITORY. Line-of-sight operations end here.

**REMARKS**

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the beginning of automatic block signaling territory and the end of line-of-sight operations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed adjacent to first signal in signalized territory.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator's normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage posts should be placed at 9 feet from track center, provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td>Signs should be installed adjacent to each track for normal and reverse running.</td>
</tr>
</tbody>
</table>
## Description

<table>
<thead>
<tr>
<th>Alphanumeric</th>
<th>Colors:</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
<td></td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
<td></td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
<td></td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches</td>
<td></td>
</tr>
<tr>
<td>Alphanumeric:</td>
<td>Type: Series D *note</td>
<td></td>
</tr>
<tr>
<td>Size:</td>
<td>3 inches</td>
<td></td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
<td></td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
<td></td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
<td></td>
</tr>
</tbody>
</table>

**Indication:**
INDICATES END OF AUTOMATIC BLOCK SIGNALING TERRITORY.
Line-of-sight operations begin here.

## Remarks

**Purpose:**
To identify the end of automatic block signaling territory and the beginning of line-of-sight operations.

**Criteria:**
- **Sign Placement:** To be placed adjacent to first signal in signalized territory.
  - Vertical:
    - Should be within Train Operator's normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.
  - Horizontal:
    - Signage posts should be placed at 9 feet from track center, provided adequate clearance exists and line-of-sight is unobstructed.

**Notes:**
- *Series E may be used for “END” but not required.
Signs should be installed adjacent to each track for normal and reverse running.
### Sign OM-7, YARD LIMIT

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td>Series C</td>
</tr>
<tr>
<td>Type:</td>
<td>5 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

**INDICATION:** INDICATES START OF YARD OPERATION LIMITS.

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the start of yard operation and the associated change in operating rules. Differences in yard operations and mainline operations are defined in Operating Rulebook.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed at signals entering the yard.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td>Signs should be installed adjacent to each track for normal and reverse running.</td>
</tr>
</tbody>
</table>
## Sign OM-8, STOP

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>REFLECTIVE WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE RED</td>
</tr>
<tr>
<td>Background Color:</td>
<td>OCTAGON</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>24 inches by 24 inches on horizontal and vertical axes for fixed signs. *note</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>24 inches by 24 inches</td>
</tr>
</tbody>
</table>

Alphanumerics:
- **Type:** Series C **note
- **Size:** 8 inches
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.
- **Border Placement:** Set flush with sign edge.

(Drawing not to scale)

### INDICATION: STOP.

### REMARKS

**Purpose:** To indicate a full stop. Should proceed only as instructed by Operating Rulebook.

**Criteria:**

**Sign Placement:** To be placed on all bumping post and stub end tracks. Also may be used as a temporary sign in approach to construction, hazards, or other locations as noted in the plans.

**Vertical:** Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.

**Horizontal:** Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.

**Notes:**

*Handheld signs (for use by maintenance crew in temporary situation) should be "18 inches by 18 inches", Series C, 6 inch; have a lightweight, tubular staff of minimum 9 inches made of a lightweight material. Use of handheld STOP Signs covered under flagging procedures in Operating Rulebook.*

**Specification as per TX MUTCD STOP sign MR1-1.**
## Sign OM-9, SAFETY STOP

### DESCRIPTION

- **Alphanumerics:** REFLECTIVE WHITE
- **Colors:** REFLECTIVE WHITE
- **Border Color:** REFLECTIVE RED
- **Background Color:** OCTAGON
- **Sign Shape:** OCTAGON
- **Sign Size:** 24 inches by 24 inches on horizontal and vertical axes for fixed signs. *note
- **Alphanumerics:**
  - **Type:** Series C *note
  - **Size:** 4 inches
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.
- **Border Placement:** Set flush with sign edge.

(Drawing not to scale)

### INDICATION: STOP. THEN PROCEED IF PERMISSIBLE AND REQUIRED.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To indicate a full stop. Should proceed only as instructed by Operating Rulebook.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criteria:</strong></td>
<td><strong>Sign Placement:</strong> To be placed approximately 25 feet prior to a bumping post or end of tail tracks as noted on the plans. Also be placed at mandatory stop stations.</td>
</tr>
<tr>
<td></td>
<td><strong>Vertical:</strong> Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td><strong>Horizontal:</strong> Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td><strong>Notes:</strong></td>
<td>Sign should be installed adjacent to each tail track.</td>
</tr>
<tr>
<td></td>
<td>* Specification as per TX MUTCD STOP sign MR1-1.</td>
</tr>
</tbody>
</table>
Sign OM-10, AUXILIARY LIGHTS ON

**DESCRIPTION**

- **Alphanumeric Colors:** BLACK
- **Border Color:** BLACK
- **Background Color:** REFLECTIVE WHITE
- **Sign Shape:** SQUARE
- **Sign Size:** 18 inches by 18 inches
- **Alphanumeric Type:** Series D
- **Size:** 5 inches
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumeric.
- **Border Placement:** Set ½ inch from sign edge.

(Drawing not to scale)

**INDICATION:** TURN AUXILIARY LIGHTS ON.

**REMARKS**

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To identify the point where auxiliary lights are to be on. Lights are to be off for CBD and Lancaster areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>Sign Placement: To be placed at Yard Limit, tunnel portals, and areas where lights are to be turned back on, such as when leaving CBD and Lancaster areas.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Alpha characters made need to be compressed 10 – 15%.</td>
</tr>
<tr>
<td></td>
<td>Sign should be installed for normal running for each track.</td>
</tr>
</tbody>
</table>
### Sign OM-11, AUXILIARY LIGHTS OFF

**DESCRIPTION**

- **Alphanumerics:**
  - **Colors:** BLACK
  - **Border Color:** BLACK
  - **Background Color:** REFLECTIVE WHITE
  - **Sign Shape:** SQUARE
  - **Sign Size:** 18 inches by 18 inches
- **Alphanumerics:**
  - **Type:** Series D
  - **Size:** 5 inches
  - **Message Position:** Centered top-to-bottom and left-to-right.
  - **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.
  - **Border Placement:** Set ½ inch from sign edge.

(Drawing not to scale)

**INDICATION:** TURN AUXILIARY LIGHTS OFF.

**REMARKS**

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the point where auxiliary lights are to be off. Lights are to be off for CBD and Lancaster areas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed at points entering areas where lights are to be off, such as CBD and Lancaster areas.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Alpha characters made need to be compressed 10 – 15%. Sign should be installed for normal running for each track.</td>
</tr>
<tr>
<td>Description:</td>
<td>Alphanumerics</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE ORANGE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>24 inches by 24 inches</td>
</tr>
<tr>
<td>Alphanumerics Type:</td>
<td>Series C *note</td>
</tr>
<tr>
<td>Size:</td>
<td>12 inches *note</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch in from sign edge.</td>
</tr>
</tbody>
</table>

**INDICATION:** REDUCE SPEED FOR TEMPORARY SPEED RESTRICTION AS POSTED.
Numerical indicates maximum authorized track speed. Continue at restricted speed until indicated to resume normal track speed.

**REMARKS**

**Purpose:** To identify a temporary maximum allowable track speed due to scheduled maintenance activities and unusual or adverse operating conditions.

**Criteria:**

<table>
<thead>
<tr>
<th>Sign Placement:</th>
<th>To be placed at full service braking distance in approach to temporary speed restriction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical:</td>
<td>Should be placed so that it can be easily staked (approx. 3 to 4 feet from top of rail.)</td>
</tr>
<tr>
<td>Horizontal:</td>
<td>Signage posts should be placed as determined by Operations Personnel in the field.</td>
</tr>
</tbody>
</table>

**Notes:** *Based on worst case of recommended m.p.h. signs for initial operations (40 m.p.h.) as illustrated above. Restricted format is a blank alphanumeric field and is to be used for restricted speeds of 20 m.p.h. or less. Sign is to be used in conjunction with the RESUME SPEED SIGN. Mounting will be temporary and capable of being staked.*
# Wayside Signs - Signal System

## Sign OM-13, Temporary Resume Speed

### Description

**Alphanumerics**
- **Colors:** REFLECTIVE WHITE
- **Border Color:** REFLECTIVE WHITE
- **Background Color:** REFLECTIVE GREEN
- **Sign Shape:** SQUARE
- **Sign Size:** 18 inches by 18 inches
- **Alphanumerics:**
  - **Type:** Series E
  - **Size:** 12 inches
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.
- **Border Placement:** Set flush with sign edge.

(Drawing not to scale)

**Indication:** Resume speed for normal authorized speed.

### Remarks

**Purpose:** To identify point at which the train can resume speed to normal maximum allowable speed for that line section.

**Criteria:**
- **Sign Placement:** To be placed at end of temporary speed restriction.
  - **Vertical:** Should be placed such that it can easily be staked (approx. 3 to 4 feet from top of rail.)
  - **Horizontal:** Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.

**Notes:** Sign is to be used in conjunction with TEMPORARY SPEED SIGN. Mounting will be temporary and capable of being staked.
**WAYSIDE SIGNS - SIGNAL SYSTEM**

### Sign OM-14, START BLOCK

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphanumerics</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE YELLOW</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>TRIANGLE (inverted)</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches by 18 inches *note</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series C</td>
</tr>
<tr>
<td>Size:</td>
<td>6 inches **note</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

**INDICATION: START OF BLOCK INDICATOR TERRITORY.**

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the start of block indicator territory. Aspect gives indication of track condition only for the associated block.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be mounted on signal mast.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be directly below signal head.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage is attached to signal mast.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Size may vary. Will be based on actual clearance available. Not to exceed signal head clearance envelope by more than 2 inches on either side.</td>
</tr>
<tr>
<td></td>
<td>**May need to compress alphanumeric width by 20%. Sign is to be used in conjunction with END BLOCK SIGN. It also will be used with INTERMEDIATE BLOCK SIGN if line section has a series of successive single block territories.</td>
</tr>
</tbody>
</table>
### Sign OM-15, INTERMEDIATE BLOCK

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumeric</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color</td>
<td>REFLECTIVE YELLOW</td>
</tr>
<tr>
<td>Sign Shape</td>
<td>TRIANGLE (inverted)</td>
</tr>
<tr>
<td>Sign Size</td>
<td>18 inches by 18 inches (noted)</td>
</tr>
</tbody>
</table>

- **Alphanumeric**
  - **Type**: Series D
  - **Size**: 6 inches
  - **Message Position**: Centered top-to-bottom and left-to-right.
  - **Border Width**: ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.
  - **Border Placement**: Set ½ inch from sign edge.

(Drawing not to scale)

#### INDICATION: BEGINNING OF A SUCCESSIVE BLOCK INDICATOR TERRITORY.

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To identify the beginning of another block indicator limit immediately successive to a previous block indicator. Aspect gives indicator of track condition only for the associated block.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td><strong>Sign Placement</strong>: To be mounted on signal mast.</td>
</tr>
<tr>
<td></td>
<td><strong>Vertical</strong>: Should be placed below signal head.</td>
</tr>
<tr>
<td></td>
<td><strong>Horizontal</strong>: Signage is attached to signal mast.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Size may vary. Will be based on actual clearance available. Not to exceed signal head clearance envelope by more than 2-inches on either side.</td>
</tr>
<tr>
<td></td>
<td>Sign is to be used in between START BLOCK SIGN and END BLOCK SIGN. It is used for line sections with a series of successive single signalized block indicators.</td>
</tr>
</tbody>
</table>
### Sign OM-16, END BLOCK

#### DESCRIPTION

**Alphanumerics**
- **Colors:** BLACK
- **Border Color:** BLACK
- **Background Color:** REFLECTIVE YELLOW
- **Sign Shape:** TRIANGLE (inverted)
- **Sign Size:** 18 inches by 18 inches by 18 inches *note

**Alphanumerics:**
- **Type:** Series C
- **Size:** 6 inches **note
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.
- **Border Placement:** Set ½ inch from sign edge.

(Drawing not to scale)

#### INDICATION:
**END OF BLOCK INDICATOR TERRITORY.**
Line-of-sight territory begins here.

#### REMARKS

**Purpose:** To identify the end of block indicator territory.

**Criteria:**

**Sign Placement:** To be placed where block indicator territory ends and line-of-sight operation begins.

- **Vertical:** Should be within Train Operator's normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.

- **Horizontal:** Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.

**Notes:**
* Size may vary. Will be based on actual clearance available. Not to exceed signal head clearance envelope by more than 2 inches on either side.

** May need to compress alphanumerics width by 20%.

Sign is to be used in conjunction with START BLOCK SIGN and, when applicable, with INTERMEDIATE BLOCK SIGN.
### Sign OM-18, NO CLEARANCE

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumeric</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color</td>
<td>REFLECTIVE YELLOW</td>
</tr>
<tr>
<td>Sign Shape</td>
<td>RECTANGLE *note</td>
</tr>
<tr>
<td>Sign Size</td>
<td>6 inches by 44 inches **note</td>
</tr>
</tbody>
</table>

Alphanumeric:
- **Type:** Series C
- **Size:** 3 inches
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch or equal but not to exceed stroke width of alphanumeric.
- **Border Placement:** Set ½ inch from sign edge.

(Drawing not to scale)

#### INDICATION:
AREA HAS NO SAFE REFUGE TO STAND OR WALK IN THE RIGHT-OF-WAY.

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify areas in the right-of-way where clearance is sufficiently reduced so as to cause hazard to patron or personnel.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed at site-specific locations where clearance is less than 8’ – 6” from center of track to a continuous structure on tangent track.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within personnel and patron normal field of view.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage should be placed as close to affected area as site allows.</td>
</tr>
<tr>
<td>Notes:</td>
<td>* Sign shape should be rectangular with long sides vertical.</td>
</tr>
<tr>
<td></td>
<td>** Based on Burlington Northern operational sign, with adjustment for adding ½ inch border and border offset. Could be used in conjunction with warning strips denoting extent of no clearance area.</td>
</tr>
</tbody>
</table>
## Sign OM-19, SECTION INSULATOR

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color: REFLECTORIZED BLUE</td>
</tr>
<tr>
<td>Size: 4 inches by 4 inches minimum *note</td>
</tr>
<tr>
<td>(6 inches by 6 inches preferred)</td>
</tr>
<tr>
<td>Type: 2-way reflectorized pavement marker</td>
</tr>
<tr>
<td>with one-color (blue housing) **note</td>
</tr>
</tbody>
</table>

(drawing not to scale)

### INDICATION: LOCATION OF SECTION INSULATOR.

### REMARKS

| Purpose: | To advise Train Operator that train will be entering an area where overhead power can be de-energized. |
| Criteria: | Sign Placement: Not a sign proper. Section Insulator indicated by reflectorized blue pavement marker affixed to tie at a minimum distance of one (1) car length. |
|          | Vertical: not applicable. |
|          | Horizontal: not applicable. |
| Notes:   | * There is no sign for section insulator indication. Section Insulator indicated by reflectorized blue pavement marker affixed to tie. |
|          | ** Pavement markers are as indicated above and as described in TX MUTCD Section 3A-3. |
## Sign OM-21, FOULING POINT MARKER

### DESCRIPTION

**Paint Color:** REFLECTIVE YELLOW  *note

USE AEXCEL – CHLORINATED RUBBER TRAFFIC PAINT OR EQUAL AND APPLY GLASS BEADS.

(Drawing not to scale)

### INDICATION:
INDICATES FOULING POINTS AT TURNOUTS IN LINE-OF-SIGHT OR YARD TERRITORY.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To identify point at turnout to prevent fouling.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sign Placement:</th>
<th>Not a sign proper. Fouling point indicated by painted yellow tie. To be installed at locations noted in the tables.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical:</td>
<td>not applicable.</td>
</tr>
<tr>
<td></td>
<td>Horizontal:</td>
<td>not applicable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes:</th>
<th>* There is no sign for fouling point indication. Fouling point is to be indicated by painted yellow tie.</th>
</tr>
</thead>
</table>
### Sign OM-22, APPLY BRAKE FOR CROSSOVER

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphanumeric Colors</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color</td>
<td>REFLECTIVE YELLOW</td>
</tr>
<tr>
<td>Sign Shape</td>
<td>DIAMOND</td>
</tr>
<tr>
<td>Sign Size</td>
<td>18 inch sides *note</td>
</tr>
<tr>
<td>Alphanumeric Type</td>
<td>Series D, E</td>
</tr>
<tr>
<td>Alphanumeric Size</td>
<td>6 inches</td>
</tr>
<tr>
<td>Message Position</td>
<td>Centered top-to-bottom and left-to-right</td>
</tr>
<tr>
<td>Border Width</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics</td>
</tr>
<tr>
<td>Border Placement</td>
<td>Set ½ inch from sign edge</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

#### INDICATION: APPLY BRAKES AT THIS POINT IF STOPPING AT NEXT CROSSOVER LOCATION.

#### REMARKS

**Purpose:**

To identify the point, under normal track conditions, where brakes should be applied to prepare for a stop at next crossover in unsignalized territory.

**Criteria:**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign Placement</td>
<td>To be placed at safe braking distance in approach to signal or fouling point of crossover. Used in line-of-sight territory.</td>
</tr>
<tr>
<td>Horizontal</td>
<td>Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Vertical</td>
<td>Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
</tbody>
</table>

**Notes:**

*Axes of diamond should be equal in length. Sides of sign should be equal length (18”). Line separating “A” and “B” should equal ½ the stroke width of alphanumerics, not to exceed ½ inch. Signs should be installed adjacent to each track for normal and reverse running.*
**WAYSIDE SIGNS - SIGNAL SYSTEM**

**Sign OM-23, BRAKE FOR STATION**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alphanumerics</strong></td>
</tr>
<tr>
<td><strong>Colors:</strong> BLACK</td>
</tr>
<tr>
<td><strong>Border Color:</strong> BLACK</td>
</tr>
<tr>
<td><strong>Background Color:</strong> REFLECTIVE YELLOW</td>
</tr>
<tr>
<td><strong>Sign Shape:</strong> SQUARE</td>
</tr>
<tr>
<td><strong>Sign Size:</strong> 18 inches by 18 inches</td>
</tr>
<tr>
<td><strong>Alphanumerics:</strong></td>
</tr>
<tr>
<td><strong>Type:</strong> Series D *note, C, B</td>
</tr>
<tr>
<td><strong>Size:</strong> 3 inches</td>
</tr>
<tr>
<td><strong>Message Position:</strong> Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td><strong>Border Width:</strong> ½ to ¾ inch or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td><strong>Border Placement:</strong> Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

**INDICATION:** APPLY BRAKES AT THIS POINT FOR MANDATORY STOP AT NEXT STATION.

**REMARKS**

| Purpose: To identify the point, under normal track conditions, where brakes should be applied to prepare for a stop at a mandatory stop station. |
| Criteria: Sign Placement: To be placed at braking distance for a train at a braking rate of 2.75 mphps to stop at the mandatory stop station. |
| **Vertical:** Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed. |
| **Horizontal:** Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed. |
| Notes: * Compress spacing on “BRAKE” by 20 to 25%. |
| Signs installed for normal direction track only. |
### Sign OM-24, END OF WIRE

**DESCRIPTION**

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE YELLOW</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>RECTANGLE *note</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>33 inches by 9 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series C</td>
</tr>
<tr>
<td>Size:</td>
<td>5 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

**INDICATION:** STOP, END OF CATENARY WIRE.

**REMARKS**

**Purpose:** To identify the point on tracks where catenary ends; or locations where the pantograph would come off the wire.

**Criteria:** Sign Placement: (A or B as applicable)

- A. To be placed in catenary structure one car length approaching end of wire condition.

- B. To be placed on a signpost or structure in advance of where the pantograph would lose contact with the catenary wire.

**Notes:** *Rectangle should have long sides horizontal and rounded corners.*
Sign OM-25, BERTHING MARKER

DESCRIPTION

Alphanumerics: REFLECTIVE WHITE
Colors:
Border Color: REFLECTIVE WHITE
Background Color: REFLECTIVE BLUE
Sign Shape: RECTANGLE *note
Sign Size: 8 inches by 12 inches
Alphanumerics:
  Type: Series D
  Size: 8 inches
Message Position: Centered top-to-bottom and left-to-right.
Border Width: ½ to ¾ inch or equal but not to exceed stroke width of alphanumerics.
Border Placement: Set flush with sign edge.

(Drawing not to scale)

INDICATION: STOPPING LOCATION FOR 1, 2 OR 3 VEHICLE CONSISTS.
Numeral indicates berthing position for 1, 2 or 3 vehicle consists.

REMARKS

Purpose: To identify areas in the right-of-way where train of designated consist is required to stop.

Criteria:

Sign Placement: To be affixed to ties by brackets. The locations of berthing markers for stations are noted in the tables.

Vertical: Signage is tilted so base of sign rests flush with tie. Top of signage to be tilted so aligned with top-of-rail but still providing clearance.

Horizontal: To be placed to the fullest extent of the tie.

Notes: * Rectangular to have long sides vertical.
## Sign OM-26, MILE POST MARKER

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>REFLECTIVE WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>RECTANGLE *note</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>8 inches by 24 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series D</td>
</tr>
<tr>
<td>Size:</td>
<td>2 inches to 2 ½ inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set flush with sign edge.</td>
</tr>
</tbody>
</table>

### INDICATION:
Indicates mile location along right-of-way. Letters identify main trunk or branch line section. Numerals indicate tens, units, tenths and hundredths of miles.

### REMARKS

**Purpose:**
To identify mile location along right-of-way.

**Criteria:**

<table>
<thead>
<tr>
<th>Sign Placement:</th>
<th>To be affixed to signal masts, freestanding posts, and tunnel walls as required. To be placed every 0.1 miles in tunnels.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical:</td>
<td>Signage to be placed within maintainers' field of view (approx. 3 to 4 foot height from top-of-rail) except in tunnel areas.</td>
</tr>
<tr>
<td>Horizontal:</td>
<td>Signage on freestanding posts should be placed in-between tracks, except on bridges with center walkways, provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
</tbody>
</table>

**Notes:**
*Mile markers have five total spaces with top space identifying line section using Y = YARD, P = NC-1 & 2, T = TRUNK (OC-1 & 2/CBD), S = SOC-1 & 2, and W = WOC-1 & 2.; remaining spaces indicating tens of miles, unit miles; tenths of a mile; and hundredths of a mile; and whole miles separated from fractional miles section by a horizontal line equal to stroke width of the numerals. For whole miles under ten, the tens space will be blank.*
### Sign OM-27, SHOP TRACK NUMBER

#### DESCRIPTION

| Alphanumerics | REFLECTIVE WHITE |
| Border Color   | N/A               |
| Background Color| REFLECTIVE BLUE  |
| Sign Shape     | SQUARE            |
| Sign Size      | 24 inches by 24 inches |
| Alphanumerics: |                   |
| Type:          | Series E          |
| Size:          | 12 inches         |
| Message Position: | Centered top-to-bottom and left-to-right. |
| Border Width   | N/A               |
| Border Placement: | N/A             |

#### INDICATION: IDENTIFIES MAINTENANCE SHOP TRACK.

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To identify track for use in maintenance shop area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td></td>
</tr>
<tr>
<td>Sign Placement:</td>
<td>To be affixed above shop doors as described in shop design package.</td>
</tr>
<tr>
<td>Vertical:</td>
<td>As per shop design package.</td>
</tr>
<tr>
<td>Horizontal:</td>
<td>As per shop design package.</td>
</tr>
</tbody>
</table>

Notes:
## Sign OM-28, YARD TRACK NUMBER

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>REFLECTIVE WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE *note</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>24 inches by 24 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td>Series D or E</td>
</tr>
<tr>
<td>Type:</td>
<td>Series D or E</td>
</tr>
<tr>
<td>Size:</td>
<td>12 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set flush with sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

### INDICATION: IDENTIFIES YARD SHOP TRACK.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify track for use in yard and vehicle storage area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be hung on span wire above each track.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Determined by catenary wire height.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Above each track as shown in the contract drawings.</td>
</tr>
</tbody>
</table>

Notes:
### Sign OM-28A, TIE-MOUNTED YARD TRACK NUMBER

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>REFLECTIVE WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>RECTANGLE *note</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>12 inches by 14 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series D or E</td>
</tr>
<tr>
<td>Size:</td>
<td>8 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set flush with sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

#### INDICATION:
IDENTIFIES A YARD TRACK NUMBER WITHIN A YARD.

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify track for use in yard and vehicle storage area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be affixed to tie at entrance to yard track.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Bottom edge of sign is at tie elevation. Top of sign is elevated so that sign is at approximately 20 degree incline.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Centered on tie.</td>
</tr>
<tr>
<td>Notes:</td>
<td>* The Rectangle’s horizontal dimension shall be longer than the vertical dimension.</td>
</tr>
</tbody>
</table>
## Wayside Signs - Signal System

### Sign OM-29, Interlocking, Crossover, Grade Crossing, or Substation Identification

#### Description

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphanumeric</td>
<td>Series C or D</td>
</tr>
<tr>
<td>Size</td>
<td>5 inches</td>
</tr>
<tr>
<td>Message Position</td>
<td>Centered top-to-bottom and left-to-right</td>
</tr>
<tr>
<td>Border Width</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Placement</td>
<td>Set flush with sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

#### Indication

Identifies interlocking, crossover, grade crossing, or substation by name.

#### Remarks

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To identify signal bungalow, interlocking, crossover or substation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td>Sign Placement: To be affixed to side of signal bungalow, grade crossing case, or substation, as appropriate.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator's normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: For structures, should be placed as near to trackside as possible. For post mounting, should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes</td>
<td>*Rectangle has long sides horizontal. **Width of sign determined by number of letters utilized.</td>
</tr>
</tbody>
</table>
# Sign OM-30, START TEST ZONE MARKER

## DESCRIPTION

![START TEST ZONE](image)

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>24 inches by 24 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type:</td>
<td>Series C or D</td>
</tr>
<tr>
<td>Size:</td>
<td>5 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

## INDICATION:
IDENTIFIES BEGINNING OF A TESTING ZONE. PROCEED ONLY AS OPERATING RULEBOOK INDICATES.

## REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the beginning of a test zone. Should proceed only as instructed by Operating Rulebook.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed at the starting point of a test zone.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be so that it can be easily staked (approx. 3 to 4 feet from top of rail.)</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage posts should be placed as determined by Test Controller and Operations Personnel in the field.*</td>
</tr>
<tr>
<td>Notes:</td>
<td>*FRA guidelines recommend center track placement but may not apply for all tests due to inadequate clearance.</td>
</tr>
<tr>
<td></td>
<td>Sign is to be used in conjunction with TEMPORARY END TEST ZONE MARKER.</td>
</tr>
<tr>
<td></td>
<td>Mounting will be temporary and sign capable of being staked.</td>
</tr>
</tbody>
</table>
## Sign OM-31 END TEST ZONE MARKER

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alphanumerics</strong></td>
</tr>
<tr>
<td><strong>Colors:</strong> REFLECTIVE WHITE</td>
</tr>
<tr>
<td><strong>Border Color:</strong> REFLECTIVE WHITE</td>
</tr>
<tr>
<td><strong>Background Color:</strong> REFLECTIVE RED</td>
</tr>
<tr>
<td><strong>Sign Shape:</strong> SQUARE</td>
</tr>
<tr>
<td><strong>Sign Size:</strong> 24 inches by 24 inches</td>
</tr>
<tr>
<td><strong>Alphanumerics:</strong></td>
</tr>
<tr>
<td><strong>Type:</strong> Series D</td>
</tr>
<tr>
<td><strong>Size:</strong> 5 inches</td>
</tr>
<tr>
<td><strong>Message Position:</strong> Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td><strong>Border Width:</strong> ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td><strong>Border Placement:</strong> Set flush with sign edge.</td>
</tr>
</tbody>
</table>

### INDICATION:
STOP. PROCEED ONLY AS OPERATING RULEBOOK INDICATES.
Identifies the end point of a test zone.

### REMARKS

| Purpose: | To identify the end of a test zone. Stop; then proceed only as instructed by Operating Rulebook. |
| Criteria: | Sign Placement: To be placed at the end point of a testing zone. |
| | Vertical: Should be so that it can be easily staked (approx. 3 to 4 feet from top of rail.) |
| | Horizontal: Signage posts should be placed as determined by Test Controller and Operations Personnel in the field.* |
| Notes: | *FRA guidelines recommend center track placement but may not apply for all tests due to inadequate clearance. |
| | Sign is to be used in conjunction with TEMPORARY START TEST ZONE MARKER. |
| | Mounting will be temporary and sign capable of being staked. |
### Sign OM-32, SHOP LIMIT

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td>Series C</td>
</tr>
<tr>
<td>Type:</td>
<td>5 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

#### INDICATION: IDENTIFIES START OF SHOP OPERATION LIMITS.

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the start of shop operation and the associated change in operating rules. Differences in shop operations and yard or mainline operations are defined in Operating Rulebook.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed at the insulated joints outside of the apron at the shop tracks. Vertical: Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed. Horizontal: Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td></td>
</tr>
</tbody>
</table>
## Sign OM-33, CHAIN MARKER

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alphanumerics</strong></td>
<td>BLACK</td>
</tr>
<tr>
<td><strong>Colors:</strong></td>
<td>NONE</td>
</tr>
<tr>
<td><strong>Background Color:</strong></td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td><strong>Sign Shape:</strong></td>
<td>RECTANGLE WITH ROUNDED CORNERS</td>
</tr>
<tr>
<td><strong>Sign Size:</strong></td>
<td>4 inches by 28 inches</td>
</tr>
<tr>
<td><strong>Alphanumerics:</strong></td>
<td>Series D</td>
</tr>
<tr>
<td><strong>Type:</strong></td>
<td>2 inches to 2 ½ inches</td>
</tr>
<tr>
<td><strong>Size:</strong></td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td><strong>Message Position:</strong></td>
<td>NONE</td>
</tr>
<tr>
<td><strong>Border Width:</strong></td>
<td>NONE</td>
</tr>
<tr>
<td><strong>Border Placement:</strong></td>
<td>NONE</td>
</tr>
</tbody>
</table>

### INDICATION:
INDICATES CHAIN MARKER ALONG THE RIGHT-OF-WAY IN EACH DIRECTION.

### REMARKS

**Purpose:** To identify location of chain marker along right-of-way in each direction. The signs reflect the engineering stationing.

**Criteria:**

| Sign Placement: | To be affixed to catenary poles at stationings shown in the schedule (Placed approx. every 500 feet.) |
| Vertical: | Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists between LRV and Freight and line-of-sight is unobstructed. |
| Horizontal: | Signage to be affixed to catenary poles as noted in the schedule. |

**Notes:** For each sign legend see the schedule.
## Sign OM-34, GATE IDENTIFICATION

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>REFLECTIVE WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>RECTANGLE*</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>12 inches by 14 inches</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>12 inches by 14 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td>Series D</td>
</tr>
<tr>
<td>Type:</td>
<td>2 inches and 6 inches</td>
</tr>
<tr>
<td>Size:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Message Position:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

### INDICATION: INDICATES GATE LOCATION ON LINE SECTIONS.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify gate location at the stations on each corridor.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be affixed to each gate approx. at stationing shown in schedule.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within personnel and patron normal field of view.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage to be affixed to the gates and centered from left to right.</td>
</tr>
</tbody>
</table>

| Notes: | *Rectangle to have long sides horizontal. |
|        | **Signs shall be mounted back-to-back to be visible from both sides of the gate. |
## Sign OM-35, TWC CALL

### DESCRIPTION

| Alphanumerics: | BLACK |
| Colors: | BLACK |
| Background Color: | REFLECTIVE WHITE |
| Sign Shape: | SQUARE |
| Sign Size: | 18 inches by 18 inches |
| Alphanumerics: | Series D *note, C, B |
| Type: | 2 inches |
| Size: | Centered top-to-bottom and left-to-right. |
| Message Position: | ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics. |
| Border Width: | Set ½ inch from sign edge. |

(Drawing not to scale)

**INDICATION:** INITIATE TWC CALL AT THIS POINT AT STATIONS THAT HAVE LONG PRE-EMPTIONS.

### REMARKS

**Purpose:** To identify location of TWC Call at this point.

**Criteria:**

| Sign Placement: | To be placed in advance of TWC Loop. |
| Vertical: | Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed. |
| Horizontal: | Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed. |

**Notes:** *Compress spacing by 20 – 25% if necessary.*
## Sign OM-36, COAST

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumeric Colors</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>RECTANGLE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>8 inches by 14 inches</td>
</tr>
<tr>
<td>Alphanumeric:</td>
<td>Series E</td>
</tr>
<tr>
<td>Type:</td>
<td>Series E</td>
</tr>
<tr>
<td>Size:</td>
<td>8 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

**INDICATION:** POSITION MAIN CONTROLLER HANDLE TO THE "COAST" POSITION AND COAST UNTIL THE REAR OF THE TRAIN HAS CLEARED INSULATOR.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify point prior to passing through a catenary section insulator for operator to have the main controller handle in the &quot;COAST&quot; position.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td></td>
</tr>
<tr>
<td>Sign Placement:</td>
<td>To be placed on the catenary support structure prior to passing through the insulator.</td>
</tr>
<tr>
<td>Vertical:</td>
<td>Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Horizontal:</td>
<td>Signage should be mounted to the catenary support structure, provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Rectangle to have long sides horizontal.</td>
</tr>
</tbody>
</table>
## Sign OM-37, POWER

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphanumerics</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>RECTANGLE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>8 inches by 14 inches</td>
</tr>
</tbody>
</table>

- **Alphanumerics:**
  - **Type:** Series E
  - **Size:** 8 inches
  - **Message Position:** Centered top-to-bottom and left-to-right.

- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.

- **Border Placement:** Set ½ inch from sign edge.

(Drawing not to scale)

### INDICATION:
POSITION MAIN CONTROLLER HANDLE FROM THE "COAST" POSITION TO THE "POWER" POSITION. INDICATES TRAIN IS CLEAR OF SECTION INSULATOR; RESUME NORMAL OPERATION.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify point where operator is to position the main controller handle to the &quot;POWER&quot; position subsequent to using the &quot;COAST&quot; position to pass through a catenary section insulator.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Criteria:</th>
<th>Sign Placement: To be placed on the catenary support structure. (no less than 98 feet past the insulator, but not more than 150 feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator's normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage should be mounted to the catenary support structure, provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
</tbody>
</table>

| Notes: | *Rectangle to have long sides horizontal. |
**Sign OM-38, BEGIN CAB SIGNAL BLOCK**

### DESCRIPTION

<table>
<thead>
<tr>
<th>Alphaneumics</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Border Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Background Color:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>SQUARE</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>18 inches by 18 inches</td>
</tr>
<tr>
<td>Alphaneumics:</td>
<td>Series D *note, C, B</td>
</tr>
<tr>
<td>Type:</td>
<td>Series D *note, C, B</td>
</tr>
<tr>
<td>Size:</td>
<td>3 inches</td>
</tr>
<tr>
<td>Message Position:</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width:</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement:</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

### INDICATION: ENTERING CAB SIGNAL TERRITORY. OPERATE IN ACCORDANCE WITH ON-BOARD ATP SPEED INDICATOR.

### REMARKS

<table>
<thead>
<tr>
<th>Purpose:</th>
<th>To identify the point where trains operation begins according to Cab signal requirements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be placed at the location of the first track circuit in Cab Signal territory.</td>
</tr>
<tr>
<td></td>
<td>Vertical: Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed.</td>
</tr>
<tr>
<td></td>
<td>Horizontal: Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed.</td>
</tr>
</tbody>
</table>

| Notes: | *Compress spacing by 20 – 25% if necessary. **Signs installed for normal and reverse direction track. |

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DART Standard Specifications – July 2014

16996 - 41
### Sign OM-39, END CAB SIGNAL BLOCK

#### DESCRIPTION

| Alphanumerics | BLACK |
| Colors:       | BLACK |
| Border Color: | REFLECTIVE WHITE |
| Background Color: | SQUARE |
| Sign Shape:   | 18 inches by 18 inches |
| Sign Size:    | Series D *note, C, B |
| Type:         | 3 inches |
| Size:         | Centered top-to-bottom and left-to-right. |
| Message Position: | ½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics. |
| Border Width: | Set ½ inch from sign edge. |

(Drawing not to scale)

#### INDICATION:
ENTERING LINE-OF-SIGHT TERRITORY. OPERATE ACCORDING TO LINE-OF-SIGHT RULES OR CONTROLLER’S INSTRUCTIONS.

#### REMARKS

| Purpose: | To identify the point where cab signal operation end and line-of-sight operation begins. |
| Criteria: | Sign Placement: |
| Vertical: | To be placed at the exit boundary of the last track circuit in Cab Signal territory. |
| Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed. |
| Horizontal: | Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed. |
| Notes: | *Compress spacing by 20 – 25% if necessary. |
| **Signs installed for normal and reverse direction track. |
**WAYSIDE SIGNS - SIGNAL SYSTEM**

### Sign OM-40, EMERGENCY NOTIFICATION

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphanumerics</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Colors</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Border Color</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Background Color</td>
<td>REFLECTIVE BLUE</td>
</tr>
<tr>
<td>Sign Shape</td>
<td>RECTANGLE*</td>
</tr>
<tr>
<td>Sign Size</td>
<td>12 inches by 24 inches</td>
</tr>
<tr>
<td>Alphanumerics:</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Series C</td>
</tr>
<tr>
<td>Size</td>
<td>1.75 inch</td>
</tr>
<tr>
<td>Message Position</td>
<td>Centered top-to-bottom and left-to-right.</td>
</tr>
<tr>
<td>Border Width</td>
<td>½ to ¾ inch, or equal but not to exceed stroke width of alphanumerics.</td>
</tr>
<tr>
<td>Border Placement</td>
<td>Set ½ inch from sign edge.</td>
</tr>
</tbody>
</table>

(Drawing not to scale)

#### INDICATION:

EMERGENCY NOTIFICATION. (Modified TXMUTCD I-13A sign with TCC telephone number.)

#### REMARKS

<table>
<thead>
<tr>
<th>Purpose</th>
<th>To provide emergency notification at grade crossings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria:</td>
<td>Sign Placement: To be affixed below the railroad crossbuck sign (R15-1).</td>
</tr>
<tr>
<td>Vertical:</td>
<td>Should have a minimum mounting height of five feet.</td>
</tr>
<tr>
<td>Horizontal:</td>
<td>Signage to be affixed to the gate mast or flasher mast.</td>
</tr>
<tr>
<td>Notes:</td>
<td>*Rectangle to have long sides horizontal.</td>
</tr>
<tr>
<td></td>
<td>**One sign should be placed for each roadway approach direction.</td>
</tr>
</tbody>
</table>

### Sign OM-41, EMERGENCY NOTIFICATION

#### DESCRIPTION

**REPORT PROBLEMS TO 214-928-6000 CROSSING #XXX-XXXX ON STREETNAME ROAD**

<table>
<thead>
<tr>
<th>Alphanumericss</th>
<th>BLACK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colors:</td>
<td></td>
</tr>
<tr>
<td>Border Color:</td>
<td>BLACK</td>
</tr>
<tr>
<td>Background Color:</td>
<td>REFLECTIVE WHITE</td>
</tr>
<tr>
<td>Sign Shape:</td>
<td>RECTANGLE*</td>
</tr>
<tr>
<td>Sign Size:</td>
<td>12 inches by 24 inches</td>
</tr>
</tbody>
</table>

Alphanumericss:
- **Type:** Series C
- **Size:** 1.75 inch
- **Message Position:** Centered top-to-bottom and left-to-right.
- **Border Width:** ½ to ¾ inch, or equal but not to exceed stroke width of alphanumericss.
- **Border Placement:** Set ½ inch from sign edge.

*Rectangle to have long sides horizontal.
One sign should be placed for each roadway approach direction.

#### INDICATION: EMERGENCY NOTIFICATION. (Modified TXMUTCD R15-4 sign with TCC telephone number and street name.)

#### REMARKS

**Purpose:** To provide emergency notification at grade crossings.

**Criteria:**
- **Sign Placement:** To be affixed below the railroad crossbuck sign (R15-1).
  - **Vertical:** Should have a minimum mounting height of five feet.
  - **Horizontal:** Signage to be affixed to the gate mast or flasher mast.

**Notes:** *Rectangle to have long sides horizontal.
One sign should be placed for each roadway approach direction.*
**Sign OM-42, INTERLOCKING LIMIT**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alphanumeric</strong></td>
</tr>
<tr>
<td><strong>Border Color:</strong></td>
</tr>
<tr>
<td><strong>Background Color:</strong></td>
</tr>
<tr>
<td><strong>Sign Shape:</strong></td>
</tr>
<tr>
<td><strong>Sign Size:</strong></td>
</tr>
<tr>
<td><strong>Alphanumeric:</strong></td>
</tr>
<tr>
<td><strong>Size:</strong></td>
</tr>
<tr>
<td><strong>Message Position:</strong></td>
</tr>
<tr>
<td><strong>Border Width:</strong></td>
</tr>
<tr>
<td><strong>Border Placement:</strong></td>
</tr>
</tbody>
</table>

(drawn not to scale)

**INDICATION: INTERLOCKING LIMIT – PROCEED ON PROPER INDICATION**

**REMARKS**

| Purpose: | To provide operator the designation of interlocking limit. |
| Criteria: | Sign Placement: To be placed approximately (but no greater than) 12 feet in approach to the insulated joints that define the interlocking limit. |
| Vertical: | Should be within Train Operator’s normal field of view (9 feet from top of sign to top of rail), provided adequate clearance exists and line-of-sight is unobstructed. |
| Horizontal: | Signage posts should be placed at 9 feet from the track center, provided adequate clearance exists (including between LRT and Freight) and line-of-sight is unobstructed. |

| Notes: | * Sign nomenclature shall include the direction and track corresponding to the location of the sign, in this example: "North-2" is North end of interlocking on track 2. Bottom line shall be abbreviated interlocking designation and entrance nomenclature. In this example: "MC-2S" is the 2S entrance to Malcolm Interlocking. |
| Signs should be installed adjacent to each track for normal and reverse running. |

END OF SECTION 16996
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work to be done under this Section consists of providing and installing miscellaneous components and products as specified herein and as shown on Contract Drawings.

1.2 REFERENCE STANDARDS

A. American Railway Engineering And Maintenance-of-Way Association (AREMA):
   1. AREMA, Communications & Signals Manual, Part 1
   2. AREMA, Communications & Signals Manual, Part 2
   3. AREMA, Communications & Signals Manual, Part 14
   4. AREMA, Communications & Signals Manual, Part 15

B. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE C37.14 - Standard For Low-Voltage DC Power Circuit Breakers Used In Enclosures

C. National Electrical Manufacturers Association (NEMA):
   1. NEMA 4 - NEMA Standards Publication 250-2003 Enclosures for Electrical Equipment (1000 Volts Maximum)
   2. NEMA 1 - NEMA Standards Publication 250-2003 Enclosures for Electrical Equipment (1000 Volts Maximum)

1.3 SUBMITTALS

A. Submittals shall be in accordance with the requirements of these Specifications.
   1. The Contractor shall submit performance data or a sample for each component or product type proposed as an "approved equal" to the Authority for approval. The Contractor shall obtain Authority's written approval to use equivalent component or product types.

1.4 QUALITY ASSURANCE

A. Miscellaneous components and products shall be inspected prior to shipment. Inspection shall conform to the manufacturers Inspection procedure.

B. Miscellaneous components and products shall meet the requirements of the AREMA Communications & Signal Manual.

C. Each miscellaneous component and product shall be inspected after it has been installed in the field. This inspection shall conform to the Contractor's Installation and Inspection Procedure as approved by the Authority. Installation shall not be considered complete until all installation defects have been corrected to the Authority's satisfaction.

D. Miscellaneous components and products shall be tested according to Authority approved test procedures.

PART 2 - PRODUCTS

2.1 AUTHORITY FURNISHED MATERIAL

A. Not Used

2.2 CONTRACTOR FURNISHED MATERIAL

A. All miscellaneous components and products used on this Contract shall be:
   1. New and free of manufacturing defects.
   2. Clearly and permanently labeled with value or type identification.
   3. All electrical component ratings shall be at least 20 percent greater than the maximum power, voltage, current, and temperature values that are expected for the components in service.

B. Printed Circuit Cards
   1. Printed circuit (PC) cards shall be of glass epoxy construction. Card material shall meet the requirements of NEMA Type FR-4. Cards shall have sufficient thickness to permit easy insertion and removal, and shall be physically keyed to protect against incorrect interchange. Circuits shall be formed by etching. Conductor material shall be copper and shall be protected from exposure to air by a conformal coating.
   2. PC cards containing components that may be damaged when a plug connector or plug-in unit is removed while equipment is energized shall be clearly marked or labeled with a warning label and the PC card shall contain a means to remove power from the cards.
   3. Components mounted on the PC card, weighing more than one-half ounce or with a displacement of more than one-half cubic inch, shall have a mechanical supporting attachment to the card that is separate from all electrical connections.
   4. Stacking or piggybacking of printed circuit card sections on printed circuit cards is not permitted.

C. Printed Circuit Card Connectors
1. Connectors shall have gold plating a minimum thickness of 0.000050 inch.

D. Circuit Breakers, Fuses and Fuse Clips

1. Fuses and circuit breakers shall be of suitable capacities to protect the wiring and the apparatus from the effects of short circuits or overloads. All circuit breakers and fuses shall be in accordance with these Specifications.

2. Circuit fuses shall be non-renewable and of fiber-case, time-lag, fusion type. Circuit breakers and fuses shall be correct size and rating for circuit current interruption and protect electrical equipment and circuits from short-term and long-term overloads.

3. In DC branch circuits, where fusing is impractical, a protective resistance unit shall be provided. All fuses shall be centrally located on power distribution panel and power racks.

4. Fuse clips shall be so constructed to retain their resilience under all installation and service conditions to assure a positive contact between clips and fuse.

E. Diodes

1. All diodes provided under this Contract shall carry a JEDEC number or be available from more than one manufacturer and be used within the published specifications for such number. All diodes shall be silicon type, unless otherwise Authority approved.

F. Resistors

1. All resistors, other than those required for electronic circuits, shall be in accordance with AREMA Communications & Signals Manual, Part 14.2.15.

G. Reactors

1. All reactors, other than those required for electronic circuits, shall be in accordance with AREMA Communications & Signals Manual, Part 14.2.20.

H. Capacitors

1. Capacitors, for electronic circuits, shall be in accordance with the applicable requirements of AREMA Communications & Signals Manual, Part 14.2.40.

I. Signal Terminal Blocks

1. Signal System terminal blocks shall be in accordance with the applicable requirements of AREMA Communications & Signals Manual, Part 14.1.5.

J. Signal Terminal Binding Posts

1. Signal System Terminal binding posts, other than those required for supervisory control circuits, shall be in accordance with AREMA Communications & Signals Manual, Part 14.1.10.

K. Terminal Post Insulators

1. All terminal posts, located on terminal boards in the wayside cases and wayside instrument houses used to terminate 50 Volts or greater, shall be provided with a protective insulator.

2. The type of insulator shall be individual for each terminal post and be fire-resistant.

L. Insulated Test Link

1. Insulated test links shall be in accordance with AREMA Communications & Signals Manual, Part 14.1.15.

M. Lightning Arrestors and Equalizers

1. Lightning arresters and equalizers shall be mounted on three-post porcelain or Authority approved type base in accordance with AREMA Communications & Signals Manual, Part 11.3.1.

N. Terminals for Wires and Cables

1. All solderless terminals shall be in accordance with AREMA Communications & Signals Manual, Part 14.1.1.

2. Terminals shall be of the solderless crimp-on type. Samples of all solderless terminals shall be submitted for Authority approval.

3. All stranded copper wire shall be fitted with an Authority approved terminal at all points where the wires are to be terminated on terminal binding posts.

4. Terminating means shall be of five types:
   a. A lug for terminating heavy wires or signal power wires;
   b. A solderless insulated terminal manufactured by AMP, Inc. under the trade name of "Ring Tongue Plasti-Bond", similar to Catalog Number 35628, or Authority approved equal, for terminating Numbers 16 and 14 AWG stranded wires;
   c. A solderless insulated terminal AMP Catalog Number 35627, or Authority approved equal, for terminating insulated Number 12-10 AWG wires;
d. A solderless insulated terminal AMP Catalog Number 324108 for terminating other stranded vital circuit insulated wires Number 20-16 AWG having a maximum diameter of 0.200 inches or Authority approved equal;
e. A solderless insulated terminal, AMP Catalog Number 320554, or Authority approved equal, for Number 8 studs and AMP Catalog Number 320571 or Authority approved equal, and be provided for one-quarter inch studs for nonvital circuit insulated stranded wires Numbers 16 to 22 AWG having a maximum diameter of 0.125 inches.

5. Where flag type terminals are required, they shall be AMP Catalog Number 322313, for terminating Number 16 AWG and 14 AWG stranded wires or Authority approved equal. Other pre-insulated terminals shall be as described in AMP Product Bulletin Number 109-1 or Authority approved equal.

6. Terminals shall be attached to the conductor ends in a manner that conductor flexibility shall not be impaired and terminal breakage probability will be reduced to a minimum.

7. Terminals shall be installed with a tool made and recommended by the Authority approved terminal manufacturer.

8. Tools shall be equipped with a ratchet device to insure proper terminal indentation and will not release until proper indentation is complete.

9. The Contractor shall provide to the Authority three terminal tools, which are new and unused.

O. Tagging for Cables, Wires, and Equipment

1. Except as otherwise specified in this Section, both ends of each cable, each cable wire and all single wires that terminate in all wayside enclosure and on equipment shall be permanently identified with a tag. Tags shall not obscure connecting links between terminal binding posts. Tags shall be installed so they may be read with a minimum of disturbance of tags and wiring. Each cable conductor shall be identified before applying tag.

2. Tags for wire, cable, transformers identification, resistors, reactors and other components shall meet the following requirements and be Authority approved:

   a. Sleeve Type Tags

   1) Tags for identification of all individual cable conductors and field-installed wires shall be sleeve type as manufactured by Raychem Corporation, Thermofit Marker System (TMS), W. H. Brady Co., Bradsleeve (XB-321,-322,-323), or Authority approved equal. Application of conductor nomenclature shall be in accordance with manufacturer's instructions and result in a permanently bonded and legible identification.

   2) Field change wiring tags for identification shall be wrap around and self-adhesive.

   b. Flat Plastic Tags

   1) Tags for identification of vital relay plug boards, individual transformers, resistors, reactors, terminals and other miscellaneous components shall be the flat plastic laminated type.

   2) Tags shall be 1.5 inches long by 0.75 inch wide with one, 0.3125 inch hole located in the center of the width. Distance from the edge of tag to the hole shall be approximately 0.28125 inch. Untreated tag shall be milk white "vinylite," or Authority approved equal.

   3) Identifying nomenclature space shall allow for three rows of lettering, and the tag material capable of receiving typed-on characters by conventional means. Lettering height shall be not less than 0.125 inch.

   4) After lettering, both face and tag backside shall be covered with a clear plastic "vinylite" coating or Authority approved equal. The coating shall be at least 0.01 inch thick.

   5) Nomenclature applied to tags on entrance racks and boards shall show terminal post identification on the top line. Functional nomenclature shall appear on the bottom line, or, if required, on the middle and bottom lines. Geometry coordinates, such as rack, row and post number, shall identify terminal posts.

   c. Flag Marker Tags for individual wire identification of shelf-mounted relays and wires and conductors in junction boxes shall be miniature locking type flag marker tags.

P. Pressure Sensitive Labels
1. Pressure-sensitive labels bearing the geometric coordinates shall identify the rows and columns on entrance racks.

2. Mark front of relay and rear of plug boards.

Q. Hardware

1. All mounting hardware exposed to the elements shall be hot-dip galvanized or other Authority approved material.
   
a. Galvanizing
      1) Hot dip galvanizing process shall be used. All parts shall be pickled so that scale and adhering impurities will be removed. The zinc coating shall be of commercially pure zinc, continuous, and thorough. It shall not scale or blister or be removable by handling or installation. Finished surface shall be free from fine line cracks, holes, or other indications of faulty galvanizing. It shall be smooth and free from adhering flux and other impurities. Edges and ends of parts shall be free from lumps and globules. Parts shall be coated with at least 2 ounces of zinc per square foot of galvanized surface, after all bending, cutting, drilling, and final fabrication.

b. Bolts in Cast Metal
   1) Any bolt installed in a cast metal assembly shall be coated with “Never-seize” prior to assembly.

R. Special Conduit

1. Flexible Conduit and Hose
   
a. Hose for TWC shall be Braided Cordura Rayon, vari-purpose hose, internal tube neoprene cover, or Authority approved equal. Hose shall be clamped at both ends with stainless steel clamps.

S. Stainless Steel Clamps

1. Hoses shall be clamped at each end using stainless steel clamps.

T. Cabinet Locks, LCP Locks, Padlocks and Keys

1. Cabinet locks, LCP locks, and keys shall be with key change in accordance with the Authority standard for signal equipment requiring cabinet locks and LCP locks. A minimum of 12 keys shall be included for cabinet and LCP locks and 150 keys for each type of signal and switch padlock. The Contractor shall obtain keying information from the Authority to ensure that keying is identical to keying used on the existing system.

2. Padlocks for signal apparatus requiring padlocks shall be as follows, or Authority approved equal:
   


d. Padlocks shall be provided and installed for all housings, doors and signal equipment covers. Switch padlocks shall be provided and installed for operations access side of electric locks, power and hand-throw levers of switch-and-lock movements, and manual control and panel operation.

e. All padlocks shall be stamped with the Authority logo and inscribed with the words "Property of Dallas Area Rapid Transit."

U. Sealing Compound

1. Sealing compound for use in sealing cable entrances shall be in accordance with AREMA Communications & Signal Manual, Part 15.2.15.

V. Paint and Finish

1. Signal equipment paint and painting procedures shall be provided and applied in accordance with AREMA Communications & Signal Manual, Part 2.4.30.

W. Cable Entrance Conduits

1. Cable entrance conduits for ground-mounted wayside signal cases shall be four inch galvanized steel, three feet six inches long, threaded on one end, reamed and chamfered and provided complete with one locknut and one
bushing for each conduit. One spare entrance conduit assembly shall be provided for each ground mounted wayside case.

2. Cable entrance pipes for ground-mount signal instrument houses shall be galvanized rigid steel (GRS) conduit running directly between the house and the nearest manhole or as approved by the Authority. Two spare conduits shall be provided and installed within each Signal Equipment Enclosures or Central Instrument House (CIH).

X. Rubber Mats
1. Rubber mats shall be provided for installation in the Signal Instrument House. Rubber mats shall meet the applicable sections of IEEE C-37-14 and NEMA-Standard 1CS-1970.

Y. Switch Circuit Controllers
1. Switch Circuit Controllers shall be GRS Model 7, US&S Co. Model U-5, Safetran Systems Corporation SSC-402, or Authority approved equal.
2. The Contractor shall submit switch circuit controller layout drawings for Authority approval. If a switch circuit controller layout comprises a portion of a larger layout that requires a drawing submittal, switch circuit controller layout submittal may be considered as a part of the total drawing submittal.
3. Switch circuit controller layouts shall be provided and installed complete with connecting rod, switch point lug, cable entrance, all bolts, nuts, washers, and fastenings.

Z. Lubrication
1. Switch tie plates lubrication for all switch-and-lock movement layouts shall be an Authority approved graphite lubricant, similar to Dixon’s Graphite “Railroad 60” or Authority approved equal.

AA. Train Stops
1. All train stops not made of cast aluminum shall be painted black.

BB. Environmental Protection
1. Protection for machined-finished surfaces, threaded rods and nuts and other parts that are susceptible to rusting shall be a corroding preventive compound, NO-OX-IDE Number 90918, or Authority approved equal. The product must have sufficient body to resist weather and rusting for at least six months.
2. Two gallons or equivalent weight shall be provided to the Authority as a deliverable.

CC. Trench Marker Tape
1. The Contractor shall provide and install trench marker tape for signal cable, bright yellow, six inches wide and continuously coded in black lettering with the following legend:

CAUTION CAUTION CAUTION BURIED SIGNAL CABLE

DD. Tamper-Proof Bolts
1. Equipment with covers that are not furnished with locks shall have at least one tamper-proof bolt per cover. The Contractor shall provide six tools for each type of bolt keying to the Authority as a deliverable. The Contractor shall provide tamper proof bolts compatible with those used on Authority’s existing system.

EE. Maintenance Materials:
1. Two rectifiers of each type and rating used in the system, including those normally considered an internal component of any given equipment.
2. Twenty fuses and 10 circuit breakers of each type and rating used in the system, including those normally considered an internal component of any given equipment.
3. Eight terminal strips of each type complete with hardware.
4. Thirty wire connectors of each type and size used in the system, including all multi-conductor connectors with hardware.
5. Two dozen of each type of hardware used, such as nuts, washers and screws.
6. One transformer of each rating used in the system.
7. Two of each type Printed Circuit (PC) card used in the signal equipment supplied under this Contract, but not mentioned elsewhere.
8. Three of each type of power supply, inverter, battery and battery charger supplied under this Contract.
9. Two of each type card extender for each type electronic equipment provided under this Contract.
10. One thousand feet of each type of wire and cable used.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All material and apparatus specified shall be installed in accordance as described in these Specifications.
PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16997
SECTION 16998
TEST AND INSPECTION - SIGNAL SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Work to be done under this Section consists of tests and inspections that shall be performed to demonstrate that the systems, subsystems, assemblies, subassemblies and components provided under this Contract are in compliance with these Specifications.

B. Work shall include conductor disconnecting and reconnecting as required for testing.

C. Contractor shall perform all Work related to assisting Authority Corrosion Testing when the testing relates to Signal System components.

1.2 REFERENCED STANDARDS

A. American Railway Engineering And Maintenance-of Way Association (AREMA)

1. Communications and Signals Manual of Recommended Practice (C&S Manual)

B. National Institute of Standards and Technology (NIST)

1.3 SUBMITTALS

A. General Test Submittal Requirements

1. Contractor shall provide certified test results for all required tests. Contractor’s test program manager, the individual performing the test, and all witnesses shall sign all test results.

2. Test reports shall record each instrument’s calibration date and calibration expiration date. A certified metrology laboratory that maintains National Institute of Standards and Technology (NIST) traceability shall perform instrument calibration. Calibration shall be maintained as specified by each instrument’s manufacturer. Out-of-calibration instruments will be considered non-certified. Tests conducted with non-certified instruments will be summarily rejected.

3. Contractor’s engineer shall review all test reports prior to submittal to the Authority.

4. Any tests not described in these Specifications and required by the Contractor’s design to ensure safe operation or required reliability of the system shall be identified by the Contractor during the preliminary design review and included in the Test Program Plan.

B. Test Program Plan

1. Contractor shall submit for Authority approval, a Test Program Plan that includes:

a. A flow diagram indicating the logical sequence of tests, starting with Qualification Tests and ending with Integrated Testing.

b. A list of test procedures in test procedure number order and a brief test description.

c. A preliminary tests schedule that shows each test for each location with start and finish dates. The schedule portion of the Plan shall be a dynamic document that the Contractor updates monthly as the program progresses.

d. An organization chart and description of the Contractor’s in-house and field test organization.

e. Requirements and recommendations for witnessing by the Authority.

2. Qualification Test Procedures: Contractor shall submit for Authority approval, Qualification Test documentation. Documentation shall include either Qualification Test procedures or prior Qualification Test Results, as applicable.

3. Qualification Test Results: Contractor shall submit for Authority approval, completed Qualification Test Results for that equipment type.

4. Manufacturing Test Procedures: Contractor shall submit procedures for component Manufacturing Test as described in the Authority approved Test Program Plan.

5. Manufacturing Test Results: Contractor shall submit for Authority approval, completed component Manufacturing Test Results.

6. Factory Test Procedures: Contractor shall submit for Authority approval Factory Test Procedures for the sub-system or control point

7. Factory Test Results: Contractor shall submit for Authority approval, completed tested equipment Factory Test Results.

8. Installation Test Procedures: Contractor shall submit for Authority approval,
completed Installation Test procedures for the equipment type to be installed.

9. Installation Test Results: Contractor shall submit for Authority approval, completed Installation Test Results for the test.

10. Field Test Procedures: Contractor shall submit for Authority approval, Field Test Procedures for the system portion to be tested.

11. Field Test Results: Contractor shall submit for Authority approval, completed Field Test results for all tests at that location. Individual Field Test results shall not be submitted without prior Authority approval.

12. Integrated Test Procedures: Contractor shall submit Integrated Test Procedures for Authority approval.

13. Integrated Test Results: Contractor shall submit Integration Test results for Authority approval.

14. Final Test Certification: Prior to placing any Project section into service, the Contractor shall submit a letter signed by the contract's authorized representative wherein the Contractor shall certify that all section tests have been performed and all results and measurements are within Authority approved engineered values.

E. All Authority approved system and subsystem tests to demonstrate that installation meets these Specifications and design requirements shall be completed prior to any operational testing of systems or subsystems.

F. The Authority retains the right to witness all field tests. The Authority shall be notified in writing at least 48 hours prior to each field test. No part of the signal system shall be placed in service without the Authority being present and witnessing in-service tests.

G. Work shall include all tests required to ensure systems and subsystems proper and safe operation and to prove the total installation adequacy and acceptability. Tests to be performed shall cause each system and subsystem to be sequenced through its required operations, including imposition of simulated conditions to prove that installation complies with all specified fail-safe requirements.

H. In event of design errors or failure to meet these Specification requirements or any design or installation corrections, all tests or retests to prove compliance, and any required regression testing shall be included in the Work at no additional cost to the Authority.

I. Inspection and Tests shall meet the requirements of the AREMA C&S Manual.

PART 2 - PRODUCTS

2.1 AUTHORITY PROVIDED MATERIAL

Not Used

2.2 CONTRACTOR PROVIDED MATERIAL

A. Site Test Equipment and Materials

1. All test instruments and equipment required to conduct tests shall be available, ready-for-use not less than 1 week in advance of test date. Ready-for-use shall mean properly matched for test parameters, properly calibrated, sufficiently supplied with leads, probes, adapters, and stands, as required to conduct a particular test.

2. All temporary or interim test-related materials, special tools, connections, jumpers, shall be provided by the Contractor and available not less than 1 week in advance of test date.

B. Test Procedures: All test procedures shall be performed on standard forms that include, as a minimum, fields for the following:

1. Procedure Number and Revision

2. Test Location

3. Test Date
4. Test Objective

5. Test Prerequisites

6. Software Version(s)

7. Test equipment, manufacturer, model number, calibration and calibration expiration dates of each test equipment item that requires NIST traceability

8. Equipment or resources required from other sources outside of the Contractor's organization.


10. Personnel required to perform the test.

11. Test Set-up

12. Temporary connections or modification required to perform the test.


14. Anticipated results for each procedure step.

15. Pass/fail criteria for each procedure step.

16. Pass/Fail Notation and Remarks

17. Tester Signature

18. Signature of Tester certifying that all temporary connections or modifications have been restored.

19. Completion Date

20. Tester's Additional Comments

21. Witness printed and signature blocks with an appropriate block for the Authority, supplier, and Contractor.

22. Where required, attached Results Tables

C. Test Results

1. Submit test results for each test activity.

2. Original test results shall contain the original test forms filled out by the person(s) performing the tests, and original signatures.

3. Unless otherwise specified, submit within 7 days of test completion.

4. Blue ink shall be used to complete all test form entries.

5. Errors shall be crossed out with a single line and initialed by the person making the correction.

6. Test results shall include test procedure forms with all fields completed. Fields that are not applicable shall be marked Not Applicable or N/A.

7. Test results shall be submitted with a Test Summary Sheet that includes, as a minimum, the following:
   a. Test Number and Revision
   b. Interim test date if not completed
   c. Test Completion Date
   d. Narrative Summary of the Test Results
   e. Listing of any procedure failures, observations and procedure field modifications.
   f. Signature of the Contractor's Testing Manager
   g. Additional Comments

8. Unless otherwise approved by the Authority, tests in which one or more procedures have failed shall be repeated in their entirety.

D. Regression Testing: Contractor shall identify and be responsible for any regression testing required due to software changes after the test program has started.

E. Prior to commencement of regression testing, the Contractor shall submit a list of tests and/or procedures that require re-testing. Contractor shall also submit a revised test schedule for Authority approval.

PART 3 - EXECUTION

3.1 QUALIFICATION TESTS

A. Contractor shall perform Qualification Testing on all equipment to verify that the equipment complies with these Specifications, the specified design, and environmental requirements.

1. Qualification tests shall ensure that vital components function in a manner required for fail-safe operation. Testing shall include a full range of interface failures to the tested equipment.

2. Qualification tests shall ensure proper operation over the temperature, humidity, vibration and shock ranges expected for a rail application in the Dallas area.
B. Qualification tests may not be required for unmodified equipment that has a proven service record in a similar operating environment. In lieu of qualification testing, the Contractor shall submit documentation of prior qualification testing.

3.2 MANUFACTURING TESTS

A. Manufacturing tests shall be performed on each first article equipment type and subsequently at frequencies identified in the Authority approved Test Program Plan.

B. Manufacturing tests shall prove that the product is within acceptable physical and operating tolerances. Where practicable or industry practice, test results shall be affixed to the product.

C. Vital Relay Tests: Prior to factory test of a location, manufacturing tests shall be completed for all associated DC vital relays in accordance with AREMA C&S Manual Part 6.4.1 and manufacturer's recommendations. All associated AC vital relays shall be tested in accordance with AREMA C&S Manual Part 6.4.5 and manufacturer's recommendations.

3.3 FACTORY TESTS

A. Contractor shall provide written confirmation that all required systems, subsystems, assembly, and sub-assembly factory tests were successfully performed. These tests shall verify design, nameplate ratings, and compliant performance with these Specifications.

B. Instrument Houses and Wayside Cases: Each instrument house, wayside case or equipment enclosure shall be wired complete with all equipment installed at the point of assembly. A wiring verification and operational test shall be conducted in accordance with the Authority approved circuit plans. Functions external to the housing shall be simulated where required.

1. Energy distribution tests shall include the following:
   a. All fuses shall be removed and breakers opened.
   b. Verify each fuse and circuit breaker size with that on Authority approved circuit plans.
   c. All energy distribution shall be checked using resistance test instruments acceptable to the Authority to verify agreement with Authority approved plans.
   d. Verify wire gauge with that called for on Authority approved circuit drawings. All discrepancies in wire sizes shall be replaced with proper size wire.
   e. Each energy buss shall be electrically independent and tested against all other energy busses to ensure that no electrical short circuits exist.

2. Wiring verification test: All circuitry shall be checked for accuracy against Authority approved circuit drawings. Tests may be performed with energy on or off and shall verify the following:
   a. Point-to-Point Wiring
   b. During the wire verification test, a wire count on each terminal, relay contact, and junction point shall be performed to ensure that only the correct wire count cited on the Authority approved circuit plans is present at each terminal, relay contact, or junction point. Any discrepancies found shall be corrected.
   c. Verify tags and nomenclature.
   d. Verify that all components are as shown on Authority approved circuit drawings and located in proper positions.

3. Vital circuit tests shall be conducted with energy on during simulation testing.
   a. All vital circuits shall be tested to ensure the opening of each contact in a circuit cuts current to the controlled device.

4. Interlocking Tests, (Vital Processor): Contractor shall simulate all operating conditions to ensure each circuit function is in accordance with these Specifications. Functions tested shall include the following:
   a. Time Locking
   b. Route Locking
   c. Detector Locking
   d. Time Release Settings Verification
   e. Proper energy polarity that will interconnect with the existing and new circuitry outside the housing or case tested.

5. Adjustments and defect corrections in house wiring shall be installed as required to obtain proper operation.
6. All required design changes to obtain proper operation shall be submitted for Authority approval.

C. Instrument Racks

1. Instrument rack components and equipment for local control panel shall be wired with all equipment installed at the point of assembly. Racks shall be interconnected in accordance with Authority approved installation drawings. All system functions shall be simulated to determine that each function operates as required.

2. Adjustments and defect corrections in rack wiring shall be made as required to obtain proper operation.

3. All design changes required to obtain proper operation shall be documented and submitted for Authority approval.

3.4 INSTALLATION TESTS

A. Installation Tests shall prove that each equipment item is installed according to Authority approved installation drawings within acceptable physical tolerances.

B. Installation quality is subject to visual inspection.

C. Installation tests shall include inspection to ensure equipment is installed plumb and level where required, and that equipment is free of damage.

D. Inspections shall include reporting of scratches, dents, rust or poor paint quality. These tests shall be performed prior to any systems or subsystems Field Testing.

E. Prior to any Work that conceals an installation, the Authority shall witness the equipment Installation Test unless otherwise directed by the Authority.

3.5 FIELD TESTS

A. Field tests performed shall cause each installed system and subsystem to be sequenced through its required operations, including imposition of simulated conditions to demonstrate that installation complies with all specified fail-safe design requirements and operational functions.

B. Should an error be discovered during field testing due to field wiring and connections that do not agree with Authority approved circuit plans, the Contractor may correct such errors without prior Authority approval. Contractor shall not, however, make any changes which affect safety of operation on Authority approved circuit(s) as designed without prior and written Authority approval.

C. The Authority will make all final determinations as to whether only a part, or the whole test, shall be rerun when any field test results do not meet requirements specified for the test. Re-testing of tests shall be at no additional cost to the Authority.

D. Any changes made after completion of a test procedure shall require that the Contractor perform a retest and related regression testing in accordance with the applicable test procedure(s).

E. General Field Tests shall include the following:

1. Ground Verification test

2. Power racks - Energy Distribution System and Failure Alarm Checks

3. Breakdown test of all vital circuitry.

4. Nonvital circuitry wiring verification.

5. Line circuit verification between wayside instrument houses.

6. Vital Function Tests

7. Operating Tests

8. All applicable tests prescribed by AREMA C&S Manual Part 2.4.1.

F. Specific Field Tests shall include:

1. Energy Distribution

   a. Energy-Off Tests: With all power to wayside instrument house or case off, the following checks and tests shall be performed.

      1) All fuses shall be removed and breakers opened.

      2) Verify circuit breaker size compares to that on Authority approved circuit plans.

      3) All energy distribution shall be checked, using resistance test instrument acceptable to the Authority, to verify agreement with the Authority approved plans.

      4) Compare wire gauges with those on Authority approved circuit drawings. Discrepancies in wire sizes shall be replaced with the proper size.

      5) During energy distribution breakdown, a wire count on each junction shall be performed to ensure that only the correct wire count cited
on Authority approved circuit plans is present at each junction. Any discrepancies found shall be corrected and additional wires, if found, removed.

6) Tags shall be verified for proper nomenclature and terminal location.

7) Each energy buss shall be tested against all other energy busses to ensure that the busses are electrically independent and no crosses exist.

b. Energy-On Tests: Upon completion of energy-off tests, the following checks and tests shall be performed.

1) Insert fuses for power supply feeds and verify proper size according to Authority approved circuit drawings.

2) Turn on energy feeds and test operation of power transfer for proper operation.

3) Each AC voltage input shall be measured and recorded.

4) Each power supply or charger output voltage shall be measured and recorded.

5) Verify that designed voltage is present at all distribution points.

6) Check circuit power failure alarms and all other alarms that indicate to Train Control Center (TCC).

2. Circuit Continuity Tests: All Contractor installed wire and cable shall be tested to verify continuity of each conductor and that each conductor is connected to the proper terminal as shown on Authority approved drawings. Where parallel circuits exist, each parallel path shall be tested independently to verify path continuity.

3. Vital and Nonvital Circuit Breakdown: All circuits shall be checked for compliance with Authority approved circuit drawings. Tests may be performed with energy on or off and shall verify:

a. Point-to-point wiring.

b. A wire count of all field-installed wires shall be performed for each junction to ensure that only the correct wire count cited on Authority approved circuit plans is present. Any discrepancies found shall be corrected.

c. Verify tags and nomenclature.

d. Verify that all components are the same as on Authority approved circuit drawings and located in proper positions.

4. Breakdown of Control Circuits

a. All circuits shall be tested in their entirety for correct operation and response to each contact on each circuit element, such as relays and contactors. Where parallel paths exist, tests shall validate each path and circuits opened, when required, to ensure proper test.

b. Contractor shall simulate all operating conditions to verify that each energy circuit operates in accordance with these Specifications and Authority approved plans.

5. Line Circuits: The purpose of this test procedure shall be to verify the integrity of line circuits between wayside locations. All nomenclature shall be verified and line circuits tested for continuity.

6. Traffic Circuits. The purpose of this test procedure shall be to verify the integrity of traffic circuits between interlocking locations. These tests shall include:

a. Traffic direction shall be tested by first establishing each direction of traffic and then sequentially de-energized each individual track circuit from headblock to headblock and observing that traffic cannot be reversed.

b. Once traffic is established, an attempt shall be made to clear all possible conflicting routes and ascertaining that neither the conflicting route can be cleared nor can the established direction of traffic be affected.

c. Each block repeater relay shall be tested to determine that it follows all the proper track relays opened in wayside instrument housings.
d. With an established direction of traffic, the controlled signal governing entrance to that particular route shall be put to stop with the approach track circuit occupied. It shall not be possible to establish traffic in the opposite direction until a predetermined time has passed. This predetermined time shall be as indicated on Authority approved plans. It shall be ascertained that approach or time locking is effective for this test.

7. Interlocking Tests

a. A detailed test inventory and complete test procedures shall be submitted for Authority approval. These procedures shall be used to test safe and proper operation of interlockings. Test sequences shall be designed to demonstrate each function for correct performance in accordance with these Specifications and Authority approved plans. Furthermore, test sequences shall include simulated unusual conditions to determine that interlocking circuits will respond in a predictable, safe, and Specification compliant manner. When performing Switch Indication Locking, the signal should drop red with a route lined and when switch being tested is placed in hand operation.

b. Functions to be tested shall include:

1) Approach Locking
2) Time Locking
3) Route Locking
4) Verification of timing on time releases.
5) Detector locking
6) Signal operation in accordance with route and aspect charts.

c. Time tests shall be as follows:

1) Loss of Shunt
2) Approach and Time Locking
3) Flashing Rate Time

8. Route Security Locking: Each route shall be tested for route security. This test shall be performed by establishing the routes and falsely energized the route check relay for each opposing or conflicting signal while observing that the associated signals stay at STOP and the associated signal clearing relays remain de-energized.

9. Insulated Joint Tests

a. Each running rail insulated joint, gauge plate, switch rod, throw rod and circuit controller rod shall be tested by the ratio method using a track quality meter. The track quality meter shall be manufactured by Alstom Signaling (formerly General Railway Signal Company), or Authority approved equal. With a standard 1000 ohm resistor placed across the joint and with track circuit current supplied by the track quality meter, the ratio between the current flowing through the insulated joint and the current flowing through the standard resistor shall be determined by use of the track quality meter current probe. Utilizing this ratio, calculations shall be made by an Authority approved formula to determine the insulated joint resistance.

b. If the resistance is less than 5000 ohms, the insulated joint will be regarded as defective and the Contractor shall notify the Authority. Following the Trackwork Contractors repair or replacement of the joint, the Contractor shall re-test the joint at no additional cost to the Authority.

c. Contractor shall verify that power frequency track circuit polarity stagger is correct by applying a direct shunt diagonally across insulated joints, from the West rail of one circuit to the East rail of an adjacent circuit. Contractor shall verify that the Track circuits indicate occupied when the shunt is applied. (This test is not required for the one end of the pocket track where 2 transformer ends of adjacent track circuits have the same polarity.)

10. Power Tests. The following power tests shall be performed and recorded:

a. Main power feeder voltage shall be measured and recorded.

b. A check of all fuses shall be performed for capacity and type.

c. All power supplies, battery chargers, and batteries shall be checked for correct setting and quantities.
d. Buss-to-buss checks shall be made to determine that no shorts, crosses, or grounds exist.

11. AHCW Tests

a. General
   1) Standby battery power source shall be at fully charged.
   2) Verify function on all manual test switches, cutout pushbuttons and starting pushbuttons.
   3) Verify that the instrument case, flasher and gate equipment are properly installed, grounded, clean and lubricated.
   4) Wiring resistance between crossing gate mechanism and battery terminals shall not exceed 0.1 ohm.

b. Flashing light: Perform tests and inspection to verify that:
   1) Individual light units are arranged to shine in both directions along the highway, are mounted horizontally 2'-6" on center and the center of the lenses are not less than 8'-4" above the surface of the highway.
   2) Lamps flash alternately with a 50 percent duty cycle each and there are between 40 and 55 flashes per minute per lamp.
   3) Each lamp's voltage is set in accordance with manufacturer's specifications.
   4) Phantom indications have been eliminated.
   5) With flashers operating, each flasher is aligned to provide unobstructed view in accordance with AREMA requirements.
   6) The associated bells operate at the same time the flashing lights are enabled.

c. Crossing Gates: Perform tests and inspection to verify that:
   1) Each gate arm is equipped with a minimum of 3 red light units arranged to shine in both directions along the highway. Pedestrian gates shall be equipped with 1 red light.
   2) The gate when in the raised position, does not obstruct highway traffic and has sufficient clearance of overhead wires and structures.
   3) The gate start to down in not less than 3 or more than 5 seconds after the flashing light signals are activated.
   4) Gates reach the horizontal position in not less than 10 seconds or more than 15 seconds after initial motion begins.
   5) Maximum time to reach the horizontal position does not exceed 20 seconds from the time the flashing lights are first activated.
   6) Gates reach the vertical position in not less than 8 seconds or more than 12 seconds.
   7) The torque with the gate in the horizontal position is not less than 50 foot-pounds. The torque with the gate in vertical positions not less than 175 foot-pounds for arm lengths up to 25 feet and increasing linearly to 360 foot-pounds for 38-foot arms.
   8) There is no oil, grease or dirt on the armature or pole faces of the held-clear magnet.
   9) Circuit controller contacts are clean and properly adjusted.
   10) Gate do not droop more than 1 inch below horizontal when down, and gate and counterbalance do not strike any object during any portion of their travel or when in the vertical position.
11) Clutch slippage has been adjusted to manufacturer's specifications.

12) Flashing lights are activated at all times except when the gates are locked in the vertical position. Bell will sound when the lights begin flashing and continue to sound until the gate arm has descended to within 10 degrees of the horizontal position.

13) When the gate arm is physically prevented from moving while being raised or lowered or when in any fixed position, the gate operating mechanism will stop without damage to the mechanism or motor.

12. Overlay Track Circuit Tests
   a. Test overlay track circuit to ensure proper design, installation and adjustment.
   b. For each track circuit, perform tests to determine the effectiveness of the filtering. With the transmitter disabled, measure any harmonic noise or crosstalk interference at the receiver to verify compliance with maximum crosstalk level and EMI rejection requirements.
   c. After adjustment, test all track circuits as follows: With a 3 ohm per thousand feet simulated ballast leakage, the track circuit shall de-energize when shunted with a 0.02 ohm shunt 3 feet beyond the receiving end. Place the 0.02 ohm shunt 10 feet beyond the receiving end, the track circuit shall remain energized.
   d. All tests and normal operating parameters shall be recorded for each track circuit. These records shall be submitted for approval.

13. Electromagnetic Compatibility: Perform tests required to demonstrate compliance with electromagnetic compatibility criteria in accordance with Section 16878.

14. Magnetic Train Stop Operating Test
   a. When the electromagnetic is de-energized, verify that train stop subsystem causes the train to apply its service brakes in order to come to a complete stop after passing a stop signal in the direction of that signal.

1) Clear the signal controlling the train stop under test to an aspect less restricting than stop.

2) Move the train past signal under test until the train has completely cleared the track circuit in advance of such signal. Verify the train successfully completes its move without service brake application.

3) Run the train beyond the signal in reverse direction. Verify that the train successfully completes its move without service brakes application.

4) With the same signal at stop, run the train past the signal at stop. Verify that service brakes are applied after passing over the train stop.

b. Tests shall be required at all magnetic train stops in both directions on each track.

15. Switch Indication Locking Tests: This test shall be performed by establishing a route and placing the switch in hand operation mode while observing the associated signal drops to STOP (red) with the switch contacts in the open position.

16. Train-to-Wayside Communications (TWC)
   a. A test train shall be used to test all function at each TWC location.
   b. At the TWC loop under test activate a TWC function and verify that the proper TWC function relay is energized in the CIH or equipment case.

3.6 INTEGRATED TESTS

A. In accordance with these Specifications, the Contractor shall provide procedures, personnel, test equipment, and material to perform Integrated Testing.

B. Integrated Testing shall include:
   1. Safe Braking Tests
   2. Control Line and Line Circuit Verification Tests
TEST AND INSPECTION - SIGNAL SYSTEM

3. Signal Sighting Tests
4. Train Stop Verification Tests
5. Interlocking Operating Tests
6. Train-to-Wayside Communication Tests
7. Data Communications Tests
8. Automatic Crossing Warning System Tests
9. Other System Dynamic Tests, as required.

C. System Demonstration Testing

D. Contractor shall support the Authority’s System Integration testing.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

A. The Work specified in this section will not be measured separately for payment.

4.2 PAYMENT

A. All costs connected herewith will be considered incidental to the work specified under Section 16901 “Signal System Basic Technical Requirements.”

END OF SECTION 16998
## RECORD OF PROFESSIONAL REVISIONS
### FACILITIES & SYSTEMS STANDARD SPECIFICATIONS
#### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>DART Standard Specifications – May 2016 Standard Revisions TC - 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conformed DART Standard</td>
</tr>
</tbody>
</table>

### DIVISION 1 - GENERAL REQUIREMENTS

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Section Title</th>
<th>Conformed Date</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
</tr>
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<td>01630 - Product Substitution Procedures</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>02271 - Ditch Lining and Slope Protection</td>
<td>September 2004</td>
<td>September 2014</td>
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</tr>
<tr>
<td>Table of Contents</td>
<td>Conformed DART Standard</td>
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</tr>
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<td>September 2004</td>
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<td>July 2006</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>May 2016</td>
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<td>September 2014</td>
<td>May 2016</td>
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<td>September 2004</td>
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<td>-</td>
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<td>September 2014</td>
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<td>July 2006</td>
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<td>July 2006</td>
<td>September 2014</td>
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<td>September 2004</td>
<td>September 2014</td>
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<td>September 2004</td>
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<td>Right-Of-Way Safety Signs</td>
<td>September 2004</td>
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<td>Precast Parking Bumpers</td>
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<td>Modular Retaining Wall Units</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Prefabricated Block Retaining Wall System</td>
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<td>Landscaping - General</td>
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<td>Seeding and Sodding - Irrigated Areas</td>
<td>September 2004</td>
<td>September 2014</td>
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</table>
### Record of Professional Revisions

**Facilities & Systems Standard Specifications**

**Table of Contents**

#### Division 3 - Concrete

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<td>September 2004</td>
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<td>Portland Cement Concrete</td>
<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2014</td>
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<td>September 2014</td>
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<td>September 2004</td>
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<td>Glass-Fiber Reinforced Precast Concrete</td>
<td>July 2006</td>
<td>September 2014</td>
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<td>September 2014</td>
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#### Division 4 - Masonry

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<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
<td>September 2014</td>
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<td>Stone</td>
<td>September 2004</td>
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<td>September 2004</td>
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<td>Amended 2016</td>
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<td>September 2004</td>
<td>September 2014</td>
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<td>March 2006</td>
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<td>March 2006</td>
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<td>05126 - Overhead Contact System Steel Tubular Poles</td>
<td>March 2006</td>
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<td>05130 - Structural Steel - Buildings</td>
<td>September 2004</td>
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<td>05135 - Architectural Exposed Structural Steel</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>05430 - Slotted Channel Framing</td>
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<td>September 2004</td>
<td>September 2014</td>
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<td>05510 - Metal Stairs</td>
<td>September 2004</td>
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<td>05520 - Metal Railings</td>
<td>September 2004</td>
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<td>July 2006</td>
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<td>06100 - Rough Carpentry</td>
<td>September 2004</td>
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<td>06410 - Custom Cabinetwork</td>
<td>September 2004</td>
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<td>07120 - Sheet Waterproofing</td>
<td>September 2004</td>
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<td>September 2004</td>
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<td>September 2004</td>
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<td>07140 - Metallic Waterproofing (WITHDRAWN)</td>
<td>September 2004</td>
<td></td>
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<td>07141 - Cold Fluid-Applied Waterproofing</td>
<td>July 2006</td>
<td>September 2014</td>
<td></td>
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<td>07150 - Dampproofing</td>
<td>September 2004</td>
<td></td>
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<td>07210 - Building Insulation</td>
<td>September 2004</td>
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<td>07410 - Metal Roofing</td>
<td>September 2004</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
# Table of Contents

## DART Standard Specifications – May 2016

### Conformed DART Standard

<table>
<thead>
<tr>
<th>Division</th>
<th>Specification</th>
<th>Conformed Date</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
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<tr>
<td>07531</td>
<td>Single-Ply Membrane Roofing</td>
<td>September 2004</td>
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<td>May 2016</td>
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<td>Flashing and Sheet Metal</td>
<td>September 2004</td>
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<td>07840</td>
<td>Firestopping</td>
<td>September 2004</td>
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<td>Seals and Sealants</td>
<td>September 2004</td>
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### DIVISION 8 - DOORS AND WINDOWS

<table>
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<th>Division</th>
<th>Specification</th>
<th>Conformed Date</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
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<td>08115</td>
<td>Hollow Metal Doors and Frames</td>
<td>September 2004</td>
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<td>Access Doors and Frames</td>
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<td>Aluminum-Framed Windscreens</td>
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<td>Door Hardware</td>
<td>September 2004</td>
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<td>Glass and Glazing</td>
<td>September 2004</td>
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<td>May 2016</td>
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<td>08835</td>
<td>Decorative Plastic Glazing</td>
<td>July 2006</td>
<td>September 2014</td>
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<td>08913</td>
<td>Glazed Aluminum Elevator Enclosures</td>
<td>September 2004</td>
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</tr>
</tbody>
</table>

### DIVISION 9 - FINISHES

<table>
<thead>
<tr>
<th>Division</th>
<th>Specification</th>
<th>Conformed Date</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
</tr>
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<tbody>
<tr>
<td>09253</td>
<td>Gypsum Sheathing</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Gypsum Board Assemblies</td>
<td>September 2004</td>
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<td>Ceramic Tile (WITHDRAWN)</td>
<td>September 2004</td>
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<td>Acoustical Panel Ceilings</td>
<td>September 2004</td>
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<td>Acoustical Snap-In Metal Pan Ceilings</td>
<td>September 2004</td>
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<td>09660</td>
<td>Resilient Flooring</td>
<td>September 2004</td>
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<td>09663</td>
<td>Static Dissipative Resilient Flooring</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>09920</td>
<td>Interior Painting</td>
<td>September 2004</td>
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<td>Coatings for Steel</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Coatings for Concrete and Masonry</td>
<td>September 2004</td>
<td>September 2014</td>
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</tbody>
</table>

### DIVISION 10 - SPECIALTIES

<table>
<thead>
<tr>
<th>Division</th>
<th>Specification</th>
<th>Conformed Date</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>10210</td>
<td>Wall Louvers</td>
<td>September 2004</td>
<td></td>
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</tr>
<tr>
<td>10430</td>
<td>Specialty Signs</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
</tbody>
</table>
### RECORD OF PROFESSIONAL REVISIONS
### FACILITIES & SYSTEMS STANDARD SPECIFICATIONS

#### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Division</th>
<th>Description</th>
<th>Conformed DART Standard</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>10441</td>
<td>Specialty Post and Pole Mounted Signs</td>
<td>September 2004</td>
<td>September 2014</td>
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</tr>
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<td>10522</td>
<td>Fire Extinguishers and Cabinets</td>
<td>September 2004</td>
<td></td>
<td></td>
</tr>
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<td>10525</td>
<td>Fire Department Key Keeper</td>
<td>September 2004</td>
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<td>Toilet Accessories</td>
<td>September 2004</td>
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<td>Corrosion Control</td>
<td>July 2006</td>
<td>September 2014</td>
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<td>Corrosion Control Acceptance Tests</td>
<td>July 2006</td>
<td>September 2014</td>
<td></td>
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<td>13102</td>
<td>Track-To-Earth Resistance Tests</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
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<tr>
<td>13121</td>
<td>Substation Enclosures - Traction Power Substation</td>
<td>-</td>
<td>September 2014</td>
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<td>14240</td>
<td>Hydraulic Elevators</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Mechanical Systems - General</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Electrical Requirements of Mechanical Work</td>
<td>September 2004</td>
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<td>Identification of Equipment and Piping</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Piping And Accessories</td>
<td>September 2004</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>Vibration Isolation and Sound Control</td>
<td>September 2004</td>
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<td>Pumps</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Insulation</td>
<td>September 2004</td>
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<td>Fire Protection Systems</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Electric Motor Driven Fire Pump Systems</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Plumbing</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Water Heaters</td>
<td>September 2004</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>Heat Tracing</td>
<td>September 2004</td>
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<td>September 2004</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>Self Contained Air Conditioning Units</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Heat Pumps (Air to Air)</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Amended 2016</td>
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<td>Air Handling</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Fans</td>
<td>September 2004</td>
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<td>Air Distribution</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Louvers and Dampers</td>
<td>September 2004</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>Control Equipment</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Testing and Balancing</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Electrical Systems - General</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Testing of Electrical Systems</td>
<td>September 2004</td>
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<td>Identification of Electrical Equipment</td>
<td>September 2004</td>
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<td>Fault and Coordination Power Study - Traction Power Substation</td>
<td>-</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16050</td>
<td>Basic Electrical Materials - Traction Power Substation</td>
<td>-</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16110</td>
<td>Conduit and Raceways</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16111</td>
<td>Conduits</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
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<td>Cable Trays</td>
<td>September 2004</td>
<td>September 2014</td>
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</tr>
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<td>16120</td>
<td>Wires and Cables</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
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<td>16130</td>
<td>Electrical Boxes</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Exterior Demarcation Cabinets</td>
<td>September 2004</td>
<td>September 2014</td>
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<td>Supporting Devices</td>
<td>September 2004</td>
<td></td>
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<td>16311</td>
<td>Mainline Traction Power Substations</td>
<td></td>
<td>May 2016</td>
<td></td>
</tr>
<tr>
<td>16312</td>
<td>Traction Power System Substation Installation</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16350</td>
<td>Overhead Contact System Basic Electrical Materials And Methods</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
</tr>
<tr>
<td>16351</td>
<td>Overhead Contact System Grounding and Bonding</td>
<td>March 2006</td>
<td></td>
<td>May 2016</td>
</tr>
<tr>
<td>16371</td>
<td>Overhead Contact System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
</tr>
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<td>16425</td>
<td>Low Voltage Switchboards</td>
<td>September 2004</td>
<td></td>
<td></td>
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<td>Description</td>
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<td>Amended 2014</td>
<td>Amended 2016</td>
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<td>Grounding and Bonding</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
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<td>Grounding and Bonding - Communications Facility</td>
<td>September 2004</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(WITHDRAWN)</td>
<td></td>
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<td>16460</td>
<td>Transformers</td>
<td>September 2004</td>
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<td>16470</td>
<td>Power and Lighting Panelboards</td>
<td>September 2004</td>
<td></td>
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</tr>
<tr>
<td>16490</td>
<td>Switches and Receptacles</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16500</td>
<td>Lighting Fixtures, Mounting Poles, and Control</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Devices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16502</td>
<td>Anchor Bolts and Foundations for Lighting Poles</td>
<td>September 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16605</td>
<td>Emergency Lighting Units and Power Supplies</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16620</td>
<td>Standby Power Systems</td>
<td>September 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16670</td>
<td>Lightning Protection</td>
<td>September 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16721</td>
<td>Fire Alarm and Detection Systems</td>
<td>September 2004</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16722</td>
<td>Intrusion Alarm and Detection Systems</td>
<td>September 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16750</td>
<td>Station Communications Devices</td>
<td>September 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16801</td>
<td>Basic Technical Requirements - Communications</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
</tr>
<tr>
<td></td>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16837</td>
<td>Miscellaneous Components And Products -</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
</tr>
<tr>
<td></td>
<td>Communications System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16838</td>
<td>Communications Facilities - Communications</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
</tr>
<tr>
<td></td>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16839</td>
<td>Communications Interface Cabinet - Communications</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16841</td>
<td>Communications Cable - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16845</td>
<td>Fiber Optic Cable Subsystem - Communications</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
</tr>
<tr>
<td></td>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16850</td>
<td>Basic Electrical Materials And Methods -</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Communications System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16851</td>
<td>Telephone Subsystem - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16852</td>
<td>Public Address Subsystem - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
<td>16853</td>
<td>Visual Message Board Subsystem - Communications</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
<tr>
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<td>Intrusion Alarm Subsystem - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16856</td>
<td>Closed Circuit Television - Communications System</td>
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<td>May 2016</td>
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<td>16866</td>
<td>Control Center Subsystem - Communications System</td>
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<td>SCADA RTU Subsystem - Communications System</td>
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<td>May 2016</td>
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<td>Fare Collection Local Area Network - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>Grounding and Bonding - Communications System</td>
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<td>Communications Transmission Subsystem - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>Power Supplies and Distribution - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>Manuals and Training - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>Technical Support and Spares - Communications System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>Basic Technical Requirements - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>16902</td>
<td>Block Design Criteria - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>Cab Signals - Signal System</td>
<td>October 2006</td>
<td>September 2014</td>
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<td>16904</td>
<td>Drawings - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>External Cable - Signal System</td>
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<td>Power Cable - Signal System</td>
<td>March 2006</td>
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<td>Power Switch-and-Lock Movements - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16914</td>
<td>Embedded Power Switch-and-Lock Movements - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16915</td>
<td>Motor Control Centers and Starters</td>
<td>September 2004</td>
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<td>16917</td>
<td>Signals and Indicators - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<tr>
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<td>Audio Frequency Main Line Track Circuits - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>Power Frequency Track Circuits - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<tr>
<td>16920</td>
<td>Train-To-Wayside Communications - Signal System</td>
<td>March 2006</td>
<td></td>
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<tr>
<td>16922</td>
<td>Cab Signal and B-Point Loops - Signal System</td>
<td>March 2006</td>
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</tbody>
</table>
## Table of Contents

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
<th>Conformed DART Standard</th>
<th>Amended 2014</th>
<th>Amended 2016</th>
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<td>16923</td>
<td>Impedance Bonds - Signal System</td>
<td>March 2006</td>
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<td>16924</td>
<td>Train Stops - Signal System (WITHDRAWN)</td>
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<td>16930</td>
<td>Rail Bonding - Signal System</td>
<td>March 2006</td>
<td>December 2014</td>
<td></td>
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<td>16932</td>
<td>Automatic Highway Crossing Warning System - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16935</td>
<td>Power System - Signal System</td>
<td>March 2006</td>
<td></td>
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<tr>
<td>16938</td>
<td>Instrument Houses - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>16939</td>
<td>Wayside Cases - Signal System (WITHDRAWN)</td>
<td></td>
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<td>16940</td>
<td>Junction Boxes - Signal System</td>
<td>March 2006</td>
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<td>16953</td>
<td>Instrument Racks - Signal System</td>
<td>March 2006</td>
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<td>16955</td>
<td>Internal Wire and Cable - Signal System</td>
<td>March 2006</td>
<td></td>
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<td>16957</td>
<td>Plug Connectors - Signal System</td>
<td>March 2006</td>
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<tr>
<td>16958</td>
<td>Relays - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
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<td>16959</td>
<td>Vital Microprocessor Interlocking System - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>16963</td>
<td>Transformers - Signal System</td>
<td>March 2006</td>
<td></td>
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</tr>
<tr>
<td>16969</td>
<td>Local Control Panels - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td>May 2016</td>
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<td>16972</td>
<td>Event Recorders - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16976</td>
<td>Grounding of Equipment - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16978</td>
<td>Electromagnetic Compatibility - Signal System</td>
<td>March 2006</td>
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<td>16995</td>
<td>Reliability and Maintainability - Signal System</td>
<td>March 2006</td>
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<td>16996</td>
<td>Wayside Signs - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
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<td>16997</td>
<td>Miscellaneous Components and Products - Signal System</td>
<td>March 2006</td>
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<td>16998</td>
<td>Test and Inspection - Signal System</td>
<td>March 2006</td>
<td>September 2014</td>
<td></td>
</tr>
</tbody>
</table>

END OF TABLE OF CONTENTS
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

**DIVISION 1 - GENERAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>Section Code</th>
<th>Section Title</th>
</tr>
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<tbody>
<tr>
<td>01001</td>
<td>General Requirements</td>
</tr>
<tr>
<td>01010</td>
<td>Summary of the Work</td>
</tr>
<tr>
<td>01086</td>
<td>Color Codes and Color Standards</td>
</tr>
<tr>
<td>01220</td>
<td>Measurement and Payment</td>
</tr>
<tr>
<td>01312</td>
<td>Project Meetings</td>
</tr>
<tr>
<td>01320</td>
<td>Construction Schedule And Progress Reports</td>
</tr>
<tr>
<td>01321</td>
<td>Construction Schedule And Progress Reports for Small Projects</td>
</tr>
<tr>
<td>01330</td>
<td>Submittals</td>
</tr>
<tr>
<td>01340</td>
<td>Shop Drawings, Product Data and Samples</td>
</tr>
<tr>
<td>01345</td>
<td>Construction Photographs</td>
</tr>
<tr>
<td>01423</td>
<td>Reference Standards</td>
</tr>
<tr>
<td>01430</td>
<td>Contractor's Quality Assurance</td>
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<tr>
<td>01450</td>
<td>Quality Control</td>
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<tr>
<td>01454</td>
<td>Field Samples and Mockups</td>
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<tr>
<td>01500</td>
<td>Temporary Facilities and Services</td>
</tr>
<tr>
<td>01505</td>
<td>Mobilization</td>
</tr>
<tr>
<td>01533</td>
<td>Temporary Decking</td>
</tr>
<tr>
<td>01560</td>
<td>Environmental Protection</td>
</tr>
<tr>
<td>01562</td>
<td>Soil Erosion and Sediment Control</td>
</tr>
<tr>
<td>01570</td>
<td>Maintenance and Control of Traffic</td>
</tr>
<tr>
<td>01580</td>
<td>Project Signs</td>
</tr>
<tr>
<td>01600</td>
<td>Product Requirements</td>
</tr>
<tr>
<td>01630</td>
<td>Product Substitution Procedures</td>
</tr>
<tr>
<td>01640</td>
<td>Authority-Furnished Materials and Equipment</td>
</tr>
<tr>
<td>01715</td>
<td>Pre-Construction Inspection</td>
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<tr>
<td>01722</td>
<td>Field Engineering - Surveying</td>
</tr>
<tr>
<td>01731</td>
<td>Cutting and Patching</td>
</tr>
<tr>
<td>01740</td>
<td>Cleaning</td>
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<td>01770</td>
<td>Contract Closeout</td>
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<td>Project Record Documents</td>
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<td>01786</td>
<td>Operation and Maintenance Instructions</td>
</tr>
<tr>
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<td>Spare Parts and Maintenance Materials</td>
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</table>

**CARTER BURGESS**
**JACOBS CIVIL INC**
**STV INCORPORATED**
**KAI ALLIANCE**

**CONTRACT NO. C-1002450-01**

**ISSUE**

September 2004
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**DIVISION 2 - SITE CONSTRUCTION**

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<td>02072</td>
<td>Removal and Restoration of Miscellaneous Existing Facilities</td>
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<td>02100</td>
<td>Site Preparation</td>
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<td>Survey Markers and Monuments</td>
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<td>02271</td>
<td>Ditch Lining and Slope Protection</td>
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<tr>
<td>02450</td>
<td>General Track Construction</td>
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<td>02451</td>
<td>Sub-Ballast</td>
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<td>Track Ballast</td>
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<td>Track Appurtenances</td>
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<td>Bonded Joints</td>
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<td>02458</td>
<td>Field Rail Welding</td>
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<td>02459</td>
<td>Special Trackwork</td>
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<td>02460</td>
<td>Ballasted Track Construction</td>
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<td>02462</td>
<td>Direct Fixation Track Construction</td>
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<td>02464</td>
<td>Concrete Approach Slab and Track Slab</td>
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<td>02469</td>
<td>Track Demolition and Signal Equipment Removal</td>
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<tr>
<td>02470</td>
<td>Highway Grade Crossings - Trackwork</td>
</tr>
<tr>
<td>02471</td>
<td>Highway Grade Crossings - Civil Work</td>
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<tr>
<td>02473</td>
<td>Pedestrian Crossings at Stations</td>
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<tr>
<td>02511</td>
<td>Bituminous Pavement</td>
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<tr>
<td>02525</td>
<td>Combined Curb and Gutters, Curb Ramps, and Walks</td>
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<td>02550</td>
<td>Concrete Pavement</td>
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<td>Chain Link Fencing</td>
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<td>02831</td>
<td>Wooden Screening Fence</td>
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<td>02846</td>
<td>Metal Beam Guard Rail</td>
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<td>Right-Of-Way Safety Signs</td>
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<td>02848</td>
<td>Precast Parking Bumpers</td>
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**CONTRACT NO.**

C-1002450-01

**ISSUE**

September 2004
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

DIVISION 2 - SITE CONSTRUCTION

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<th>Section Code</th>
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<tr>
<td>02140</td>
<td>Dewatering</td>
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<tr>
<td>02220</td>
<td>Grading, Excavating and Backfilling</td>
</tr>
<tr>
<td>02221</td>
<td>Utility Excavation and Backfill</td>
</tr>
<tr>
<td>02230</td>
<td>Base for Pavements</td>
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<tr>
<td>02242</td>
<td>Soil Stabilization: Portland Cement Treatment</td>
</tr>
<tr>
<td>02243</td>
<td>Soil Stabilization: Lime Treatment</td>
</tr>
<tr>
<td>02245</td>
<td>Soil Stabilization: Pressure Grouting</td>
</tr>
<tr>
<td>02275</td>
<td>Geogrid Wall Reinforcement</td>
</tr>
<tr>
<td>02316</td>
<td>Geotechnical Instrumentation</td>
</tr>
<tr>
<td>02360</td>
<td>Driven Piles</td>
</tr>
<tr>
<td>02375</td>
<td>Drilled Shaft Foundations</td>
</tr>
<tr>
<td>02870</td>
<td>Modular Retaining Wall Units</td>
</tr>
<tr>
<td>02872</td>
<td>Mechanically Stabilized Earth Retaining Wall</td>
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</tbody>
</table>
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

### DIVISION 2 - SITE CONSTRUCTION

<table>
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<tr>
<td>02150</td>
<td>Underpinning, Support, and Restoration of Structures</td>
<td>02711</td>
<td>Aerial Structure Drainage Systems</td>
</tr>
<tr>
<td>02160</td>
<td>Support of Excavation</td>
<td>02782</td>
<td>Express Trough for Aerial Structures</td>
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### DIVISION 3 - CONCRETE

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<td>03100</td>
<td>Concrete Formwork</td>
<td>03360</td>
<td>Special Concrete Finishes</td>
</tr>
<tr>
<td>03200</td>
<td>Concrete Reinforcement</td>
<td>03365</td>
<td>Prestressed Concrete</td>
</tr>
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<td>Cast-In-Place Concrete</td>
<td>03430</td>
<td>Structural Precast Concrete</td>
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<td>03305</td>
<td>Portland Cement Concrete</td>
<td>03450</td>
<td>Architectural Precast Concrete</td>
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<tr>
<td>03350</td>
<td>Concrete Finishing</td>
<td>03905</td>
<td>Concrete Repair and Restoration</td>
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### DIVISION 5 - METALS

<table>
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<th>Description</th>
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<th>Description</th>
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<tr>
<td>05120</td>
<td>Structural Steel - Bridges</td>
<td>05310</td>
<td>Permanent Metal Deck Forms</td>
</tr>
<tr>
<td>05130</td>
<td>Structural Steel - Buildings</td>
<td>05415</td>
<td>Cold-Formed Metal Framing</td>
</tr>
<tr>
<td>05135</td>
<td>Architectural Exposed Structural Steel</td>
<td>05430</td>
<td>Slotted Channel Framing</td>
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<td>05300</td>
<td>Metal Decking</td>
<td></td>
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**CONTRACT NO.**

**C-1002450-01**

**ISSUE**

September 2004
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

**DIVISION 2 - SITE CONSTRUCTION**

<table>
<thead>
<tr>
<th>Specification Code</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>02580</td>
<td>Pavement Markings and Delineators</td>
</tr>
<tr>
<td>02590</td>
<td>Traffic Signals</td>
</tr>
<tr>
<td>02845</td>
<td>Traffic Control Signs</td>
</tr>
</tbody>
</table>
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

DIVISION 2 - SITE CONSTRUCTION

02660 - Water Distribution Systems
02700 - Storm Sewer Systems
02710 - Subway Drainage Systems
02730 - Sanitary Sewer Systems
02760 - Maintenance, Support and Restoration of Existing Utility Facilities
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

**DIVISION 2 - SITE CONSTRUCTION**

01532 - Tree and Shrub Protection and Care
02131 - Tree Pruning
02900 - Landscaping - General
02910 - Topsoil and Finished Grading
02930 - Seeding and Sodding - Irrigated Areas
02931 - Seeding and Sodding - Non-Irrigated Areas
02950 - Landscape Planting
02975 - Landscape Irrigation System
02976 - Irrigation Sleeves
02980 - Landscape Maintenance - General
02981 - Landscape Maintenance - Irrigated Areas
02982 - Landscape Maintenance - Non-Irrigated Areas
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

Page 1 of 3

<table>
<thead>
<tr>
<th>DIVISION 2 - SITE CONSTRUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>02515 - Unit Pavers</td>
</tr>
<tr>
<td>02873 - Station Furnishings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIVISION 3 - CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>03462 - Glass Fiber Reinforced Concrete Warning Strips</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIVISION 4 - MASONRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>04100 - Mortar, Grout and Masonry Accessories</td>
</tr>
<tr>
<td>04210 - Brick Masonry</td>
</tr>
<tr>
<td>04220 - Concrete Masonry Units</td>
</tr>
<tr>
<td>04400 - Stone</td>
</tr>
<tr>
<td>04720 - Cast Stone</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>DIVISION 5 - METALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>05500 - Metal Fabrications</td>
</tr>
<tr>
<td>05510 - Metal Stairs</td>
</tr>
<tr>
<td>05520 - Metal Railings</td>
</tr>
</tbody>
</table>

CONTRACT NO.
C-1002450-01

ISSUE
September 2004
I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

DIVISION 6 - WOOD AND PLASTICS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>06100</td>
<td>Rough Carpentry</td>
</tr>
<tr>
<td>06410</td>
<td>Custom Cabinetwork</td>
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DIVISION 7 - THERMAL AND MOISTURE PROTECTION

<table>
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<td>Bentonite Waterproofing</td>
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<td>Crystalline Waterproofing</td>
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<td>Metallic Waterproofing</td>
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<td>Dampproofing</td>
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<td>07210</td>
<td>Building Insulation</td>
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<td>07410</td>
<td>Metal Roofing</td>
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<td>07531</td>
<td>Single-Ply Membrane Roofing</td>
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<td>Flashing and Sheet Metal</td>
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<td>07840</td>
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<td>Seals and Sealants</td>
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DIVISION 8 - DOORS AND WINDOWS

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<tr>
<td>08115</td>
<td>Hollow Metal Doors and Frames</td>
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<td>08313</td>
<td>Access Doors and Frames</td>
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<td>08413</td>
<td>Aluminum-Framed Windscreens</td>
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<td>08710</td>
<td>Door Hardware</td>
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<td>Glass and Glazing</td>
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<td>Glazed Aluminum Elevator Enclosures</td>
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I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

### DIVISION 9 - FINISHES

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<tr>
<td>09253</td>
<td>Gypsum Sheathing</td>
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<td>Gypsum Board Assemblies</td>
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<td>09310</td>
<td>Ceramic Tile</td>
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<td>09512</td>
<td>Acoustical Panel Ceilings</td>
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<td>Acoustical Snap-in Metal Pan Ceilings</td>
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<td>09660</td>
<td>Resilient Flooring</td>
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<td>09663</td>
<td>Static Dissipative Resilient Flooring</td>
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<td>Interior Painting</td>
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<td>Coatings for Steel</td>
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<td>Coatings for Concrete and Masonry</td>
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### DIVISION 10 - SPECIALTIES

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<td>Wall Louvers</td>
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<td>Specialty Signs</td>
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<td>10441</td>
<td>Specialty Post and Pole Mounted Signs</td>
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<td>10522</td>
<td>Fire Extinguishers and Cabinets</td>
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<td>Fire Department Key Keeper</td>
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<td>10800</td>
<td>Toilet Accessories</td>
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### DIVISION 14 - CONVEYING SYSTEMS

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<td>Hydraulic Elevators</td>
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JACOBS CIVIL INC
STV INCORPORATED
KAI ALLIANCE

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C-1002450-01

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**DIVISION 15 - MECHANICAL**

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<th>Section Code</th>
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<td>15001</td>
<td>Mechanical Systems - General</td>
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<td>15040</td>
<td>Electrical Requirements of Mechanical Work</td>
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<td>15055</td>
<td>Identification of Equipment and Piping</td>
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<td>15060</td>
<td>Piping And Accessories</td>
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<tr>
<td>15075</td>
<td>Vibration Isolation and Sound Control</td>
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<td>15160</td>
<td>Pumps</td>
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<td>Insulation</td>
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<td>Fire Protection Systems</td>
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<td>Electric Motor Driven Fire Pump Systems</td>
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<td>15400</td>
<td>Plumbing</td>
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<td>Self Contained Air Conditioning Units</td>
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<td>Heat Pumps (Air to Air)</td>
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<td>Air Handling</td>
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<td>Fans</td>
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<td>Air Distribution</td>
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<td>Louvers and Dampers</td>
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<td>Control Equipment</td>
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<td>Testing and Balancing</td>
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**DIVISION 16 - ELECTRICAL**

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<td>Identification of Electrical Equipment</td>
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<td>Conduits</td>
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<td>16114</td>
<td>Cable Trays</td>
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<td>Wires and Cables</td>
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<td>16130</td>
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<td>16190</td>
<td>Supporting Devices</td>
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<td>Low Voltage Switchboards</td>
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<td>16450</td>
<td>Grounding and Bonding</td>
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<td>Grounding and Bonding - Communications Facility</td>
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<td>Transformers</td>
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<td>Power and Lighting Panelboards</td>
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<td>Switches and Receptacles</td>
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<td>16500</td>
<td>Lighting Fixtures, Mounting Poles, and Control Devices</td>
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<td>16502</td>
<td>Anchor Bolts and Foundations for Lighting Poles</td>
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<td>Emergency Lighting Units and Power Supplies</td>
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<td>Standby Power Systems</td>
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<td>Station Communications Devices</td>
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<td>Motor Control Centers and Starters</td>
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**DIVISION 16 - ELECTRICAL**

| 16135 - Exterior Demarcation Cabinets |

---

**GERARD & ASSOCIATES**

CONSULTING ENGINEERS

Mechanical Electrical Plumbing Systems Design

**CARTER BURGESS**

**JACOBS CIVIL INC**

**STV INCORPORATED**

**KAI ALLIANCE**

**STATE OF TEXAS**

**WALTER S. GERARD**

**52704**

**ISSUE**

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I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

**DIVISION 16 - ELECTRICAL**

- 16721 - Fire Alarm and Detection Systems
- 16722 - Intrusion Alarm and Detection Systems

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**JACOBS CIVIL INC**

**STV INCORPORATED**

**KAI ALLIANCE**

**STATE OF TEXAS**

**SHAWN C. YATES**

**90414**

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DIVISION 2 - SITE CONSTRUCTION

02376 - OCS Pole Foundations and Guy Anchor Piers

DALLAS SYSTEMS CONSULTANTS
A PARSONS / PARAGON JOINT VENTURE
1401 Pacific Avenue
Dallas, Texas 75202

STATE OF TEXAS
LICENSED PROFESSIONAL ENGINEER
ANUJ M. PATIL
93079
September 2004

CONTRACT NO.
C-1002450-01

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I hereby certify that the following Sections of the Specifications were prepared under my direct supervision.

DIVISION 2 - SITE CONSTRUCTION

02390 - Precast Concrete Foundations for Signal Equipment

DALLAS AREA RAPID TRANSIT LIGHT RAIL PROJECT
FACILITIES STANDARD SPECIFICATIONS

DALLAS SYSTEMS CONSULTANTS
A PARSONS / PARAGON JOINT VENTURE
1401 Pacific Avenue
Dallas, Texas 75202

KENNETH A. HUANG
92226
LICENSED PROFESSIONAL ENGINEER

STATE OF TEXAS

ISSUE

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DIVISION 2 - SITE CONSTRUCTION

<table>
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<tr>
<th>Code</th>
<th>Description</th>
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<tr>
<td>02780</td>
<td>Underground Electrical and Communications Distribution Systems</td>
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<td>Precast Express Trough</td>
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Dallas, Texas 75202

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**DIVISION 13 - SPECIAL CONSTRUCTION**

<table>
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<th>Section</th>
<th>Description</th>
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<td>13100</td>
<td>Corrosion Control</td>
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<td>Corrosion Control Acceptance Tests</td>
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<td>13102</td>
<td>Track-To-Earth Resistance Tests</td>
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A PARSONS / PARAGON JOINT VENTURE
1401 Pacific Avenue
Dallas, Texas 75202

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### DIVISION 1 – GENERAL REQUIREMENTS

- 01047 - System Safety Program
- No Additional Items

### DIVISION 5 – METALS

- 05124 - Overhead Contact System Steel Poles - Wide Flange
- 05125 - Overhead Contact System Fabricated Metal Supports
- 05126 - Overhead Contact System Steel Tubular Poles
- No Additional Items

### DIVISION 16 – ELECTRICAL

- 16110 - Conduit and Raceways
- 16312 - Traction Power System Substation Installation
- 16350 - Overhead Contact System Basic Electrical Materials And Methods
- 16351 - Overhead Contact System Grounding and Bonding
- 16371 - Overhead Contact System
- No Additional Items
DALLAS AREA RAPID TRANSIT
LIGHT RAIL PROJECT
SYSTEMS STANDARD
SPECIFICATIONS
BASELINE

I hereby certify that the following Specifications Sections were prepared under my direct supervision.

DIVISION 16 – ELECTRICAL

16801 - Basic Technical Requirements - Communications System
16837 - Miscellaneous Components And Products - Communications System
16838 - Communications Facilities - Communications System
16839 - Communications Interface Cabinet - Communications System
16841 - Communications Cable - Communications System
16845 - Fiber Optic Cable Subsystem - Communications System
16850 - Basic Electrical Materials And Methods - Communications System
16851 - Telephone Subsystem - Communications System
16852 - Public Address Subsystem - Communications System
16853 - Visual Message Board Subsystem - Communications System
16854 - Fire Alarm Subsystem - Communications System
16855 - Intrusion Alarm Subsystem - Communications System
16869 - Fare Collection Local Area Network - Communications System
16876 - Grounding and Bonding - Communications System
16877 - Communications Transmission Subsystem - Communications System
16879 - Power Supplies and Distribution - Communications System
16897 - Manuals and Training - Communications System
16899 - Technical Support and Spares - Communications System
No Additional Items
I hereby certify that the following Specifications Sections were prepared under my direct supervision.

### DIVISION 16 — ELECTRICAL

16901 - Basic Technical Requirements - Signal System  
16902 - Block Design Criteria - Signal System  
16904 - Drawings - Signal System  
16908 - External Cable - Signal System  
16909 - Power Cable - Signal System  
16911 - Power Switch-and-Lock Movements - Signal System  
16914 - Embedded Power Switch-and-Lock Movements - Signal System  
16917 - Signals and Indicators - Signal System  
16918 - Audio Frequency Main Line Track Circuits - Signal System  
16919 - Power Frequency Track Circuits - Signal System  
16920 - Train-To-Wayside Communications - Signal System  
16922 - Cab Signal and B-Point Loops - Signal System  
16923 - Impedance Bonds - Signal System  
16924 - Train Stops - Signal System  
16930 - Rail Bonding - Signal System  
16932 - Automatic Highway Crossing Warning System - Signal System  
16935 - Power System - Signal System  
No Additional Items
I hereby certify that the following Specifications Sections were prepared under my direct supervision.

## DIVISION 16 — ELECTRICAL

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<th>Section Code</th>
<th>Section Description</th>
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<td>16938</td>
<td>Instrument Houses - Signal System</td>
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<td>16939</td>
<td>Wayside Cases - Signal System</td>
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<td>16940</td>
<td>Junction Boxes - Signal System</td>
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<td>16953</td>
<td>Instrument Racks - Signal System</td>
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<td>16955</td>
<td>Internal Wire and Cable - Signal System</td>
</tr>
<tr>
<td>16957</td>
<td>Plug Connectors - Signal System</td>
</tr>
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<td>16958</td>
<td>Relays - Signal System</td>
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<td>16959</td>
<td>Vital Microprocessor Interlocking System - Signal System</td>
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<td>16963</td>
<td>Transformers - Signal System</td>
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<td>Local Control Panels - Signal System</td>
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<td>Event Recorders - Signal System</td>
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<td>16976</td>
<td>Grounding of Equipment - Signal System</td>
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<td>Electromagnetic Compatibility - Signal System</td>
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<td>16995</td>
<td>Reliability and Maintainability - Signal System</td>
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<td>16996</td>
<td>Wayside Signs - Signal System</td>
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<td>Miscellaneous Components and Products - Signal System</td>
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<td>Test and Inspection - Signal System</td>
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### DIVISION 1 – GENERAL REQUIREMENTS

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<tr>
<th>Section Code</th>
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<tbody>
<tr>
<td>01010</td>
<td>Summary of the Work</td>
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<td>01047</td>
<td>Systems Safety Program</td>
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<td>01312</td>
<td>Project Meetings</td>
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<td>01320</td>
<td>Construction Schedule And Progress Reports</td>
</tr>
<tr>
<td>01321</td>
<td>Construction Schedule And Progress Reports for Small Projects</td>
</tr>
<tr>
<td>01340</td>
<td>Shop Drawings, Product Data and Samples</td>
</tr>
<tr>
<td>01345</td>
<td>Construction Photographs</td>
</tr>
<tr>
<td>01454</td>
<td>Field Samples and Mockups</td>
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<tr>
<td>01500</td>
<td>Temporary Facilities and Services</td>
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<td>01505</td>
<td>Mobilization</td>
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<td>Temporary Decking</td>
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<td>Environmental Protection</td>
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<td>Product Substitution Procedures</td>
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<td>Pre-Construction Inspection</td>
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<td>01722</td>
<td>Field Engineering - Surveying</td>
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<td>01785</td>
<td>Project Record Documents</td>
</tr>
<tr>
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<td>Operation and Maintenance Instructions</td>
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TBPE Firm  
Registration No. 15329  

**HNTB Corporation**  
The HNTB Companies  
Engineers Architects Planners  
TBPE Firm Registration No. 420  

**Contract No.** C-1022575-01  
**Issue**  
SEPTEMBER 2014
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DIVISION 1 – GENERAL REQUIREMENTS

01562 - Soil Erosion and Sediment Control

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DIVISION 1 – GENERAL REQUIREMENTS

01330 - Submittals
01450 - Quality Control

DIVISION 2 – SITE CONSTRUCTION

02375 - Drilled Shaft Foundations

DIVISION 3 – CONCRETE

03100 - Concrete Formwork
03000 - Cast-In-Place Concrete
03050 - Portland Cement Concrete
03350 - Concrete Finishing

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HNTB

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**DIVISION 2 – SITE CONSTRUCTION**

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<tr>
<td>02072</td>
<td>Removal and Restoration of Miscellaneous Existing Facilities</td>
</tr>
<tr>
<td>02131</td>
<td>Tree Pruning</td>
</tr>
<tr>
<td>02230</td>
<td>Base for Pavements</td>
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<tr>
<td>02246</td>
<td>Geogrid Reinforcement of Sub-Ballast</td>
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<tr>
<td>02271</td>
<td>Ditch Lining and Slope Protection</td>
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<td>02316</td>
<td>Geotechnical Instrumentation</td>
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<td>02451</td>
<td>Sub-Ballast</td>
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<td>02457</td>
<td>Bonded Joints</td>
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<td>Field Rail Welding</td>
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<td>Special Trackwork</td>
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<td>Ballasted Track Construction</td>
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<td>Direct Fixation Track Construction</td>
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<td>Highway Grade Crossings - Trackwork</td>
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<td>Grade Crossing Panels</td>
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<td>Bituminous Pavement</td>
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<td>Sanitary Sewer Systems</td>
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<td>Precast Parking Bumpers</td>
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<td>Prefabricated Block Retaining Wall System</td>
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<td>Mechanically Stabilized Earth Retaining Wall</td>
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<td>Topsoil and Finished Grading</td>
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<td>Seeding and Sodding - Irrigated Areas</td>
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<td>Landscape Planting</td>
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HNTB

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SEPTEMBER 2014
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<table>
<thead>
<tr>
<th>DIVISION 3 – CONCRETE</th>
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<tbody>
<tr>
<td>03360 - Special Concrete Finishes</td>
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<td>03365 - Prestressed Concrete</td>
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<tr>
<td>03430 - Structural Precast Concrete</td>
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<td>03490 - Glass-Fiber Reinforced Precast Concrete</td>
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<td>03905 - Concrete Repair and Restoration</td>
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</tbody>
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A Joint Venture
TBPE Firm
Registration No. 15329

HNTB
HNTB Corporation
The HNTB Companies
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CONTRACT NO. C-1022575-01
ISSUE
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### DIVISION 4 – MASONRY

<table>
<thead>
<tr>
<th>Section Code</th>
<th>Section Name</th>
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<tbody>
<tr>
<td>04100</td>
<td>Mortar, Grout and Masonry Accessories</td>
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<td>04220</td>
<td>Concrete Masonry Units</td>
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<tr>
<td>04400</td>
<td>Stone</td>
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### DIVISION 5 - METALS

<table>
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<tr>
<th>Section Code</th>
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<tbody>
<tr>
<td>05120</td>
<td>Structural Steel - Bridges</td>
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<tr>
<td>05500</td>
<td>Metal Fabrications</td>
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<td>Ornamental Metal</td>
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### DIVISION 6 – WOOD AND PLASTIC

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<tr>
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<td>Rough Carpentry</td>
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**DIVISION 7 – THERMAL AND MOISTURE PROTECTION**

| 07141 – Cold Fluid-Applied Waterproofing | 07531 – Single-Ply Membrane Roofing |

**DIVISION 8 – DOORS AND WINDOWS**

| 08835 – Decorative Plastic Glazing |

**DIVISION 9 - FINISHES**

| 09253 – Gypsum Sheathing | 09970 – Coatings for Steel |
| 09260 – Gypsum Board Assemblies | 09980 – Coatings for Concrete and Masonry |
| 09663 – Static Dissipative Resilient Flooring |
DALLAS AREA RAPID TRANSIT
LIGHT RAIL PROJECT
FACILITIES AND SYSTEMS
STANDARD SPECIFICATIONS
RECORD OF PROFESSIONAL REVISIONS

I hereby certify that the following Sections to the Standard Specifications and new Specification Section that are contained herein were prepared under my direct supervision.

**DIVISION 10 – SPECIALTIES**

10430 - Specialty Signs
10441 - Specialty Post and Pole Mounted Signs

**DIVISION 13 – SPECIAL CONSTRUCTION**

13121 – Substation Enclosures – Traction Power
Substation

**DIVISION 14 - CONVEYING SYSTEMS**

14240 – Hydraulic Elevators

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DIVISION 13 – SPECIAL CONSTRUCTION

13100 - Corrosion Control
13101 - Corrosion Control Acceptance Tests
13102 - Track-To-Earth Resistance Tests
# DALLAS AREA RAPID TRANSIT LIGHT RAIL PROJECT

## FACILITIES AND SYSTEMS

### STANDARD SPECIFICATIONS

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## DIVISION 15 – MECHANICAL

<table>
<thead>
<tr>
<th>15001</th>
<th>Mechanical Systems - General</th>
</tr>
</thead>
<tbody>
<tr>
<td>15055</td>
<td>Identification of Equipment and Piping</td>
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<td>15060</td>
<td>Piping And Accessories</td>
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<tr>
<td>15160</td>
<td>Pumps</td>
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<td>15300</td>
<td>Fire Protection Systems</td>
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<td>15380</td>
<td>Electric Motor Driven Fire Pump Systems</td>
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<td>15400</td>
<td>Plumbing</td>
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<td>Water Heaters</td>
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<td>Self Contained Air Conditioning Units</td>
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<td>15840</td>
<td>Heat Pumps (Air to Air)</td>
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<td>15850</td>
<td>Air Handling</td>
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<tr>
<td>15880</td>
<td>Air Distribution</td>
</tr>
<tr>
<td>15911</td>
<td>Louvers and Dampers</td>
</tr>
<tr>
<td>15950</td>
<td>Control Equipment</td>
</tr>
<tr>
<td>15990</td>
<td>Testing and Balancing</td>
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**HNTB**

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**CONTRACT NO. C-1022575-01**

**ISSUE**

SEPTEMBER 2014
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<tr>
<th>Division 16 - Electrical</th>
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</tr>
</thead>
<tbody>
<tr>
<td>16001 - Electrical Systems - General</td>
<td>16114 - Cable Trays</td>
<td></td>
</tr>
<tr>
<td>16110 - Conduit and Raceways</td>
<td>16130 - Electrical Boxes</td>
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<td>16111 - Conduits</td>
<td>16135 - Exterior Demarcation Cabinets</td>
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The HNTB Companies
Engineers, Architects, Planners
TBPE Firm Registration No. 420

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<tr>
<td>16045</td>
<td>Fault and Coordination Power Study – Traction Power Substation</td>
</tr>
<tr>
<td>16050</td>
<td>Basic Electrical Materials – Traction Power Substation</td>
</tr>
<tr>
<td>16311</td>
<td>Mainline Traction Power Substations</td>
</tr>
<tr>
<td>16312</td>
<td>Traction Power System Substation Installation</td>
</tr>
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<tr>
<th>DIVISION 16 – ELECTRICAL</th>
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<tbody>
<tr>
<td>16120 - Wires and Cables</td>
</tr>
<tr>
<td>16450 - Grounding and Bonding</td>
</tr>
<tr>
<td>16490 - Switches and Receptacles</td>
</tr>
<tr>
<td>16500 - Lighting Fixtures, Mounting Poles, and Control Devices</td>
</tr>
<tr>
<td>16605 - Emergency Lighting Units and Power Supplies</td>
</tr>
</tbody>
</table>

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TBPE Firm
Registration No. 15329

EUGENE C. BOWMAN, JR.
28157
11/7/2014

Swayzer Engineering Incorporated
3102 Maple Avenue
Suite 450
Dallas, TX 75201
Firm Registration No. F-5328

CONTRACT NO. C-1022575-01
ISSUE
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<thead>
<tr>
<th>16350 - Overhead Contact System Basic Electrical Materials And Methods</th>
<th>16371 - Overhead Contact System</th>
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<tr>
<td>16721</td>
<td>Fire Alarm and Detection Systems</td>
</tr>
<tr>
<td>16801</td>
<td>Basic Technical Requirements – Communications System</td>
</tr>
<tr>
<td>16837</td>
<td>Miscellaneous Components And Products – Communications System</td>
</tr>
<tr>
<td>16838</td>
<td>Communications Facilities – Communications System</td>
</tr>
<tr>
<td>16839</td>
<td>Communications Interface Cabinet – Communications System</td>
</tr>
<tr>
<td>16841</td>
<td>Communications Cable – Communications System</td>
</tr>
<tr>
<td>16845</td>
<td>Fiber Optic Cable Subsystem – Communications System</td>
</tr>
<tr>
<td>16850</td>
<td>Basic Electrical Materials and Methods – Communications System</td>
</tr>
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<td>16851</td>
<td>Telephone Subsystem – Communications System</td>
</tr>
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<td>16852</td>
<td>Public Address Subsystem – Communications System</td>
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<td>16853</td>
<td>Visual Message Board Subsystem – Communications System</td>
</tr>
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<td>16854</td>
<td>Fire Alarm Subsystem – Communications System</td>
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<tr>
<td>16855</td>
<td>Intrusion Alarm Subsystem – Communications System</td>
</tr>
<tr>
<td>16856</td>
<td>Closed Circuit Television – Communications System</td>
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<tr>
<td>16857</td>
<td>Control Center Subsystem – Communications System</td>
</tr>
<tr>
<td>16858</td>
<td>SCADA RTU Subsystem – Communications System</td>
</tr>
<tr>
<td>16859</td>
<td>Fare Collection Local Area Network – Communications System</td>
</tr>
<tr>
<td>16866</td>
<td>Communications Transmission Subsystem – Communications System</td>
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<tr>
<td>16879</td>
<td>Power Supplies and Distribution – Communications System</td>
</tr>
<tr>
<td>16897</td>
<td>Manuals and Training – Communications System</td>
</tr>
<tr>
<td>16899</td>
<td>Technical Support and Spares – Communications System</td>
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<td>Basic Technical Requirements - Signal System</td>
</tr>
<tr>
<td>16902</td>
<td>Block Design Criteria - Signal System</td>
</tr>
<tr>
<td>16903</td>
<td>Cab Signals - Signal System</td>
</tr>
<tr>
<td>16908</td>
<td>External Cable - Signal System</td>
</tr>
<tr>
<td>16911</td>
<td>Power Switch-and-Lock Movements - Signal System</td>
</tr>
<tr>
<td>16917</td>
<td>Signals and Indicators - Signal System</td>
</tr>
<tr>
<td>16918</td>
<td>Audio Frequency Main Line Track Circuits - Signal System</td>
</tr>
<tr>
<td>16919</td>
<td>Power Frequency Track Circuits - Signal System</td>
</tr>
<tr>
<td>16930</td>
<td>Rail Bonding – Signal System</td>
</tr>
<tr>
<td>16932</td>
<td>Automatic Highway Crossing Warning System - Signal System</td>
</tr>
<tr>
<td>16938</td>
<td>Instrument Houses - Signal System</td>
</tr>
<tr>
<td>16958</td>
<td>Relays - Signal System</td>
</tr>
<tr>
<td>16959</td>
<td>Vital Microprocessor Interlocking System - Signal System</td>
</tr>
<tr>
<td>16969</td>
<td>Local Control Panels - Signal System</td>
</tr>
<tr>
<td>16972</td>
<td>Event Recorders - Signal System</td>
</tr>
<tr>
<td>16976</td>
<td>Grounding of Equipment - Signal System</td>
</tr>
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<td>16996</td>
<td>Wayside Signs - Signal System</td>
</tr>
<tr>
<td>16998</td>
<td>Test and Inspection - Signal System</td>
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CONTRACT NO. C-1022575-01

ISSUE

SEPTEMBER 2014
# DALLAS AREA RAPID TRANSIT LIGHT RAIL PROJECT
## FACILITIES AND SYSTEMS
### STANDARD SPECIFICATIONS

The following Sections contain revisions to the Standard Specifications. I certify that the following Sections were revised under my direct supervision.

### DIVISION 1 – GENERAL REQUIREMENTS

- 01330 – Submittals

### DIVISION 2 – SITE CONSTRUCTION

- 02458 – Field Rail Welding
- 02462 – Direct Fixation Track Construction

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C–1022575–01

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**DIVISION 7 – THERMAL AND MOISTURE PROTECTION**

07531 – Single-Ply Membrane Roofing

**DIVISION 8 – DOORS AND WINDOWS**

08800 – Glass and Glazing

**DIVISION 15 – MECHANICAL**

15060 – Piping And Accessories
15458 – Water Heaters
15600 – Heating Systems
15911 – Louvers and Dampers
The following Sections contain revisions to the Standard Specifications. I certify that the following Sections were revised under my direct supervision.

### DIVISION 16 – ELECTRICAL

16311 – Mainline Traction Power Substations
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