**DALLAS AREA RAPID TRANSIT**

**SOLICITATION, OFFER AND AWARD FORM**

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### SOLICITATION INFORMATION

**Request for Proposals (RFP)**

1. **SOLICITATION NO.:** P-1021774
2. **ISSUE DATE:** May 7, 2012
3. **FOR INFORMATION CONTACT:** (No collect calls)
   - **NAME:** Barry Pierce
   - **TELEPHONE:** 214-749-2539
   - **FAX:** 214-749-3666
   - **E-MAIL:** bpierce@dart.org
4. **BRIEF DESCRIPTION:**
   - Streetcar Vehicle Purchase

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5. **PRE-PROPOSAL CONFERENCE:**
   - **LOCATION:** DALLAS AREA RAPID TRANSIT
   - **DATE:** Dallas, Texas 75202-7235
   - **TIME:** <AM/PM> Local Dallas

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6. **SUBMIT OFFER TO:**
   - **Mailing Address:**
     - DALLAS AREA RAPID TRANSIT
     - P.O. Box 660163
     - Dallas, Texas 75266
     - Solicitation #1021774
   - **Hand/Commercial Courier Delivery:**
     - DALLAS AREA RAPID TRANSIT
     - 1401 Pacific Ave.
     - Dallas, Texas 75202
     - Solicitation #1021774

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7. **OFFER SUBMISSION DUE DATE AND TIME:**
   - **DATE:** June 7, 2012
   - **TIME:** 2:00 PM Local Dallas

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8. **SUBMIT WITH OFFER:**
   - Original offer and 3 photocopies including exhibits and attachments so indicated on Page 2 of this form.

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9. **OFFER**
   - (To be completed by Offeror)
   - **CAUTION:** A false statement in any offer (bid or proposal) submitted to DART may be a criminal offense in violation of Section 37.10 of the Texas Penal Code.

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10. **DISCOUNT FOR PROMPT PAYMENT:**
    - **__%__, ____ Calendar Days** (Invoice/Payment terms are set forth in Exhibit D)

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11. **OFFEROR'S NAME, ADDRESS, and DART VENDOR NO.:**
    - **TYPE OR PRINT**

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12. **NAME AND TITLE OF PERSON AUTHORIZED TO SIGN THE OFFER:**
    - (Type or Print)

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13. **OFFEROR'S SIGNATURE & DATE:**
    - (To be completed by Offeror)

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14. **D/M/WBE:**
    - The D/M/WBE participation for this contract is as follows based on:
      - Percentage of the total contract amount, or
      - Other ______________________________

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15. **ACCEPTED AS TO:**
    - **NAME:** Joe Ramirez
    - **SIGNATURE:** ____________________________________
    - **DATE:** ____/____/____

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Form 33.201 (01/11)  Page 1 of 2
### 22. CONTENTS:

<table>
<thead>
<tr>
<th>NAME</th>
<th>FORM DESCRIPTION</th>
<th>FORM NO.</th>
<th>SUBMIT WITH OFFER?</th>
</tr>
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<tbody>
<tr>
<td>Cover Sheet</td>
<td>Solicitation, Offer and Award Form</td>
<td>33.201</td>
<td>YES</td>
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<tr>
<td>Schedule</td>
<td>Schedule</td>
<td>33.202A</td>
<td>YES</td>
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<tr>
<td>Exhibit A</td>
<td>Representations and Certifications</td>
<td>33.204</td>
<td>YES</td>
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<tr>
<td>Exhibit B</td>
<td>Special Solicitation Instructions and Conditions</td>
<td>33.B</td>
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<tr>
<td>Attachment 1</td>
<td>Schedule of Subcontractor(s)/Subconsultant(s)</td>
<td>None</td>
<td>YES</td>
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<tr>
<td>Exhibit C</td>
<td>Solicitation Instructions and Conditions</td>
<td>33.206L</td>
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<td>Exhibit D</td>
<td>Special Provisions</td>
<td>33.D</td>
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<td>Exhibit E</td>
<td>Addendum to General Provisions</td>
<td>33.214</td>
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<td>Exhibit F</td>
<td>General Provisions</td>
<td>33.301</td>
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<tr>
<td>Exhibit G</td>
<td>DBE, or MBE and WBE Program</td>
<td>33.212</td>
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<tr>
<td>Attachment 1</td>
<td>Intent to Perform as a Subcontractor</td>
<td>None</td>
<td>YES</td>
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<tr>
<td>Attachment 2</td>
<td>Sample Vendor Payment Report</td>
<td>None</td>
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<td>Attachment 2</td>
<td>Transit Vehicle Manufacturer’s Compliance</td>
<td>None</td>
<td>Yes</td>
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<tr>
<td>Exhibit I</td>
<td>Specifications</td>
<td>33.I</td>
<td></td>
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<tr>
<td>Exhibit L</td>
<td>Business Questionnaire</td>
<td>33.253</td>
<td>YES</td>
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<tr>
<td>Exhibit O</td>
<td>Solicitation Question Submission Form</td>
<td>33.225</td>
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<td>Exhibit U</td>
<td>Buy America Certificate</td>
<td>33.606B</td>
<td>YES</td>
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<tr>
<td>Exhibit V</td>
<td>Employee Information Report</td>
<td>33.254</td>
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</tbody>
</table>

### 23. SUBMIT THE BELOW ITEM(S) WITH OFFER, IN ADDITION TO THE ABOVE IDENTIFIED SUBMITTALS:

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
</tr>
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<tbody>
<tr>
<td>TECHNICAL PROPOSAL (ACCEPTED AS IDENTIFIED IN BLOCK 18)</td>
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### 24. ACKNOWLEDGMENT OF AMENDMENTS:

Offeror acknowledges receipt of the following amendment(s) to the solicitation:

(Identify amendment number and date of each.)
DALLAS AREA RAPID TRANSIT
DALLAS, TEXAS

SCHEDULE

CAUTION: A false statement in any offer submitted to DART may be a criminal offense in violation of Section 37.10 of the Texas Penal Code.

NOTE: For Invitations for Bids the terms "Offer" and "Offeror" shall mean "Bid" and "Bidder", respectively; and for Request for Proposals the terms "Bid" and "Bidder" shall mean "Offer" and "Offeror", respectively, in this solicitation and any associated exhibits.

THE OFFEROR MUST SIGN AND DATE THIS SCHEDULE WHERE PROVIDED AND SUBMIT ALL PAGES WITH THE OFFER.

The line item unit price(s) for both the Base Contract and Option Years, if applicable, must include all costs that the offeror intends to recover, such as, but not limited to: supervision, labor, equipment, materials, vehicle licensing, vehicle title, warehousing, freight, pick-up, financing, carrying charges, and all other such charges to accommodate the supplies/services and delivery requirements. No price adjustments will be made, unless specifically provided for by an additional provision included in this contract. (B-100.07A, SEP 06)

<table>
<thead>
<tr>
<th>Line Item Number</th>
<th>DESCRIPTION</th>
<th>Unit of Measure</th>
<th>Estimated Quantity</th>
<th>Unit Price x</th>
<th>Extended Price =</th>
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<tbody>
<tr>
<td>1</td>
<td>Base Vehicle</td>
<td>Each</td>
<td>2</td>
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<tr>
<td>2</td>
<td>Closed Circuit Television</td>
<td>Each</td>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
<td>Automatic Passenger Counter</td>
<td>Each</td>
<td>2</td>
<td></td>
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<tr>
<td>4</td>
<td>Fare Collection Equipment (Genfare Odyssey or equal)</td>
<td>Each</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Load-Leveling System for 14-inch Platform Height</td>
<td>Each</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Automatic Train Protection (Power and Space ONLY, provisions for future GETS CSS compatible system or equal)</td>
<td>Each</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Communications/Radio Equipment (Harris M5300 Front Mount or equal – 2 per car)</td>
<td>Each</td>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>8</td>
<td>Train Stop System (TSS) (4 systems – 2 per car) (Siemens magnetic TSS or equal)</td>
<td>Each</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Train to Wayside Communications (TWC) (4 transponders – 2 per car) (VECOM, Phillips VETAG, or equal)</td>
<td>Each</td>
<td>4</td>
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</table>

TOTAL FOR STREETCARS (SCHEDULE A) : (Line Items 1-9) $__________
<table>
<thead>
<tr>
<th>Line Item Number</th>
<th>DESCRIPTION</th>
<th>Unit of Measure</th>
<th>Estimated Quantity</th>
<th>Unit Price</th>
<th>Extended Price</th>
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<tbody>
<tr>
<td></td>
<td><strong>System Support (Schedule B)</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>Management</td>
<td>Lump Sum</td>
<td>1</td>
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<tr>
<td>11</td>
<td>Engineering</td>
<td>Lump Sum</td>
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<td>Design</td>
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<td>Testing</td>
<td>Lump Sum</td>
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<td>Training</td>
<td>Lump Sum</td>
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<td>15</td>
<td>Two-year warranty</td>
<td>Lump Sum</td>
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<td>16</td>
<td>Manuals and Catalogs</td>
<td>Lump Sum</td>
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<tr>
<td>17</td>
<td>Insurance – All Risk</td>
<td>Lump Sum</td>
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<td>18</td>
<td>Insurance - Liability</td>
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<td>19</td>
<td>Insurance – Workers Compensation</td>
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<td>Shipping</td>
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<td>Shipping Insurance</td>
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<tr>
<td>22</td>
<td>Import Duties and Customs</td>
<td>Lump Sum</td>
<td>1</td>
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<td>23</td>
<td>Performance Security</td>
<td>Lump Sum</td>
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<tr>
<td></td>
<td><strong>TOTAL FOR SYSTEM SUPPORT (SCHEDULE B): (Line Items 10-23)</strong></td>
<td></td>
<td></td>
<td></td>
<td>$______________</td>
</tr>
<tr>
<td></td>
<td><strong>Spare Part (Schedule C)</strong></td>
<td></td>
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<tr>
<td>24</td>
<td>Car Body - All exterior skirts and equipment covers</td>
<td>Car Set</td>
<td>1</td>
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<td></td>
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<tr>
<td>25</td>
<td>Car Body - Cab front end cover assembly</td>
<td>Each</td>
<td>1</td>
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<tr>
<td>26</td>
<td>Coupling System - Folding coupler and draft gear assembly, complete and assembled, including cables</td>
<td>Each</td>
<td>1</td>
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</tr>
<tr>
<td>Line Item Number</td>
<td>DESCRIPTION</td>
<td>Unit of Measure</td>
<td>Estimated Quantity</td>
<td>Unit Price x</td>
<td>Extended Price =</td>
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<tr>
<td>27</td>
<td>Operators Cab - Master controller, complete</td>
<td>Each</td>
<td>2</td>
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<tr>
<td>28</td>
<td>Operators Cab - Transfer switch assembly</td>
<td>Each</td>
<td>2</td>
<td></td>
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<tr>
<td>29</td>
<td>Passenger Doors - Door operator, all parts, unassembled</td>
<td>Each</td>
<td>2</td>
<td></td>
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<tr>
<td>30</td>
<td>Passenger Doors - Crew switch</td>
<td>Each</td>
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<tr>
<td>31</td>
<td>Passenger Doors - Internal door manual release mechanism</td>
<td>Each</td>
<td>2</td>
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<tr>
<td>32</td>
<td>Passenger Doors - External door manual release mechanism</td>
<td>Each</td>
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<tr>
<td>33</td>
<td>Passenger Doors - Bridgeplate assembly, complete</td>
<td>Car Set</td>
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<tr>
<td>34</td>
<td>HVAC - Air conditioning/heating unit, complete including controller</td>
<td>Each</td>
<td>2</td>
<td></td>
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<tr>
<td>35</td>
<td>HVAC - Filter/dryer</td>
<td>Each</td>
<td>20</td>
<td></td>
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<tr>
<td>36</td>
<td>HVAC - Resilient vibration isolation mounts (all)</td>
<td>Each</td>
<td>4</td>
<td></td>
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<tr>
<td>37</td>
<td>HVAC - Fresh air and return filters</td>
<td>Each</td>
<td>20</td>
<td></td>
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<tr>
<td>38</td>
<td>HVAC - HVAC control relays, all</td>
<td>Car Set</td>
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<tr>
<td>39</td>
<td>Lighting - Lenses for all lights and indicators, interior and exterior (including cab console, mounted, door, and bridge plate inductors)</td>
<td>Car Set</td>
<td>1</td>
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<tr>
<td>40</td>
<td>Electrical Equipment - Pantograph assembly, complete</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>41</td>
<td>Electrical Equipment - Pantograph shoe carbon insert set</td>
<td>Each</td>
<td>10</td>
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<tr>
<td>42</td>
<td>Electrical Equipment - Pantograph mounting insulators</td>
<td>Each</td>
<td>4</td>
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<tr>
<td>43</td>
<td>Electrical Equipment - Lightning arrester</td>
<td>Each</td>
<td>1</td>
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<tr>
<td>44</td>
<td>Electrical Equipment - High speed circuit breaker, complete</td>
<td>Each</td>
<td>1</td>
<td></td>
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<tr>
<td>45</td>
<td>Electrical Equipment - Battery box assembly including sliding tray</td>
<td>Each</td>
<td>1</td>
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<td>46</td>
<td>Electrical Equipment - Battery circuit breaker</td>
<td>Each</td>
<td>1</td>
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</tr>
<tr>
<td>Line Item Number</td>
<td>DESCRIPTION</td>
<td>Unit of Measure</td>
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<td>Extended Price =</td>
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<td>47</td>
<td>Electrical Equipment - Battery over temperature sensor</td>
<td>Each</td>
<td>1</td>
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<tr>
<td>48</td>
<td>Electrical Equipment - Auxiliary inverter, complete</td>
<td>Each</td>
<td>1</td>
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<tr>
<td>49</td>
<td>Electrical Equipment - Auxiliary inverter and LVPS power semiconductors</td>
<td>Car Set</td>
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<tr>
<td>50</td>
<td>Electrical Equipment - Knife switch assembly, complete</td>
<td>Each</td>
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<tr>
<td>51</td>
<td>Electrical Equipment - Ground Brush assembly, complete</td>
<td>Car Set</td>
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<tr>
<td>52</td>
<td>Electrical Equipment - Car mounted shop power plug assembly, complete</td>
<td>Each</td>
<td>1</td>
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<tr>
<td>53</td>
<td>Propulsion - Traction motor electrical disconnect</td>
<td>Car Set</td>
<td>1</td>
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<tr>
<td>54</td>
<td>Propulsion - Propulsion/dynamic brake resistors assembly, complete</td>
<td>Car Set</td>
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<tr>
<td>55</td>
<td>Propulsion - Propulsion AC inverter, complete, in enclosures</td>
<td>Each</td>
<td>1</td>
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<tr>
<td>56</td>
<td>Propulsion - Propulsion electronic control each, complete</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Propulsion - Fuses, all</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>58</td>
<td>Propulsion - Inverter ventilation blowers (if applicable)</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Trucks - Motor truck, complete (ready to install under car)</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>60</td>
<td>Trucks - Traction motor/gearbox assembly, coupled</td>
<td>Each</td>
<td>1</td>
<td></td>
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<tr>
<td>61</td>
<td>Trucks - Primary springs</td>
<td>Car Set</td>
<td>1</td>
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<tr>
<td>62</td>
<td>Trucks - Secondary springs</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>Trucks - Motor truck axle (machined)</td>
<td>Each</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>64</td>
<td>Trucks - Journal box or equivalent</td>
<td>Each</td>
<td>2</td>
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<tr>
<td>65</td>
<td>Trucks - Wheels, complete and assembled</td>
<td>Car Sets</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Brakes - Printed circuit cards, complete set for electronic control unit</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>Brakes - All manually controlled valves and cocks for brake equipment</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line Item Number</td>
<td>DESCRIPTION</td>
<td>Unit of Measure</td>
<td>Estimated Quantity</td>
<td>Unit Price x</td>
<td>Extended Price =</td>
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</tr>
<tr>
<td>68</td>
<td>Communications System - complete (including but not limited to control unit, speakers, microphones, emergency intercom and mounting hardware)</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Communication System – Event Recorder Assembly</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Interior/Exterior - Glazing strip, windshield</td>
<td>Each</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Interior/Exterior - Glazing strip, complete car</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td>Interior/Exterior - Seat inserts, back and bottom, complete with padding and cover</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>Interior/Exterior - Seats, complete, including complete inserts</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>Interior/Exterior - Interior ceiling panels</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>Interior/Exterior - Destination sign units, complete</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>Interior/Exterior - Exterior and interior graphics, all</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>Interior/Exterior - All floor covering (equivalent amount in rolls)</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>Interior/Exterior - Cab end replaceable caps, complete</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>Interior/Exterior - Side body panels</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Interior/Exterior - Stanchions and rails (all horizontal and vertical sections plus all fittings and hardware)</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>Interior/Exterior - Cab partition and linings, complete</td>
<td>Car Set</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>Interior/Exterior - Cab door, complete</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>Interior/Exterior - Cab shade</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>Interior/Exterior - Cab coat-hook</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>Interior/Exterior – Cab waste receptacle</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>86</td>
<td>Interior/Exterior - Cab seat, complete</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>Interior/Exterior - Master controller key</td>
<td>Each</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line Item Number</td>
<td>DESCRIPTION</td>
<td>Unit of Measure</td>
<td>Estimated Quantity</td>
<td>Unit Price x</td>
<td>Extended Price =</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>88</td>
<td>Interior/Exterior - Interior and exterior locks assemblies not part of other spare parts</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>89</td>
<td>Interior/Exterior - Flooring cove molding (if appropriate)</td>
<td>Each</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Authority reserves the right to make minor adjustments to the quantities of individual spare parts provided that the Total Price is not changed. Any such adjustments will be mutually agreed with the Contractor.

**TOTAL FOR SPARE PARTS (SCHEDULE C)** :  (Line Items 24-89)  $

**TOTAL FOR SPECIAL TOOLS (SCHEDULE D)** :  (Line Items 90-100)  $

<table>
<thead>
<tr>
<th>Special Tools (Schedule D)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>90 Propulsion System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>91 Braking System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>92 HVAC System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>93 Cable Connector Tools</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>94 Auxiliary Power System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>95 Truck</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>96 Door Systems</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>97 Communication System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>98 WabTec Coupler Adapter</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>99 Re-railing Equipment</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>100 Jack Socket Adapters</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL FOR SPECIAL TOOLS (SCHEDULE D)** :  (Line Items 90-100)  $

<table>
<thead>
<tr>
<th>Test Equipment - Portable Test Equipment and Software (Schedule E)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>101 Propulsion System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>102 Braking System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>103 HVAC System</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Line Item Number</td>
<td>DESCRIPTION</td>
<td>Unit of Measure</td>
<td>Estimated Quantity</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>104</td>
<td>Cable Connector Tools</td>
<td>Lump Sum</td>
<td>1</td>
</tr>
<tr>
<td>105</td>
<td>Auxiliary Power System</td>
<td>Lump Sum</td>
<td>1</td>
</tr>
<tr>
<td>106</td>
<td>Truck</td>
<td>Lump Sum</td>
<td>1</td>
</tr>
<tr>
<td>107</td>
<td>Door Systems</td>
<td>Lump Sum</td>
<td>1</td>
</tr>
<tr>
<td>108</td>
<td>Communication System</td>
<td>Lump Sum</td>
<td>1</td>
</tr>
</tbody>
</table>

**TOTAL FOR TEST EQUIPMENT (SCHEDULE D)** (Line Items 101-108) \$ __________

<table>
<thead>
<tr>
<th>Line Item Number</th>
<th>DESCRIPTION</th>
<th>Unit of Measure</th>
<th>Estimated Quantity</th>
<th>Unit Price ( \times )</th>
<th>Extended Price =</th>
</tr>
</thead>
<tbody>
<tr>
<td>109</td>
<td>Facilities for Final Vehicle Assembly</td>
<td>Lump Sum</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL BASE (NOT-TO- EXCEED) TOTAL:** (Line Items 1-109) \$ __________

**OPTION FOR ADDITIONAL STREETCARS**

<table>
<thead>
<tr>
<th>Line Item Number</th>
<th>DESCRIPTION</th>
<th>Unit of Measure</th>
<th>Estimated Quantity</th>
<th>Unit Price ( \times )</th>
<th>Extended Price =</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>Streetcars, in accordance with the Exhibit D, Special Provisions, paragraph 4 (Unit Price Before Escalation)</td>
<td>Each</td>
<td>Up to 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>Streetcars, in accordance with the Exhibit D, Special Provisions, paragraph 4 (Unit Price with Escalation)</td>
<td>Each</td>
<td>Up to 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NAME & TITLE OF OFFEROR'S REPRESENTATIVE:**
(print or type)

______________________________
(Name & Title)

______________________________
(Offeror's Name)

**SIGNATURE & DATE:**

______________________________
(Signature of Offeror's Representative) __/__/___
REPRESENTATIONS AND CERTIFICATIONS
(FEDERALLY ASSISTED SUPPLY/SERVICE CONTRACT)

** NOTE: THIS FORM MUST BE COMPLETED AND RETURNED WITH THE OFFER **

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REPRESENTATIONS

1. ** Affirmative Action Compliance (A-107, JAN 94) **
   
   (a) The offeror represents as part of its offer that it has a workforce of (# of employees): ______
   
   (b) It (Mark one with an "X"):

   - [ ] has developed and has on file
   - [ ] has not developed and does not have on file

   at each establishment, affirmative action programs required by the rules and regulations of the Secretary of Labor (41 CFR 60-1 and 60-2), or it (Mark one with an "X"):

   - [ ] has
   - [ ] has not

   previously had contracts subject to the written affirmative action programs requirement of the rules and regulations of the Secretary of Labor.

2. ** Contingent Fee (A-103, AUG 02) **

   Except for full-time bona fide employees working solely for the offeror, the offeror represents as part of its offer that it (Mark one with an "X"):

   - [ ] has
   - [ ] has not

   employed or retained any company or persons to solicit or obtain this contract, and (Mark one with an "X"):

   - [ ] has
   - [ ] has not

   paid or agreed to pay any person or company employed or retained to solicit or obtain this contract any commission, percentage, brokerage, or other fee contingent upon or resulting from the award of this contract.

3. ** Covenant Against Gratuities (A-105, JAN 94) **

   The offeror represents as part of its offer that neither it nor any of its employees, representatives or agents have offered
or given gratuities (in the form of entertainment, gifts or otherwise) to any director, officer or employee of the Authority with the view toward securing favorable treatment in the awarding, amending, or the making of any determination with respect to the performing of the contract. See the General Provisions Clause entitled "Interest of Public Officials."


The offeror represents as part of its offer that it (Mark one with an "X"):

- [ ] is
- [ ] is not

a disadvantaged business enterprise (DBE). A DBE is defined as "a for-profit small business concern which is at least 51 percent owned by one or more socially and economically disadvantaged individuals, or in case of any publicly owned business, at least 51 percent of the stock is owned by one or more socially and economically disadvantaged individuals and whose management and daily business operations are controlled by one or more of the socially and economically disadvantaged individuals who own it." For purposes of this definition, socially and economically disadvantaged individuals include Black Americans, Hispanic Americans, Asian-Pacific Americans, Subcontinent Asian Americans, Native Americans; women; and any additional groups whose members are designated as socially and economically disadvantaged by the Small Business Administration (SBA), at such time as the SBA designation becomes effective.

5. **Interest of Public Officials (A-104, JAN 94)**

The offeror represents and warrants that no employee, official, or member of the Board (Executive Committee) of the Authority is or will be pecuniarily interested or benefited directly or indirectly in this contract.

6. **Parent Company and Identifying Data (A-108, JAN 05)**

   (a) The offeror represents as part of its offer that it (Mark one with an "X"):

   - [ ] is
   - [ ] is not

owned or controlled by a parent company. A parent company, for the purpose of this provision, is one that owns or controls the activities and basic business policies of the offeror. To own the offering company means that the parent company must own more than 50 percent of the voting rights in that company. A company may control an offeror as a parent even though not meeting the requirements for such ownership if the company is able to formulate, determine, or veto basic policy decisions of the offeror through the use of dominant minority voting rights, use of proxy voting, or otherwise.

   (b) If the offeror is not owned or controlled by a parent company, it shall insert its own Employer's Identification Number below:

   ____________________________________________________________

   (c) If the offeror is owned or controlled by a parent company, it shall enter in the blocks below the name and main office address of the parent company, and the parent company's Employer's Identification Number.

   **NAME OF PARENT COMPANY AND MAIN OFFICE ADDRESS (INCLUDE ZIP AND PHONE):**

   ____________________________________________________________

   **PARENT COMPANY'S EMPLOYER'S IDENTIFICATION #:**

   ____________________________________________________________

7. **Previous Contracts and Compliance Reports (A-106, JAN 94)**

   (a) The offeror represents as part of its offer that it (Mark one with an "X"):

   - [ ] has
   - [ ] has not

participated in a previous contract or subcontract subject either to the Equal Opportunity clause of this solicitation, the clause originally contained in Section 310 of Executive Order Number 10925, or the clause contained in Section 201 of
Executive Order Number 11114; and

(b) It (Mark one with an "X"):

☐ has    ☐ has not

filed all required compliance reports.

(c) Representations indicating submission of required compliance reports, signed by proposed subcontractors, will be obtained before subcontractor awards.

8. **Type of Business (A-101, DEC 04)**

(a) The offeror represents as part of its offer that it operates as (Mark one with an "X"):

☐ an individual     ☐ a sole proprietorship

☐ a partnership     ☐ a corporation

☐ another entity ____________________.

(b) If incorporated, under the laws of the State of:


(c) Age of the firm: ___ years, ___ months

(d) Previous year’s annual gross receipts:

☐ less than $500K   ☐ $500K - $2 mil.   ☐ $2 mil. - $5 mil.   ☐ more than $5 mil.

**CERTIFICATIONS**

9. **Certification of Independent Price Determination (A-109, JAN 94)**

(a) By submission of this offer, the offeror certifies, and in the case of a joint offer, each party thereto certifies as to its own organization, that in connection with this procurement:

(1) The prices in this offer have been arrived at independently, without consultation, communication, or agreement, for the purpose of restricting competition, as to any matter relating to such prices with any other offeror or with any competitor.

(2) Unless otherwise required by law, the prices which have been quoted in this offer have not been knowingly disclosed by the offeror and will not knowingly be disclosed by the offeror prior to the opening (in the case of an advertised procurement) or prior to award (in the case of a negotiated procurement), directly or indirectly to any other offeror or to any competitor; and

(3) No attempt has been made or will be made by the offeror to induce any other person or firm to submit or not to submit an offer for the purpose of restricting competition.

(b) Each person signing this offer certifies that:

(1) He is the person in the offeror's organization responsible within that organization for the decision as to the prices being offered herein and that he has not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above; or

(2) He: (i) is not the person in the offeror's organization responsible within that organization for the decision as to the prices being offered herein but that he has been authorized in writing to act as an agent for the persons responsible for such decision in certifying that such persons have not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above, and as their agent does hereby so certify; and (ii) has not participated, and will not participate, in any action contrary to (a)(1) through (a)(3) above.
10. Certification of Non-Segregated Facilities (A-113, JAN 94)

(a) By the submission of this offer, the offeror certifies that it does not and will not maintain or provide for its employees any segregated facilities at any of its establishments, and that it does not and will not permit its employees to perform their services at any location under its control, where segregated facilities are maintained.

(b) The offeror agrees that a breach of this certification is a violation of the Equal Opportunity Clause in the contract.

(c) As used in this certification, the term "segregated facilities" means any waiting rooms, work areas, rest rooms and wash rooms, restaurants and other eating areas, time clocks, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees that are segregated by explicit directive or are in fact segregated on the basis of race, color, religion or nation origin, because of custom, local custom or otherwise.

(d) It further agrees that (except where it has obtained identical certifications from proposed subcontractors for specific time periods) it will:

   (1) obtain identical certifications from proposed subcontractors before the award of subcontracts under which the subcontractor will be subject to the Equal Opportunity clause;

   (2) Retain such certifications in its files; and

   (3) Forward the following notice to the proposed subcontractors (except if the proposed subcontractors have submitted identical certifications for specific time periods).

   **NOTICE TO PROSPECTIVE SUBCONTRACTORS OF REQUIREMENTS FOR CERTIFICATIONS OF NONSEGREGATED FACILITIES**

   A Certification of Nonsegregated Facilities must be submitted before the award of a subcontract under which the subcontractor will be subject to the Equal Opportunity clause. The certification may be submitted either for such subcontract or for all subcontracts during a period (i.e., quarterly, semiannually or annually).

   Note: the penalty for making false statements in offers is prescribed in 18 U.S.C. 1001.

11. Certification of Restrictions on Lobbying (A-114, NOV 04)

This Certification is applicable if the offer exceeds $100,000.

(a) By submission of this offer, the offeror certifies, to the best of his or her knowledge or belief, that:

   (1) No Federal appropriated funds have been paid, or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, or the entering into of any cooperative agreement; and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

   (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer of employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, Disclosure of Lobbying Activities, in accordance with its instructions [as amended by “Government-wide Guidance for New restrictions on Lobbying,” Fed. Reg. 1413 (1/19/96)].

   (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

(b) This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by
31 U.S.C. § 1352 (as amended by the Lobbying Disclosure Act of 1995). Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 or not more than $100,000 for each such failure.

12. **Clean Air and Water Certification (A-112, JAN 94)**

Applicable if the offer exceeds $100,000, or the Contracting Officer believes that orders under an indefinite contract in any year will exceed $100,000, or a facility to be used has been the subject of a conviction under the Air Act [42 U.S.C. 7413(c)(1)] or the Water Act [33 U.S.C. 1319 (c)], and is listed by the Environmental Protection Agency (EPA) as a violating facility, and the acquisition is not otherwise exempt.

By submission of this offer, the offeror certifies that:

(a) Any facility to be used in the performance of this proposed contract (Mark one with an "X"):

- [ ] is
- [ ] is not listed on the EPA List of Violating Facilities;

(b) It will immediately notify the Contracting Officer, before award, of the receipt of any communication from the Administrator, or a designee of the EPA, indicating that any facility which it proposes to use for the performance of the contract is under consideration to be listed on the EPA List of Violating Facilities; and

(c) It will include a certification substantially the same as this certification, including this paragraph (c), in every nonexempt subcontract.

13. **Certificate Concerning Board Members and Employees of the Authority (A-116, JAN 05)**

The Dallas Area Rapid Transit Authority (DART) has adopted Rules of Procedure for DART Board members and DART personnel policies for employees that prohibit their participation in contractual or employment relationships for certain periods after their relationship with DART ends. These prohibitions may be found in Board Resolution No. 940175 dated June 28, 1994, and the relevant DART personnel policy, respectively. These restrictions also apply to the spouses of former Board members and former employees.

For former Board members, the prohibition is for a period of one year following the end of the member's term or the date of his/her resignation, and applies to participation as a principal in a DART contract or first-tier subcontract, or as an employee of a DART contractor or first-tier subcontractor. For former DART employees, the prohibition is for one year after leaving DART, and relates to participation in any contract or employment relationship that results in an assignment to work on any DART project for which the employee had significant responsibilities. (A copy of Board Resolution No. 940175 and the relevant DART personnel policy may be obtained from the DART Contracting Officer.)

The Board of Directors may waive the above prohibitions, by a two-thirds vote, for a particular person and/or relationship if it determines that it is in the best interest of DART to do so.

(a) By submission of this offer the offeror hereby certifies that, to the best of his/her knowledge and belief, with the exception of any information described in this certification or attached hereto, the offeror has no information concerning a violation or possible violation of the DART Board Rules of Procedures as established in Resolution No. 940175, approved June 28, 1994, or the above DART personnel policy for former employees, which would result if the Authority awards a contract based upon this offer.

(b) Violations or possible violations. (Continue on plain bond paper and label Certificate Concerning Former Board Member and Employees of the Dallas Area Rapid Transit Authority, Continuation Sheet.)

CHECK "NONE" IF NONE EXISTS.

- [ ] NONE

(Please make entry in this space, if applicable.)

VIOLATIONS OR POSSIBLE VIOLATIONS:
(c) This certification concerns a material representation of fact upon which reliance will be placed in awarding a contract. If it is later determined that the offeror knowingly rendered an erroneous certification, in addition to any other remedies the Authority may have, the Contracting Officer may terminate the contract resulting from this solicitation for default and/or recommend that the offeror be debarred or suspended from doing business with the Authority in the future in accordance with the procedures set forth in the DART Procurement Regulations.

(d) The offeror shall provide immediate written notice to the Contracting Officer if, at any time prior to contract award, he/she learns that the certification was erroneous when submitted or has become erroneous by reason of changed circumstances.

(e) The offeror further agrees by submitting this bid/offer that it will include this Certificate, without modification, in all first-tier subcontracts. The offeror shall be responsible for compliance by any first-tier subcontractor with the provisions set forth in this Certificate.

14. Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion (A-126, SEP 94)

(a) Primary Covered Transactions. [This certification applies to the offer submitted in response to this solicitation and will be a continuing requirement throughout the term of the prime contract.]

(1) In accordance with the provisions of Appendix A to 49 Code of Federal Regulations (CFR) Part 29, the offeror certifies to the best of its knowledge and belief, that it and its principals:

(i) are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;

(ii) have not within a three-year period preceding this offer been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes, or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(iii) are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(ii) of this Certification; and

(iv) have not within a three-year period preceding this offer had one or more public transactions (Federal, State, or local) terminated for cause or default.

(2) Where the offeror is unable to certify to any of the statements in this certification, the offeror shall attach an explanation to this offer.

(b) Lower Tier Covered Transactions. [This certification applies to a subcontract at any tier expected to equal or exceed $25,000 and will be a continuing requirement throughout the term of the prime contract.]

(1) In accordance with the provisions of Appendix B to 49 Code of Federal Regulations (CFR) Part 29, the prospective lower tier participant (subcontractor) certifies, by submission of this offer, that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.

(2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

(c) The Certification required by subparagraph (b), above, shall be included in all applicable subcontracts and a copy kept on file by the prime contractor. The prime contractor shall be required to furnish copies of certifications to the Contracting Officer upon the Contracting Officer's request.
15. Communication Policy and Certification (A-129, JAN 05)

(a) All oral and written communications with DART regarding this solicitation should be exclusively with, or on subjects and with persons approved by, the person identified in Block 3 of the solicitation cover sheet. Discussions or communications with any other person could result in disclosure of proprietary or other competitive sensitive information or otherwise create the appearance of impropriety or unfair competition and, thereby, compromise the integrity of DART's procurement system. If competition issues cannot be resolved through normal communication channels, the DART Procurement Regulations contain protest provisions for actual or prospective competitors claiming any impropriety in connection with this procurement.

(b) By submission of this offer, the offeror certifies that it has not, and will not prior to contract award, communicate orally or in writing with any DART employee or other representative (including DART Board members, DART contractors, or DART consultants) other than the individual, or person(s) and on subjects approved by the individual, named in Block 3 of the solicitation, except as described below: (CHECK "NONE" IF NONE EXISTS.)

☐ NONE

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<tr>
<th>Name of DART Representative</th>
<th>Date and Subject of Communication</th>
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(provide attachment, if necessary)

(c) This certification concerns a material representation of fact upon which reliance will be placed in awarding a contract. If it is later determined that the offeror knowingly rendered an erroneous certification, in addition to any other remedies the Authority may have, the Contracting Officer may terminate the contract resulting from this solicitation for default and/or recommend that the offeror be debarred or suspended from doing business with the Authority in the future in accordance with the procedures set forth in DART's Procurement Regulations. In addition, a false entry could be a violation of Texas Penal Code paragraph 37.10.

(d) The offeror shall provide immediate written notice to the Contracting Officer if, at any time prior to contract award, he/she learns that its certification was, or a subsequent communication makes, the certification erroneous.

16. Conflict of Interest Certification (A-117, JAN 94)

This Certification is required to be completed if the solicitation is a Request for Proposals (not required for Invitation for Bids).

By submission of this proposal, I certify that:

(a) I have read and understand the General Provisions clause entitled "Interest of Public Officials" that will be incorporated into any contract resulting from this solicitation. I further understand that the pecuniary interest in that clause includes employment relationships.

(b) I understand the Authority has an internal conflict of interest policy for its employees which includes as an actual or possible conflict of interest whether or not a member of the employee's immediate family works for a firm doing, or seeking to do, business with the Authority.

(c) Mark one with an "X":

☐ To the best of my knowledge and belief, no employee of my firm is related to an Authority employee; or

☐ An employee of my firm is related to an Authority employee and a letter to the Contracting Officer explaining that relationship is attached to this Exhibit A.

(d) The requirement of this certification has been passed through to all first-tier subcontractors or subconsultants anticipated to be used at the time of the submission of my proposal.
17. **Disadvantaged Business Enterprise Goals (A-110, APR 04)**

If goals have been established, by submission of this offer, the offeror certifies that it will comply with the provisions of Exhibit G entitled "Disadvantaged Business Enterprise Provisions," and will meet such goals as are established in any ensuing contract.

******************************************************
SIGNATURE BLOCK FOR ALL REPRESENTATIONS & CERTIFICATIONS
******************************************************

NAME OF OFFEROR & ADDRESS (INCLUDE ZIP & PHONE)

Signature:

TYPE NAME:

DATE:

OFFERORS MUST SET FORTH FULL, ACCURATE AND COMPLETE INFORMATION AS REQUIRED BY THIS SOLICITATION (INCLUDING THIS ATTACHMENT). FAILURE TO DO SO MAY RENDER THE OFFER NONRESPONSIVE OR UNACCEPTABLE.

A FALSE STATEMENT IN ANY OFFER SUBMITTED TO THE AUTHORITY MAY BE A CRIMINAL OFFENSE IN VIOLATION OF SECTION 37.10 OF THE TEXAS PENAL CODE.
1. Introduction and Purpose of Solicitation

(a) The Dallas Area Rapid Transit Authority (the "Authority" or "DART") is a public transportation agency providing an assortment of transportation services to 13 cities in the Dallas, Texas, Metroplex. Transportation services include bus, an electric light-rail system, a commuter rail line, high occupancy vehicle (HOV) lanes, ride-share programs, curb-side services for the mobility impaired, and transit educational services.

Project Overview - The City of Dallas, a Texas home rule municipal corporation, has entered into an agreement with Dallas Area Rapid Transit to design and build the Union Station to Oak Cliff Streetcar TIGER Project (the Project). The Federal Transit Administration (FTA) is the lead federal agency for the Project. As the grant recipient, the North Central Texas Council of Governments (NCTCOG) is the Project sponsor. The Project consists of an approximately 1.6 mile streetcar alignment operating on an at-grade track in a dedicated, bi-directional streetcar lane. From Union Station over the Houston Street Viaduct, track placement will be located in the outside southbound travel lane. South of the Trinity River, the track alignment will transition to Zang Boulevard and proceed in a dedicated lane adjacent to the roadway median. At the Colorado Boulevard intersection, the track alignment will shift and extend to the westbound curb lane along Colorado Boulevard terminating at the Colorado Boulevard and Beckley Avenue intersection. There are a total of four stops, all located within the roadway right-of-way. The streetcar stop infrastructure will be minimal – consisting simply of signage and a raised curb area for level boarding. This project is expected to be the first use of the streetcar vehicles that are subject of this solicitation and resulting contract, but is not intended to be the exclusive location for use of the vehicles.

Streetcar Vehicles - DART and the City of Dallas intend to procure two new modern streetcar vehicles (Vehicles) that have the capability to operate without the use of overhead power for intermittent periods. The Vehicles will be capable of operating in either an exclusive, semi-exclusive or shared environment with automobiles. The Vehicles will contain a single or multiple articulations that will allow them to navigate the tighter curves present in an urban setting.

(b) The Authority is seeking sealed offers from qualified firms or individuals interested in providing two (2) streetcars, with an option for up to two additional vehicles, as described in Exhibit I, Specification, the solicitation Schedule, and elsewhere in this solicitation.

(c) Request for Proposals (RFP) Structure and Procedure - This is an RFP Competitive Negotiated Procurement. DART will award a contract through a competitive negotiation process as outlined in this solicitation document and consistent with all applicable laws and regulations. Proposers shall submit price and technical proposals for evaluation by the Authority. DART reserves the right to reject any and all...
proposals that do not conformed to the requirements of this solicitation. The Authority may conduct written or oral discussions regarding both technical and price proposals. The Authority may also request revised proposals and/or final revised proposals in making its Best Value selection.

(d) Examination of RFP Documentation - Each Offeror shall thoroughly examine and be familiar with all provisions and requirements of the RFP, including, but not limited to, exhibits, attachments, legal and procedural documents, general conditions, special conditions, specifications, drawings and addenda, if any, and with the Federal, state or local regulations, laws, ordinances, resolutions, environmental documents and other material referenced in the RFP. Each Offeror shall thoroughly investigate and become familiar with the conditions under which the vehicles will be operated, including, but not limited to, climate, terrain, grades, traffic congestion, legal speed limits (maximum and minimum), road configurations and anticipated loads. The submission of a proposal and any BAFO shall constitute representation upon which DART may rely that the Offeror has thoroughly examined and is familiar with all requirements of the RFP as well as with such regulations, laws, ordinances, resolutions, environmental documents and local conditions that may affect or relate to performance of the Contract, and, if awarded the Contract, Offeror agrees to comply with same. The failure or neglect of an Offeror to receive, investigate, examine or evaluate any of these requirements or other factors shall in no way relieve the Offeror from any obligations with respect to their proposal, BAFO or to the Contract. No claim for additional compensation will be allowed which is based upon a lack of knowledge or misunderstanding of any provision in the RFP, Federal, state or local regulations, laws, ordinances, resolutions, environmental documents, local conditions or any other materials referenced in the RFP.

2. Submission of Schedule of Subcontractor(s)/Subconsultant(s) (B-100.23, SEP 03)

Each offeror should include a completed Schedule of Subcontractor(s)/Subconsultant(s) form provided as Attachment 1 to Exhibit B with their offer. The contents of the form may be a factor used in determining an offeror's responsibility.

3. Evaluation and Basis for Award (B-100.03, JAN 02)

(a) One Award (B-100.03A, AUG 04)

One contract award is anticipated under this solicitation. Multiple contract awards shall not be made.

(b) Brand Name or Equal Brand Name Specifications (B-100.04E, OCT 04)

Some items called for in this solicitation are specified by Brand Name Only; or by Brand Name(s) with a listing of salient characteristics (Brand Name or Equal Brand Name).

(1) Offers for items specified as “Brand Name Only” shall be accepted only for the brand names specified by the Authority.

(2) The brand name identifications associated with items described as "Brand Name or Equal Brand Name" are not intended to be restrictive. The salient characteristics provided for each item are the minimum criteria that shall be acceptable to the Authority. Items offered must be the same brand names specified or different brand names that meet or exceed the salient characteristics listed. Offers for items that do not satisfy the required salient characteristics shall not be considered for award. The Authority reserves the right to determine if items meet or exceed the salient characteristics. Offers for "Equal Brand Name" items shall be considered for award if such items are clearly identified in the offer, and are determined by the Authority to satisfy the stipulated salient characteristics.

(c) Unit and Extended Pricing (B-100.08A, OCT 04)

Offerors shall insert the unit price and extended amount for each line item offered on the Schedule. If a line item is offered at “No Cost,” enter “No Cost” in the unit price column. Additionally, offerors shall calculate and insert the total price in the space provided on the Schedule.
(d) **Right to Reject Materially Unbalanced Offers (B-100.09A, JUL 04)**

The Authority reserves the right to reject offers that are materially unbalanced, i.e., that contain unreasonably high unit prices for some items and/or unreasonably low unit prices for other items.

(e) **All or None Pricing (B-100.10A, FEB 05)**

Failure of an offeror to provide prices for all line items listed on the Schedule may be cause for rejection of the entire offer. However, an offeror may enter "No Cost" in the unit price and extended amount columns to indicate that the item is being offered at "No Cost."

(f) **Detailed Description of Supplies/Services Not in Schedule (B-100.12A, OCT 04)**

Item descriptions in the Schedule are not intended as complete descriptions of the required supplies and/or services to be purchased under this solicitation. Complete descriptions are provided in the Specification in this solicitation document.

(g) **Evaluation of Offers Inclusive of Options (B-100.06B, JUL 04)**

The Authority shall evaluate offers for award purposes by including the total price for the basic requirement together with any option pricing, i.e., option pricing will be included in the evaluation for award purposes. Optional items shall not necessarily be purchased under this solicitation.

4. **Descriptive Literature (B-100.13B, APR 05)**

(a) Offerors should submit, as part of the technical proposal, descriptive literature for all items that are not described by specific manufacturer, and/or for items that the offeror is proposing as an "Equal Brand Name." Descriptive literature must be (1) received by the time specified in this solicitation for receipt of offers, and (2) clearly marked to identify the specific item(s) of the offer to which it applies.

(b) "Descriptive literature" means information furnished, such as cuts, illustrations, drawings, and brochures that clearly show an item’s characteristics, construction, or explains its operation.

(c) Descriptive literature is used to determine whether the item(s) offered comply with the solicitation requirements. It is used to identify details of the item(s) pertaining to such significant elements as: (1) design; (2) materials; (3) components; (4) performance characteristics; and (5) methods of manufacture, assembly, construction, and/or operation. Descriptive literature includes only that information required to determine the technical acceptability of the offered product. It does not include other information such as that used to determine a prospective contractor’s responsibility, or for maintaining the item(s).

(d) Failure of an offeror to submit any descriptive literature, or failure of the descriptive literature to clearly show that the item(s) offered conform to the requirements of this solicitation, may result in a determination by the Contracting Officer that the proposal submitted is technically unacceptable.

5. **Submission of Proposal**

DART intends to procure double sided, double ended, partial or 100% low floor streetcars. The streetcars will operate as a single one car train and must incorporate an onboard energy storage system (OESS) to permit operation through certain wireless segments in the Union Station to Oak Cliff streetcar alignment and potentially other alignments in the City of Dallas.

DART recognizes that OESS is an emerging technology with no proven examples on streetcars in revenue service in the United States to date. Offerors shall provide a thoughtful, comprehensive, and detailed response to the OESS requirements in the vehicle specifications.

Offerors shall submit a proposal consisting of both technical and price proposal components in response to this solicitation.

(a) See the Solicitation, Offer and Award Form for the number of proposal copies to submit and for the
date and time specified for receipt of offers.

(b) Technical proposals shall be submitted in two formats (1) sealed envelopes or cartons clearly marked “Technical Proposal” with the solicitation number and electronically in MS Word format or PDF file as indicated in the DART Form 33.201, block 8. NO email (s) will be accepted as submission and response to this solicitation.

c) Price proposals shall be submitted in a separately sealed envelope clearly marked “Price Proposal” with the solicitation number.

6. Proposal Preparation and Format

(a) Offerors shall submit one original , (6) copies and electronically in MS Word format or PDF file of their proposal, consisting of both technical and price components. Proposals must be received in the specific office specified on the solicitation cover sheet (Solicitation, Offer and Award Form) before June 7, 2012, 2:00 p.m., Local Dallas. Unnecessarily elaborate proposals or lengthy presentations are not desired.

(b) Proposals shall be organized as follows:

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<tr>
<th>Section</th>
<th>Description</th>
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<tr>
<td>1</td>
<td>Firm’s Introduction and Required Submittals (Forms)</td>
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<tr>
<td>2</td>
<td>Proposed Vehicle</td>
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<td>3</td>
<td>System Requirements</td>
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<td>4</td>
<td>Management’s Approach</td>
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<td>5</td>
<td>System Support Plan</td>
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<td>6</td>
<td>Qualifications of Firm</td>
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<td>7</td>
<td>Exceptions</td>
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(c) Please limit your submission to a maximum of fifty (50) pages (not including resumes). A maximum two (2) page introductory letter may be submitted within the fifty (50) page limitations. There is a limitation of up to thirty (30) pages of information directly related to the Sections 2, 3, 4, 5, and 7 listed above. The remaining pages of supportive information may include graphs, charts, photos, references etc., and is totally at the offeror’s discretion, provided the total fifty (50) page limit is maintained. Proposals that exceed these limits may be excluded from consideration --- or --- only the first fifty (50) pages will be evaluated. The Authority strongly encourages responsive information be contained in the first (30) pages.

d) Proposals will be evaluated for award based on the following “technical” to “price” split. A breakdown of points is provided below.

(1) Technical acceptability (600 Total Maximum Points) and
(2) Price (400 Total Maximum Points)

e) Technical proposals shall contain the following sections. Factors and any sub factors described with relative weights or points will be evaluated to determine whether the proposal submitted shall be characterized as “Acceptable”, “Potentially Acceptable” (that is, susceptible of being made “Acceptable”), or “Unacceptable”. Evaluation factors (with the exception of the price proposal) are specifically keyed to the information requested in this provision.

(1) Section 1 - Introduction and Submittals (No Points). Include, at a minimum, the following items, completed and signed:

(a) Solicitation, Offer and Award Form (DART Form 33.201),
(b) Exhibit A,
(c) Exhibit B, Attachment 1,
(d) Exhibit G, Attachment 1,
(e) Exhibit L
(f) Exhibit U, and
(g) Exhibit V
(h) An introductory letter with general information not provided in the above forms or with the offeror’s technical proposal.

(2) Section 2 - Proposed Vehicle per DART’s Technical Specification - General Description (150 Total Maximum Points).

Offerors shall provide a general overview description of the proposed vehicle including conceptual design drawings of the proposed vehicle, indicating all pertinent dimensions, including:

A. Preliminary artist renderings (45° front / side view)
B. General exterior and interior arrangement plans
C. Floor plan, including passenger seats and standee area (m2)
D. Exterior side and end elevations
E. Dynamic envelope diagrams
F. Roof and undercar arrangement drawings

These conceptual design drawings are intended to represent a general understanding of the requirements of the Technical Specifications and are not intended to represent precise design for initiation of the design review process.

Unique Features/Characteristics: A detailed technical explanation of the features or characteristics of the proposed vehicle that make it superior to comparable vehicles in the transit market, your explanation must include and address reliability, maintainability, or life cycle cost, inclusive of all optional items, as identified in the price schedule.

(3) Section 3 – System Requirements (200 Total maximum Points).

A. General
The offeror shall provide propulsion and braking characteristics for conventional (non-OESS) operation, including graphs of:

1. Vehicle speed vs. time and vehicle speed vs. distance
2. Tractive effort vs. speed for maximum acceleration
3. Tractive effort vs. speed for maximum braking

The offeror shall indicate if the above plots depict actual performance of an existing car or represent Proposer’s estimate of anticipated performance.

The offeror shall provide braking system performance calculations for blended and friction only service braking at maximum command at AW3 loading conditions on level, tangent track. The Proposer shall also define the stopping distance and time from 20 kph, 30 kph, 40 kph, 50 kph, and 70 kph for blended and friction-only service braking and emergency braking, and shall indicate if the above information depicts actual performance of an existing car or represents Proposer’s estimate of anticipated performance.

The offeror shall provide anticipated car weight and axle weight distribution.

The offeror shall provide exterior and interior noise data for the proposed vehicle, and shall indicate whether the data are based on an existing vehicle with similar subsystems or are estimates only.

The offeror shall provide evidence of service proven design for systems and components. DART realizes that no existing vehicles may meet all requirements of the TS, and modifications to existing designs will likely be necessary. However, proposers should base their overall vehicle design on proven subsystems to the extent possible. Concepts based on a single vehicle or hybrids of two or more existing vehicles are acceptable.
B. **Carbody Requirements**  
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of TS 3, Carbody Structure and TS 15, Interior and Exterior Appointments.

The offeror shall describe the approach used to achieve the carbody structural design load requirements and shall indicate previous experience in providing the levels of car body strength similar to those specified. If necessary, the offeror shall describe the approach required to modify an existing car to be compatible with DART’s specifications and shall describe the level of testing necessary for verification.

The offeror shall provide a narrative description and, where necessary, a graphic illustration of flooring configuration; interior step arrangement; descriptions and locations of all equipment lockers and boxes in the interior; and proposed interior lining and trim materials.

C. **Coupler Requirements**  
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of TS 4, Coupler. The narrative shall include assembly-level drawings; a description of the collision behavior of the coupler/anti-climber system; and a description of the features and operation of the coupler shroud; including procedures for opening, closing, stowing and any other operational characteristics.

D. **Operator’s Cab Requirements**  
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of Section TS 5, Operator Cab. The narrative shall include operator cab area plan and elevation drawings; a description of the proposed master controller group; and a description of the arrangement of the operator’s control console.

E. **Passenger Doors Requirement**  
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of Section TS 6, Passenger Doors. The narrative shall include a description of the general arrangement and function of the door system as well as the pushbutton arrangement.

F. **Heating, Ventilation, and Air Conditioning Requirements**  
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of Section TS 7, Heating, Ventilation and Air Conditioning. The narrative shall include a description of the cooling and heating capacities of the equipment; the general arrangement drawings of the HVAC unit and ducting; and the control functions of the heating and the cooling systems.

G. **Lighting System Requirements**  
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of TS 8, Lighting.

H. **Auxiliary Electrical Equipment Requirements**  
The offeror shall provide a narrative which addresses how the offeror intends to meet or exceed the requirements of TS 9, Auxiliary Electric Equipment. The narrative shall include a block diagram showing the proposed auxiliary power generation and distribution; a description of the auxiliary power supply, including anticipate loads, load management and load shedding, technical and performance data, “limp home” capabilities, and diagnostic capabilities; a preliminary listing of anticipated loads connected to the LVPS; a preliminary listing of the anticipated emergency loads connected to the battery; a description of the batteries, battery charger, high-speed circuit breaker, knife switch assembly; a description of the pantograph; a description of car safety grounding and power return arrangement.
A description of the on-board energy storage system shall be included in the appropriate section below.

I. **Propulsion System Requirements**
The offeror shall provide a narrative addressing how the offeror intends to meet or exceed the requirements of TS 10, Propulsion System and Controls. The narrative shall include drawings showing the general arrangement and the location of propulsion equipment on the vehicle; a description of spin/slide correction system and its interface with the braking system; a description of traction motor and gear drive; a description of propulsion control system, including interface to friction brake system; a description of propulsion system diagnostic capabilities; a description of the EMI control; and a description of overload and transient protection.

J. **Truck Assemblies Requirement**
The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of TS 11, Truck Assemblies. The narrative shall include general arrangement drawings of the proposed trucks; a description of the truck/bolster and the truck to carbody interface; a description of the proposed wheels and axles; a description of the primary and secondary suspension arrangement of the trucks, including anticipated vertical deflection of the vehicle floor from its leveled AW0 position in response to passenger loading for AW1, AW2, AW3 and AW4; and a description of suspension adjustment for wheel wear.

K. **Friction Braking Requirements**
The Proposer shall provide a narrative addressing how the Proposer intends to meet or exceed the requirements of TS 12, Friction Brake System. The narrative shall include a description of the electronic control system; a description of hardware components; a description of the diagnostic capabilities; a description of the friction brake blending method; and a description of the parking brake system and the parking brake application and release in case of failure.

L. **Vehicle Communication Requirements**
The offeror shall provide a completed Schedule of Subcontractor(s)/Subconsultant(s) form (Attachment 1 to Exhibit B), for the base supplier and one alternate supplier (if proposed).

M. **OESS**
The offeror shall provide a narrative addressing how the offeror intends to meet or exceed the requirements of TS 2, 9, 10, and 15 as they relate to the onboard energy storage system (OESS). The narrative shall include a complete description of the OESS, including number, size, weight, and proposed location of the components of the OESS; the maximum acceleration rate and maximum (balancing) speed achievable at AW0 and AW3 on level tangent track, on a 3% uphill grade, and on a 6% uphill grade; the capacity, charging and discharging rates and times, recommended charging and discharging levels, protective measures, and any temperature constraints; the run times and energy expended for operation in the Baseline wireless segments (see TS 2.6.2) on the Union Station to Oak Cliff alignment at AW2 and assuming a 20 sec stop at passenger stations and all cross streets with a minimum 2 minute dwell time at terminal stops.

DART has identified minimum performance requirements of an On-Board Energy Storage System in the Technical Specifications. DART is interested in the potential to exceed the minimum performance requirements and anticipates that this will be a significant consideration in evaluation of the Technical Proposals. Proposal narratives and performance simulations shall identify the ability to exceed or improve the minimum requirements for maximum acceleration rates and top speeds, and/or charging time.

(4) **Section 4 – Management, Key Personnel and Project Approach (100 Maximum Points).**

A. The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the requirements of Section TS 19, Program Control and Quality Assurance. Special
consideration shall be given to the contract schedule. The Project schedule requires delivery of the first vehicle to DART facilities by May 8, 2014. Proposals should include suggested measures and methods to assure schedule adherence during design, manufacture and assembly.

B. The offeror shall include a complete organization chart, including major sub-contractors, with the following information:

1. Key individuals and their departments
2. Their responsibilities within the organization
3. System integration responsibilities
4. Design, manufacturing and testing responsibilities of the Contractor and each sub-contractor or supplier for all systems and major subsystems

C. The offeror shall also provide the resumes of key personnel listed in the organization chart; a manufacturing plan indicating plants and locations for manufacture of major components and for final assembly; a narrative describing the level of engineering required to complete vehicle design and enter it into the proposed production window, and a comprehensive schedule showing key milestones. The comprehensive schedule should specifically address the ability of Proposer to deliver vehicle Number One by May 8, 2014.

D. Offeror's ability to comply with the project schedule and provide assurance that the schedule can be maintained will be extremely important. The Organization and Management Chart, Resumes, Manufacturing Plan and Schedule in conjunction shall demonstrate that there is sufficient design and production staff and plant capacity available at the times indicated in the schedule, and that processes and structures are in place or are planned to ensure that the schedule will be maintained.

E. Note that Section TS 19 of the Technical Specifications requires that the Contractor provide a Management Plan and Project Schedule for DART's review and approval after Notice to Proceed is given. The Proposal submittals required here are conceptual in nature and are intended to present a general understanding of the requirements of the Technical Specifications and demonstrate the Proposer's ability to properly perform this project. They are not intended to represent the detailed submittals required by the Technical Specifications for initiation of the design review process.

(5) **Section 5 – System Support Plan (50 Maximum Points).**

The offeror shall provide a narrative that addresses how the offeror intends to meet or exceed the quality assurance and inspection requirements of the Technical Specifications. The narrative shall include a description of the approach applied by the offeror for the incorporation of safety considerations in its design; a preliminary plan and approach for on-site support during delivery, testing and the warranty period; and representative samples of QA Plans, training materials, maintenance manuals, and parts catalogs from Proposer's previous projects that demonstrate Proposer's experience, capability and approach.

(6) **Section 6 - Qualifications of Firm (100 Maximum Points).**

A. The offeror shall provide a narrative describing the offeror capacity to perform the work under this contract. The capacity information should include annual volume figures for the past five years, facility and resource capabilities, and a listing of current commitments and ongoing projects. The narrative should describe how the offeror delivered streetcars or LRVs on a similar schedule, complete with names of properties, dates of Notice to Proceed, and acceptance and revenue service dates for the vehicles.

B. The offeror shall provide three (3) customer references to demonstrate that similar work has been successfully performed in the past. Each referenced project shall include the following information:
1. Customer's name, address, email address and telephone number of current client employee who is familiar with the Proposer's work
2. Number and type of vehicles supplied
3. Original amount of Contract
4. Amount of Change Orders
5. Amount (if any) of claims (by either party)

(7) **Section 7 – Exceptions – (No Points)**

Exceptions to RFP terms and conditions – Proposers are cautioned to limit exceptions, conditions, and limitations to the solicitation documents as they may be determined to be so fundamental as to cause rejection of the Proposal for not responding to the requirements of the RFP.

Exceptions taken to the terms and conditions of the solicitation, to any of its formal attachments or to other parts of the solicitation shall be clearly identified. Each exception shall be specifically related to each paragraph and/or specific part of the solicitation to which the exception is taken. Proposer shall provide rationale in support of the exception and fully explain its impact, if any, on the performance.

(8) **Section 8 – Price (400 Total Maximum Points)**

Price proposals should be submitted on the Schedule form provided by the Authority. Offerors shall provide a unit price and extended price in the Schedule. The Authority reserves the right to request a full breakout of costs in their price proposal. Please carefully review the “Travel Expenses” clause in Exhibit T prior to submitting pricing.

(9) **Section 9 - Promotional Literature (No Points)**

This section should contain any promotional literature submitted for informational purposes only.

7. **Evaluation of Proposals and Selection Procedure**

(a) Upon receipt of proposals, the Authority will initiate the evaluation and selection procedure described herein.

(b) The Authority’s Contracting Officer will appoint a Selection Committee to evaluate and score technical proposals. Technical proposals will be evaluated applying the evaluation factor(s) above. The evaluation team will recommend award of the contract to the responsible offeror that is most advantageous to DART. The objective of the evaluation is to determine which proposal provides the best value to DART in terms of acceptability of technical and all other evaluation factors, including price.

(c) Based on the evaluations, the Contracting Officer will determine if a technical proposal is “Acceptable”, “Potentially Acceptable” (that is, susceptible of being made “Acceptable”), or “Unacceptable”. Proposals evaluated as technically “Unacceptable” shall be rejected, and will receive no further consideration for award.

(d) In addition, the Contracting Officer will conduct an evaluation of the prices offered. The price score will be established by the following procedure:

The sealed price envelope (i.e. Schedule) will be opened by the Contracting Officer after the technical evaluation has been completed. The lowest proposed price will be assigned an unweighted Price Score of four hundred (400) points. All other Price Proposals will be prorated by the following formula:

\[
\text{Unweighted Price Score} = (2 - \frac{\text{Proposed Price}}{\text{Lowest Proposed Price}}) \times 400 \text{ Points}
\]
Unweighted Price Scores calculated to be less than zero will retain their negative value.

(e) After a complete evaluation of the initial technical and price proposals, the Contracting Officer may:

(1) Proceed directly to award of the contract based on the total scores received; or

(2) Request clarifications from offerors; and/or

(3) Request that offerors make oral presentations concerning their technical proposals. The Contracting Officer will establish the specific criteria and parameters for oral presentations. Oral presentations shall not be considered discussions. They shall be used solely to facilitate evaluation of the submitted proposals to further determine their appropriate characterization. The Contracting Officer may then proceed directly to award of the contract; or

(4) Reject any proposals subsequently determined to be “Unacceptable”; and

(5) Invite those offerors whose proposals were determined to be “Acceptable” or “Potentially Acceptable,” and in the competitive range to participate in discussions. The competitive range will consist of all proposals that have a reasonable chance of being selected for award. Discussions may address either the technical or price proposal, or both. At the conclusion of discussions, the Contracting Officer will set a time and date for the submission of best and final offers. If an offeror chooses not to submit a best and final offer, its initial proposal, to include price, will be evaluated for award. After the date and time set for receipt of best and final offers:

(i) The Contracting Officer will evaluate the best and final offers (or the initial proposal if no best and final offer is submitted) with or without referring the technical proposal of the best and final offer to the Selection Committee for evaluation.

(ii) The Contracting Officer will make a determination for award based upon the total points for both the technical and price components of each offeror’s best and final offer (or initial proposal if no best and final offer was submitted).

(iii) The Authority reserves the right, during the selection procedure, to investigate the qualifications of all offerors under consideration; to confirm any part of the information furnished by an offeror; and/or to require other evidence of managerial, financial, or technical capabilities that are considered necessary for the successful performance of work under a resulting contract.

(iv) Offerors are hereby reminded that the Authority reserves the right to award a contract following evaluation of initial proposals submitted. Offerors should therefore ensure that they submit their best technical and price proposals in their initial proposal submissions.

8. **Incorporation of Offeror’s Proposal (B-100.16A, AUG 04)**

(a) The Authority reserves the right to incorporate the successful offeror’s proposal into any resulting contract, by reference or full text. This includes any revisions and supplements through the date set for submission of best and final offers, if applicable. Additionally, any modification of the otherwise successful offer prior to award of the contract, which makes its terms more favorable to the Authority, will be considered and may be accepted.

(b) If, after contract award, it is discovered that changes were agreed to in writing during negotiations, but were not incorporated into the resulting contract, such changes shall be
considered administrative in nature and incorporated by unilateral modification at no change in
the contract cost or price, or other terms and conditions.

(c) To satisfy the contract requirements, the offeror shall adhere to the proposal approach accepted
by the Authority.

9. Requirement for Cost or Pricing Data (DPR 3-502)

(1) Except as provided in 3-502(2), cost or pricing data may be required to be submitted in support of a
proposal when:

   (a) any contract for property, services (except professional services), or construction expected to
   exceed $500,000 is to be awarded by competitive sealed proposals or by sole source procurement; or

   (b) adjusting the price of any contract for property, services (except professional services), or
   construction (including a contract awarded by competitive sealed bidding containing a Cost or Pricing
   Data Clause, whether or not cost or pricing data were required in connection with the initial pricing of
   the contract) if the adjustment involves aggregate increases and/or decreases in costs plus applicable
   profits expected to exceed $100,000. For example, the requirement applies to a $30,000 net
   modification resulting from a reduction of $70,000 and an increase of $40,000 when the reduction and
   increase are related. However, this requirement shall not apply when unrelated and separately priced
   adjustments for which cost or pricing data would not be required if considered separately are
   consolidated for administrative convenience.

(2) Cost and pricing data shall not be required:

   (a) when the contract or adjusted price is based on:

       (i) adequate price competition;

       (ii) established catalogue prices or market prices; or

       (iii) prices set by law or regulation; or

   (b) when the Vice President of Contracts determines in writing to waive the applicable requirement
   for submission of cost or pricing data in a particular pricing action and the reasons for such waiver are
   stated in the determination. A copy of such determination shall be kept in the contract file and made
   available to the public upon request.

(3) If, after cost or pricing data were initially requested and received, it is determined that adequate price
competition does exist, the data need not be certified.

(4) Any contractor required to submit and certify cost or pricing data shall be required to submit accurate,
current, and complete cost or pricing data from prospective or actual subcontractors in support of
each subcontract cost estimate included in the contractor's submission whenever the subcontract
cost estimate is either (i) more than $100,000 or (ii) more than 10% of the contractor's price for the
contract or contract modification, as the case may be. The exceptions stated in subsection (2),
above, also shall be applicable to this requirement for subcontractor cost or pricing data. Contractors
agree to include provisions in all subcontracts by which the contractor can require subcontractors to
submit cost or pricing data in accordance with this subsection in support of subcontract modifications.
While contractors shall be required to submit a subcontractor's certified cost or pricing data only from
the prospective subcontractor most likely to be awarded the subcontract, other subcontractor
quotations and information may be cost or pricing data of the contractor required to be submitted.
Prospective subcontractor cost or pricing data shall be certified to be current, accurate, and complete
as of the same date specified in contractors' certificates.
10. Certificate of Current Cost or Pricing Data (OPR 3-505)

(1) When cost or pricing data must be certified, a certificate substantially as set forth below shall be included in the contract file along with any award documentation required under these regulations. The offeror or contractor shall be required to submit the certificate as soon as practicable after agreement is reached on the contract price or adjustment.

CERTIFICATE OF CURRENT COST OR PRICING DATA

This is to certify that, to the best of my knowledge and belief, cost or pricing data as defined in the DART Procurement Regulations submitted, either actually or by specific identification, in writing, to the Contracting Officer in support of __________________________.*, are accurate, complete, and current as of (date) (month) (year) _____________________**

This certification includes the cost or pricing data supporting any advance agreement(s) between the offeror and the Authority which are part of the proposal.

Firm _______________________________________
Name _______________________________________
Title _______________________________________
Date of Execution _______________________***

(End of Certificate)

*Describe the proposal, quotation, request for price adjustment or other submission involved, giving appropriate identifying number (e.g., RFP No. ________)

**The effective date shall be a mutually determined date prior to but as close to the date when price negotiations were concluded and the contract price was agreed to as possible. The responsibility of the offeror or contractor is not limited by the personal knowledge of the offeror's or contractor's negotiator if the offeror or contractor had information reasonably available, at the time of agreement, showing that the negotiated price is not based on accurate, complete, and current data.

***This date should be as soon after the date when the price negotiations were concluded and the contract price was agreed to as practical.

(2) Although the certificate pertains to "cost or pricing data," it is not to be construed as a representation as to the accuracy of the offeror's or contractor's judgment on the estimated portion of future costs or projections. It does, however, constitute a representation as to the accuracy of the data upon which the offeror's or contractor's judgment is based. A Certificate of Current Cost or Pricing Data shall not substitute for examination and analysis of the offeror's or contractor's proposal.

(3) Whenever it is anticipated that a Certificate of Current Cost or Pricing Data may be required, notice of this requirement shall be included in the solicitation. If such a certificate is required, the contract shall include a clause giving the Authority a contract right to a reduction in the price as provided in 3-506.

(4) The exercise of an option at the price established in the initial negotiation in which certified cost or pricing were used does not require recertification or further submission of data.

11. Organizational Conflict of Interest (B-200.28A, AUG 03)

(a) The Contracting Officer has determined that this procurement may give rise to a potential organizational conflict of interest as defined in §11-102 of Chapter 11 of the DART Procurement Regulations, which states:

"An 'organizational conflict of interest' exists when the nature of the work to be performed under a proposed Authority contract may, without some form of restriction on future activities, (a) result in an
unfair competitive advantage to the contractor or (b) impair the contractor's objectivity in performing
the contract work."

(b) The successful offeror shall have access to confidential and/or sensitive DART information in the
course of contract performance. Additionally, the successful offeror may be provided access to
proprietary information obtained from other contracted entities during contract performance.

(c) To the extent that the successful offeror either (1) uses confidential and/or sensitive DART
information, or proprietary information obtained from other DART contractors, to develop any form of
document, report, or concept plan that is determined by the Contracting Officer to be the basis, in
whole or in part, of any subsequent competitive solicitation issued by the Authority, or (2) develops
written specifications that are used in any subsequent competitive solicitation issued by the Authority,
the successful offeror agrees that it shall not be eligible to compete for such subsequent competitive
solicitation(s) as a prime contractor or first-tier subcontractor, or as part of any teaming arrangement,
unless the Contracting Officer provides, in writing, a specific waiver of this restriction. The duration of
any restriction imposed under this subparagraph shall not exceed the length of the performance
period of any subsequently awarded contract for which the successful offeror was ineligible to
compete.

(d) The offeror agrees to notify the Authority, in writing, within five (5) working days after it becomes
aware of any potential or actual organizational conflict of interest pursuant to the above.


(1) All oral and written communications with DART regarding this solicitation should be exclusively
with, or on subjects and with persons approved by, the person identified in Block 3 of the
solicitation cover sheet. Discussions or communications with any other person could result in
disclosure of proprietary or other competitive sensitive information or otherwise create the
appearance of impropriety or unfair competition and, thereby, compromise the integrity of DART's
procurement system. If competition issues cannot be resolved through normal communication
channels, the DART Procurement Regulations contain protest provisions for actual or prospective
competitors claiming any impropriety in connection with this procurement.

(2) By submission of this offer, the offeror certifies that it has not, and will not prior to contract award,
communicate orally or in writing with any DART employee or other representative (including
DART Board members, DART contractors, or DART consultants) other than the individual, or
person(s) and on subjects approved by the individual, named in Block 3 of the solicitation, except
as described below: (CHECK "NONE" IF NONE EXISTS.)

   ☐ NONE

   Name of DART Representative     Date and Subject of Communication
   ____________________________________________________________
   Joe Ramirez – Contracting Officer
   ____________________________________________________________
   Jay Kline – Project Manager
   ____________________________________________________________

(3) This certification concerns a material representation of fact upon which reliance will be placed in
awarding a contract. If it is later determined that the offeror knowingly rendered an erroneous
certification, in addition to any other remedies the Authority may have, the Contracting Officer
may terminate the contract resulting from this solicitation for default and/or recommend that the
offeror be debarred or suspended from doing business with DART in the future in accordance
with the procedures set forth in DART's Procurement Regulations. In addition, a false entry could
be a violation of Texas Penal Code paragraph 37.10.
(4) The bidder/offeror shall provide immediate written notice to the Contracting Officer if, at any time prior to contract award, he/she learns that its certification was, or a subsequent communication makes, the certification erroneous.

13. **Joint Ventures (3-802.09, JUN 01)**

The Authority encourages bids or offers, as appropriate, from duly constituted Joint Ventures in response to this solicitation. The Authority intends to maximize opportunities for all vendors to participate as prime contractors and actively seeks to do business with these entities. Any offeror that submits a bid or offer as a Joint Venture must identify itself as such an entity and provide a copy with its bid or offer of the Joint Venture Agreement.
Offerors should provide information on all of their prospective subcontractor(s)/subconsultant(s) who submit bids/proposals in support of this solicitation (B-100.23A SEP 03).

**Project Name:** Streetcar Purchase  
**Solicitation Number:** P-1021774  
**Name of Prime Contractor:** _______________________________________________________

<table>
<thead>
<tr>
<th>NAMES AND ADDRESSES OF SUBCONTRACTOR(S)/SUBCONSULTANT(S)</th>
<th>TYPE OF WORK TO BE PERFORMED</th>
<th>MINORITY OR WOMAN FIRM? (Check all that apply)</th>
<th>PREVIOUS YEAR’S ANNUAL GROSS RECEIPTS</th>
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<tr>
<td>NAME:</td>
<td>TYPE OF WORK:</td>
<td>YES □</td>
<td>□ less than $500K</td>
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<td>ADDRESS:</td>
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<td>NO □</td>
<td>□ $500K - $2 mil.</td>
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<td>PHONE:</td>
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<td>□ $2 mil. - $5 mil.</td>
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<td>TAX ID #:</td>
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<td>CONTACT PERSON:</td>
<td>AGE OF FIRM:</td>
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Name/Title of Person completing this form: ____________________________________________

Signature____________________________________________ Date_____________________

Form 33.B Page 15 of 15 Exhibit B
1. **Acknowledgment of Amendments to Request for Proposals** (3-804.03, JUN 91)

(a) If this solicitation is amended, then all terms and conditions which are not modified remain unchanged.

(b) Offerors shall acknowledge receipt of any amendment to this solicitation: (1) by signing and returning the amendment; or (2) by identifying the amendment number and date in the space provided for this purpose on the form for submitting an offer; or (3) by letter or telegram. The Authority must receive the acknowledgment by the time and at the place specified for receipt of offers.

2. **Administrative Remedies** (10-102, JUN 86)

By submission of a bid, proposal, offer, or quotation in response to this solicitation, the bidder or offeror agrees to exhaust its administrative remedies under Chapter 10 of the Authority's Procurement Regulations or the Disputes Clause of any resulting contract prior to seeking judicial relief of any type in connection with any matter related to this solicitation, the award of any contract, and any dispute under any resulting contract.

3. **Authority-Furnished Property** (3-804.08, JUN 86)

No material, labor, or facilities will be furnished by the Authority unless otherwise provided for in the solicitation.

4. **Award of Contract** (3-804.07, FEB 04)

(a) The contract will be awarded to that responsible offeror whose offer, conforming to the solicitation, will be most advantageous to the Authority, price and other factors considered. A responsible offeror is one who affirmatively demonstrates to the Authority that the offeror has adequate financial resources and the requisite capacity, capability, and facilities to perform the contract within the delivery period or period of performance, has a satisfactory record of performance on other comparable projects, has a satisfactory record of integrity and business ethics, and is otherwise qualified and eligible to receive award under the solicitation and laws or regulations applicable to the procurement.

(b) The Authority reserves the right to accept other than the lowest offer, reject any or all offers in part or in total for any reason, to accept any offer if considered best for its interest, and to waive informalities and minor irregularities in offers received.

(c) The Authority may accept any item or group of items of any offer, unless the offeror qualifies the offer by specific...
limitations. Unless otherwise provided in the solicitation, offers may be submitted for any quantities less than those specified, and the Authority reserves the right to make an award on any item for a unit quantity less than the quantity offered at the unit prices offered unless the offeror specifies otherwise in the offer.

(d) A written award (or acceptance of offer) which is mailed, telegraphed, or otherwise furnished to the successful offeror within the time for acceptance specified in the solicitation shall be deemed to result in a binding contract without further action by either party.

(e) The Authority may, within the time specified therein, accept any offer or part thereof, as provided in (c) above, whether or not there are negotiations subsequent to its receipt, unless the offer is withdrawn by written notice received by the Authority prior to award. If subsequent negotiations are conducted, they shall not constitute a rejection or counter offer on the part of the Authority.

(f) The Authority may award a contract, based on initial offers received, without discussion of such offers. Accordingly, each initial offer should be submitted on the most favorable terms from a price and technical standpoint which the offeror can submit to the Authority.

(g) Any financial data submitted with any offer hereunder or any representation concerning facilities or financing will not form a part of any resulting contract; provided, however, that if the resulting contract contains a clause providing for price reduction for defective cost or pricing data, the contract price will be subject to reduction if cost or pricing data furnished hereunder is incomplete, inaccurate, or not current.

5. Buy America Provision (F-108, MAR 03)

This solicitation and the resulting contract are subject to the Buy America requirements of 49 U.S.C. § 5323(j) and the Federal Transit Administration’s implementing regulations found at 49 CFR § 661, the provisions of each of which are incorporated herein by reference. These regulations require, as a matter of responsiveness, that the bidder or offeror submit with its offer a completed certification in accordance with 49 CFR § 661.6 or § 661.12, as appropriate. These certifications are set forth in Exhibit U of this solicitation.

6. Cancellation of Solicitation (3-804.12, JUN 91)

This solicitation may be cancelled by the Authority before or after receipt of bids or proposals (as applicable) in accordance with the provisions of Section 3-300 of DART’s Procurement Regulations.

7. Confidential Data (3-804.10, FEB 96)

Each offeror may clearly mark each page of its offer that contains trade secrets or other confidential commercial or financial information which the offeror believes should not be disclosed outside the Authority. Disclosure of requested information will be determined in accordance with the Texas Open Records Act.

8. Disadvantaged Business Enterprise (DBE) Minority Participation (B-100.17A, OCT 04)

(a) It is the policy of the Authority and the Department of Transportation (DOT) to ensure that Disadvantaged Business Enterprises (DBEs), as defined in Exhibit G of this solicitation and pursuant to 49 Code of Federal Regulations (CFR) Part 26, are provided a level playing field, thus fostering an equal opportunity for them to participate in the performance of contracts financed in whole or in part with Federal funds. Consequently, the DBE requirements of 49 CFR Part 26 apply to this solicitation. In this regard, all offerors shall take all necessary and reasonable steps in accordance with 49 CFR Part 26 to ensure that DBEs have a level playing field and an opportunity to compete for and perform contracts. The Authority and all offerors shall not discriminate on the basis of race, color, national origin or sex in the award and performance of DOT-assisted contracts or subcontracts.

(b) In accordance with its DBE Policy, the Authority has established a goal for DBE participation in this solicitation. The offeror will be expected to meet or exceed, and/or demonstrate its good faith efforts to meet the goal. This goal, expressed as a percentage of the total contract price, including any increases that may occur, is:

<table>
<thead>
<tr>
<th>% DBE Participation</th>
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</table>

Note: N/A denotes not applicable to this procurement.

(c) The Authority’s DBE requirements are set forth in Exhibit G of this solicitation. Offerors are advised to carefully review Exhibit G including the requisite forms attached thereto. Offerors should undertake necessary steps to plan and
adequately provide for compliance with the stated DBE utilization goal well in advance of the date specified for the bid opening or receipt of proposals.

(d) Offerors are advised that the issue of whether or not the offeror has met or exceeded the established goal, or demonstrated sufficient good faith efforts, is considered by the Authority a matter of the offeror's responsibility. DART will only award contracts to offerors determined to be responsible.

(e) The percentage agreed to between DART and the successful offeror shall be incorporated into the contract resulting from this solicitation.

9. Discounts (3-804.06, FEB 96)

(a) Prompt payment discounts will not be considered in evaluating offers for award, unless otherwise specified in the solicitation. However, offered discounts will be taken if payment is made within the discount period, even though not considered in the evaluation of offers.

(b) In connection with any discount offered for prompt payment, time shall be computed from (1) the date of completion of performance of the services or delivery of the supplies to the carrier if acceptance is at a point of origin, or date of delivery at destination or port of embarkation if delivery and acceptance are at either of these points, or (2) the date the correct invoice or voucher is received in the office specified by the Authority, if the latter is later than the date of performance or delivery. For the purpose of computing the discount earned, payment shall be considered to have been made on the date of the Authority's check.

10. Explanation to Offerors (3-804.02, JUL 91)

Any explanation desired by an offeror regarding the meaning or interpretation of the solicitation, drawings, specifications, etc., must be requested in writing from the Authority's Contracting Officer and with sufficient time allowed for a reply to reach offerors before the submission of offers. Oral explanations or instructions given before the award of any contract, at any pre-proposal conferences or otherwise, will not be binding on the Authority. Any information given to an offeror concerning an interpretation of the solicitation, if such information is necessary to offerors in submitting offers on the solicitation or if the lack of such information would be judicial to uninformed offerors.

11. Federal Transit Administration (B-100.18C, NOV 92)

As a result of the enactment of the Federal Transit Act Amendments of 1991, the Urban Mass Transportation Administration (UMTA) was redesignated as the Federal Transit Administration (FTA). Accordingly, whenever in the solicitation reference is made to either the "Urban Mass Transportation Administration" or "UMTA", that reference shall be considered as referring to either the "Federal Transit Administration" or "FTA", as appropriate.

12. FTA Protest Procedures (B-100.18B, MAY 05)

(a) In accordance with the "Administrative Remedies" provision of this solicitation and the detailed procedures set forth in Chapter 10 of the Authority's Procurement Regulations, any interested party who is aggrieved or adversely affected in connection with this solicitation, or award of a contract as a result of this solicitation, may protest to the Vice President of Procurement, and appeal any adverse decision of the Vice President of Procurement to the Authority's Board of Directors or its duly authorized representative.

(b) Paragraph 7(l) of Federal Transit Administration (FTA) Circular 4220.1F prescribes the limited circumstances under which FTA will review a protest and establishes the detailed procedures that must be followed by a protestor. Under those procedures, FTA will only review protests submitted by an "interested party" regarding: (1) the alleged failure of the Authority to have or follow its written protest procedures, or its alleged failure to review a complaint or protest; or (2) violations of Federal law or regulation.

(c) Copies of Chapter 10 of the Authority's Procurement Regulations and/or paragraph 7(l) of FTA Circular 4220.1F will be furnished to any offeror without charge upon written request to the Contracting Officer.

13. Late Submissions, Modifications and Withdrawals of Offers (3-804.05, FEB 04)

(a) Any offer received at the office designated in the solicitation after the exact time specified for receipt will not be considered unless it is received before award is made, and:
(1) it was sent by registered or certified mail not later than the fifth calendar day prior to the date specified for receipt of offers (e.g., an offer submitted in response to a solicitation requiring receipt of offers by the 20th of the month must have been mailed by the 15th or earlier);

(2) it was sent by mail (or telegram if authorized) and it is determined by the Authority that the late receipt was due solely to mishandling by the Authority after receipt at the Authority's offices;

(3) it was sent by U. S. Postal Service Express Mail Next Day Service - Post Office to Addressee, not later than 5:00 P.M. at the place of mailing two (2) working days prior to the date specified for receipt of offers. The term "working days" excludes weekends and U. S. Federal holidays; or

(4) it is the only offer received.

(b) Any modification of an offer, except a modification resulting from the Contracting Officer's request for a "best and final" offer, is subject to the same conditions as in (a)(1) and (a)(2) of this provision.

(c) A modification resulting from the Contracting Officer's request for a "best and final" offer received after the time and date specified in the request will not be considered unless received before award, and the late receipt is due solely to mishandling by the Authority after receipt at the Authority's offices.

(d) The only acceptable evidence to establish:

(1) the date of mailing of a late offer or modification sent either by registered or certified mail is the U.S. Postal Service postmark on both the envelope or wrapper and on the original receipt from the U.S. Postal Service. If neither postmark shows a legible date, the offer, modification or withdrawal shall be deemed to have been mailed late. The term "postmark" means a printed, stamped, or otherwise placed impression, exclusive of a postage meter machine impression, that is readily identifiable without further action as having been supplied and affixed on the date of mailing by an employee of the U.S. Postal Service. Therefore, offerors should request the postal clerk to place a hand cancellation bull's-eye "postmark" on both the receipt and the envelope or wrapper; and

(2) the time of receipt at the Authority is the time-date stamp of the Authority on the offer wrapper or other documentary evidence of receipt maintained by the Authority.

(3) the date of mailing of a late offer, modification, or withdrawal sent by U. S. Postal Service Express Mail Next Day Service - Post Office to Addressee is the date entered by the post office receiving clerk on the "Express Mail Next Day Service - Post Office to Addressee" label and the postmark on the envelope or wrapper and on the original receipt from the U. S. Postal Service. "Postmark" has the same meaning as defined in paragraph (d)(1) of this provision. Therefore, offerors should request the postal clerk to place a legible hand cancellation bull's-eye "postmark" on both the receipt and the envelope or wrapper.

(e) Notwithstanding (a), (b), and (c) of this provision, a late modification of an otherwise successful offer which makes its terms more favorable to the Authority will be considered at any time it is received and may be accepted.

(f) Offers may be withdrawn by written or telegraphic notice received in accordance with § 3-203.11 (Modification or Withdrawal of Proposals). An offer may be withdrawn in person by an offeror or his offeror's authorized representative, provided the identity of the person requesting withdrawal is established and the person signs a receipt for the offer prior to award.

14. **Multiple or Alternate Offers Not Accepted (B-100.20A, AUG 05)**

(a) Definitions.

(1) Multiple offers means more than one offer submitted, each satisfying the specific stated requirements of the solicitation.

(2) Alternate offers means an offer submitted that may depart from the specific stated requirements of the solicitation.

(b) Unless otherwise specified in this solicitation, multiple or alternate offers shall not be accepted in response to this solicitation. All multiple or alternate offers shall be rejected; provided however, that if the offeror clearly identifies a primary offer, it shall be evaluated and considered for award as though it were the only offer submitted.
15. **Order of Precedence (3-804.09, JUN 86)**

In the event of any inconsistency between the provisions of the solicitation (including any resulting contract), the inconsistency shall be resolved by giving precedence in the following order: (a) the Schedule; (b) Special Solicitation Instructions and Conditions; (c) Solicitation Instructions and Conditions; (d) Special Provisions; (e) General Provisions; (f) other provisions of the contract whether incorporated by reference or otherwise; and (g) the specifications or statement of work.

16. **Preparation of Offers (3-804.01, JUL 91)**

(a) Offerors are expected to examine the Schedule, solicitation instructions, Special Provisions, General Provisions, all drawings, specifications, the statement of work, and all other provisions of, and exhibits to, the solicitation, whether incorporated by reference or otherwise, prior to the submission of offers. Failure to do so will be at the offeror's risk.

(b) Each offeror shall furnish the information required by the solicitation. Offerors shall sign and print or type their name on the form provided by the Authority for submitting an offer and each continuation sheet on which they make an entry. Erasures or other changes must be initialed by the person signing the offer. Offers signed by an agent of the offeror (other than an officer or a partner of the offeror) are to be accompanied by evidence of the agent's authority (unless such evidence has been previously furnished to the Authority).

(c) Pricing for the property or services offered shall be provided by offerors in the format required by the Authority. Where property is being offered, the prices offered shall include packing unless otherwise specified. In case of any discrepancy between a unit price and any extended or total price, the unit price will be presumed to be correct, subject, however, to correction to the same extent and in the same manner as any other mistake.

(d) Offers for property or services other than those specified in the Schedule will not be considered unless specifically authorized in the solicitation.

(e) The offeror must state a definite time for delivery of property or for performance of services unless otherwise specified in the solicitation. All measurements shall be in the system of weights and measures in common usage in the United States, and pricing shall be in U.S. dollars.

(f) In computing any period of time for the solicitation or any resulting contract, "days" means calendar days, and the day of the event from which the designated period of time begins to run shall not be included, but the last day shall be included unless it is a Saturday, Sunday, or Federal or State of Texas holiday, in which event the period shall run to the end of the next business day.

17. **Pre-Proposal Conference and Questions Concerning the Solicitation (B-100.02B, AUG 04)**

(a) A pre-proposal conference is scheduled for all interested parties to discuss the solicitation requirements, if so indicated on the Solicitation, Offer and Award Form. Details concerning the conference date, time and location are also provided.

(b) Questions and requests for clarification relating to this solicitation, shall be submitted in writing, to the contact person identified in the Solicitation, Offer and Award Form by mail, facsimile or commercial courier, at least three (3) working days in advance of the scheduled conference to allow sufficient time for responses to be considered and prepared by the Authority. Questions concerning the solicitation that are not addressed at the conference, if one is held, shall be submitted in writing no later than five (5) working days in advance of the offer submission due date and time, which is the minimum time required for the Authority's reply to reach offerors before the offer submission due date and time, as required by the "Acknowledgement of Amendments to the Request for Proposals" clause. Questions received less than five (5) working days in advance of the offer submission due date and time will be responded to only if the Authority determines that the question and its response would have a material and substantive impact on the solicitation.

(c) Questions or requests for clarification may be submitted on the form provided as Exhibit O.

18. **Procurement Confidentiality (B-100.22A, AUG 04)**

(a) Offerors are cautioned that until this solicitation is either awarded or cancelled, they may have contact only with the contact person identified in the Solicitation, Offer and Award Form. Discussions or communications regarding this
solicitation with any other personnel associated in any capacity with the Authority, its consultants, contractors or members of its Board of Directors, are strictly prohibited, unless otherwise approved in writing by the Contracting Officer.

(b) Any violation of this restriction may result in the disqualification of the offeror from further participation in this procurement, and from award of any contract or subcontract under this solicitation.

19. Submission of Offers (3-804.04, FEB 94)

(a) Offers and modifications thereof shall be enclosed in sealed envelopes or sealed cartons and submitted to the Contracting Officer of the Dallas Area Rapid Transit Authority at the address specified in the solicitation. The offeror shall show the hour and date specified in the solicitation for receipt of offers, the solicitation number, and the offeror's name, address, and telephone number on the face of the envelope or carton.

(b) Telegraphic offers will not be considered unless authorized by the solicitation; however, offers may be modified or withdrawn by written or telegraphic notice, provided such notice is received prior to the hour and date specified for receipt of offers.

(c) Samples of items, when required, must be submitted within the time specified and, unless otherwise specified in the solicitation, at no expense to the Authority. If not destroyed by testing, samples will be returned at the offeror's request and expense, unless otherwise specified in the solicitation.

(d) Each copy of the offer shall include the legal name of the offeror and a statement whether the offeror is a sole proprietorship, a corporation, or any other legal entity. An offer for a corporation shall further give the state of incorporation and have the corporate seal affixed to it.
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1. Definite Quantity/Definite Delivery (D-200.01A, AUG 90)

This is a definite quantity/definite delivery (firm-fixed price) contract for the supplies or services specified. The Authority shall purchase the quantity of supplies or services specified elsewhere in this contract and the Contractor shall deliver them in accordance with the terms and conditions stipulated in this contract.

2. Independent Contractor (Jun 86)

The Contractor at all times shall be an independent contractor. The Contractor shall be fully responsible for all acts and omissions of its employees, subcontractors, and their suppliers, and shall be specifically responsible for sufficient supervision and inspection to ensure compliance in every respect with the contract requirements. There shall be no contractual relationship between any subcontractor or supplier of the Contractor and the Authority by virtue of this contract. No provision of this contract shall be for the benefit of any party other than the Authority.

3. U.S. Shipping Allowance

The Contractor may need to provide shipping in accordance with Exhibit E, Cargo Preference – Use of United States-Flag Vessels. The current prices of all items listed on the Schedule are compiled as F.O.B. Destination by use of foreign flag vessel. If the Contractor must ship by use of a U.S. Flag Vessel the
SPECIAL PROVISIONS
EXHIBIT D

difference in price for shipping of such item contained on the Schedule will be negotiated as an equitable adjustment in accordance with the “Changes” clause located within Exhibit F. The Authority will only pay for those costs actually incurred. The Authority shall not be responsible for delays due to Cargo Preference requirements.

4. **Option for Additional Rail Vehicles**

The Contracting Officer may exercise the option by written notice to the Contractor within the period specified below. Delivery of the vehicles ordered prior to exercise of an option shall continue at the rate required by Contract, unless the parties otherwise agree.

The Contracting Officer reserves the unilateral right to purchase additional vehicles in accordance with the following:

a. During the period from the date of contract award until nine (9) months after the date of award, DART may purchase additional vehicles in minimum order quantities of one (1) vehicle at the contract price listed for Option Vehicles in the Schedule.

b. During the period starting at the tenth (10th) month after contract award and continuing until the expiration of the sixtieth (60th) month after Award, DART may purchase additional vehicles in minimum order quantities of one (1) vehicle at the contract price listed in Schedule Item Number 111. “Option for Additional Streetcars, if exercised in period beginning 10 months after Award and before expiration of 60 months after award,” adjusted in accordance with the Escalation and Currency Adjustment formulas presented below.

c. Escalation and Currency Adjustment Formulas applicable to exercise of option(s) after expiration of nine (9) months after contract award:

   i. For cost components sourced in the US:

   \[ P_o = P_b \times \frac{F_o}{F_b} \]

   Where:
   
   \( P_o \) = Option Contract Adjusted Price
   
   \( P_b \) = Option Base Price (as proposed, before adjustment)
   
   \( F_o \) = NAICS code 336510 current at Option order contract NTP date
   
   \( F_b \) = NAICS code 336510 current at Base contract NTP date

   Assumptions & Comments:

   
   2 - Option NTP date is no later than five years after Contract Award date

   ii. For cost components sourced with foreign currency rate exposure:

   \[ P_o = P_b \times \frac{E_{o}}{E_{b}} \times \frac{F_o}{F_b} \]

   Where:
   
   \( P_o \) = Option Contract Adjusted Price-in US$
   
   \( P_b \) = Option Base Price (as proposed, before adjustment)- in US$
   
   \( E_{o} \) = Exchange Rate [foreign currency/US$ rate] as published in the Wall Street Journal on the date of Base contract NTP
   
   \( E_{b} \) = Exchange Rate [foreign currency/US$ rate] as published in the Wall Street Journal on the date of Option contract NTP
   
   \( F_o \) = NAICS code 336510 current at Option contract NTP date
   
   \( F_b \) = NAICS code 336510 current at Base contract NTP date
Assumptions & Comments:
1 – US-BLS, PPI Industry Data for NAICS code 336510, Railroad Rolling Stock Manufacturing
2 - Option NTP date is no later than five years after Contract Award date

.d. For administrative purposes, cost proposals for Option vehicles will be prepared by the Contractor and processed by DART as a contract modification with the latest NACIS code and currency exchange information that is available at the time of negotiations.
   i. After NTP for the Option(s), when the NACIS code information and currency exchange is available for the actual date of NTP for each Option that is exercised, the escalation and currency correction formulas will be recalculated using the information for the date of NTP.
   ii. The difference between the Option Cost and the Option Cost based on NTP data will be determined. DART will issue a contract modification to adjust the Option Cost, plus or minus, for the difference between the two calculations.

Contractor shall submit a manufacturing, delivery and acceptance schedule for the Option vehicles for approval of the Authority. The Authority shall allow a period of performance for Option vehicles of not less than the shortest period required for Conditional Acceptance in the Milestone provision of the Base Contract Exhibit D.

5. **Contract Term**

The term of the Contract is five (5) years from the date of Award of the Contract. Period of performance may be extended as a result of exercise of option(s) prior to expiration of the base contract term, as approved by the Contracting Officer, or until required performance is completed.

The Contractor shall not proceed with any work required under this contract without a written Notice to Proceed (NTP) from the Authority. Any work performed or expenses incurred by the Contractor prior to the Contractor's receipt of written Notice to Proceed shall be entirely at the Contractor's risk.

6. **Exercise of Option (D-200.03C, JAN 02)**

(a) The Authority may exercise the option listed on the Schedule of this contract by written notice to the Contractor within the term of the contract. If feasible, the Authority shall give the Contractor a preliminary written notice of its intent to extend at least 60 days before the contract expires. The preliminary notice does not commit the Authority to an extension, and any absence of notice shall not affect the validity of any exercise of the option to extend the term of this contract.

(b) If the Authority exercises this option, the extended contract shall be considered to include this option provision.

7. **Performance Guarantee**

The Contractor shall provide performance guarantees in compliance with the requirements listed below. All items listed below are subject to acceptance by and approval of the Contracting Officer. Item "a" must be submitted within ten (10) calendar days after receipt of the Notice of Award. The Notice to Proceed shall not be issued until a properly executed "No Cost" guarantee is received and accepted by the Authority. The following items must be provided under this contract:

a. A "No-Cost" Corporate Guarantee in a commercial format that is approved by the Contracting Officer, for satisfactory completion of the project as defined in the Contract Terms and Conditions and the Technical Specification.

b. Within 10 days of Award, the Contractor shall provide either an irrevocable letter of credit or performance bond for 25% of the base contract value in a format approved by the Contracting
Officer and executed by an entity acceptable to the Contracting Officer. Upon exercise of an option, the Contract shall increase the amount of the LOC or Performance Bond accordingly. The performance period of the LOC or Performance Bond shall commence at NTP and continue until Final Acceptance of the last vehicle ordered, whether option or base contract.

c. Additionally, a "Warranty Performance Guaranty" in the amount of 5% of the final total contract value shall be provided for the period beginning at the expiration of the performance guarantee listed in the preceding paragraph, and continuing in full effect until the warranty period of the last accepted vehicle expires. All letters of credit or performance bonds and the representative financial institutions must be acceptable to the Authority.

8. **Insurance**

During the term of this Contract, the Contractor shall purchase and maintain any insurance required by this Contract. Policies shall be purchased only from companies that are authorized to do business in Texas. The Contractor shall furnish acceptable certificates of insurance to DART within ten (10) days after Contract Award, and prior to Notice to Proceed and to commencement of any Contract work. The Contractor shall pay all premiums and deductibles. **The Contractor shall indemnify DART for any liability or damages that DART may incur due to the Contractor's failure to purchase or maintain any required insurance.**

Contractor shall provide at its own expense the following insurance:

A. Workers' Compensation Insurance or its equivalent, providing benefits comparable to those provided under the Workers' Compensation Act of the State of Texas and/or any other State or Federal law or laws applicable to the Contractor's employees performing work under this contract. Employer's Liability Insurance with limits of liability of not less than $500,000 each accident, $500,000 each employee for disease and $500,000 policy limit for disease. **This insurance must be endorsed with a Waiver of Subrogation Endorsement, waiving the carrier's right of recovery under subrogation or otherwise from DART.**

B. Commercial General Liability coverage, at $5,000,000.00 minimum combined single limit bodily injury and property damage, including at a minimum the following coverage:

1. Contractual Liability covering Contractor's obligations herein
2. Personal Injury Advertising Liability
3. Medical Payments
4. Fire Damage Legal Liability
5. Broad Form Property Damage
6. Liability for Independent Contractors

C. Property damage coverage of streetcars and all other Contract deliverables, at 100% of replacement cost while in transit and prior to Conditional Acceptance.

**The insurance required under this Section shall:**

D. Contain an Additional Insured Endorsement. The policy or policies providing Commercial General Liability, and Automobile Liability shall be endorsed to name DART, and its directors, officers, representatives, agents and employees as Additional Insureds as respects operations performed by or on behalf of the Contractor in performance of this contract.

E. Require the insurer to give DART not less than thirty (30) days notice prior to termination or cancellation of coverage; and

F. Include an endorsement providing that the insurance is primary insurance and that no insurance that may be provided by DART may be called in to contribute to payment for a loss.
G. The Contractor and its subcontractors shall be solely responsible for damage to their own equipment. The Contractor shall be responsible for vehicles until they have been accepted by DART.

9. **Contractor’s Program Manager**

   The Contractor shall designate in writing its Program Manager for this Contract, and submit the qualifications to the Contracting Officer for approval. The Contractor's designated Program Manager shall be the Contractor's representative for the daily administration of the contract documents and the supervision of the work in all matters relating to the performance of the work and payment therefore. In all situations involving actual, recommended or proposed changes, the Authority shall accept commitments and instructions of the Contractor only from the Program Manager or a duly authorized representative of the Program Manager so designated in writing and approved by the Contracting Officer. After initial approval by the Authority, the Contractor shall not change the Program Manager without the prior written approval of the Authority.

10. **Final Subcontractor Data Subcontractors**

    No later than 180 days after Award, or by any such later date as may be approved by the Contracting Officer, the Contractor shall notify the Authority of its final selection of subcontractors for supply of those major subsystems identified in Exhibit G. Any subsequent change in any of those selected subcontractors must have the prior written approval of the Contracting Officer. At this time, all subcontractors must be listed on Attachment #1 to Exhibit G and submitted to the Authority in order to comply with 49 CFR Part 26.

11. **Removal of Contract Personnel or Subcontractors**

    The Contracting Officer may require, in writing, that the Contractor remove or terminate any employee, subcontractor, consultant, or supplier working on the project that the Contracting Officer deems objectionable even if previously approved. The Contractor shall include this clause in every subcontract. If the Contracting Officer requires removal or termination without cause, the Contractor may request an equitable adjustment in accordance with the terms and conditions of the "Changes" clause of this contract.

12. **Cooperation and Access**

    The Contractor shall cooperate with the Authority, City of Dallas or other entities, and with other contractors involved in the Union Station to Oak Cliff Streetcar Project and make all reasonable efforts to facilitate project progress and avoid project delays.

    The Contractor shall provide Authority representatives reasonable access to its facilities and those of its subcontractors for purposes of survey of the contract work and inspection of work processes and products, or any other purpose under this Contract. The Contractor and its subcontractors shall make available relevant engineering documents, production documents, inspection records, and other contract data necessary to verify contract compliance at any reasonable time and location.

    When requested by the Contracting Officer, the Contractor shall provide Authority representatives with office space and facilities necessary for support of DART on-site inspection activities at each Contractor plant where production, fabrication, or assembly of materials is performed.

13. **Communications/Documentation**

    a. Official communications, written, oral and data, shall be in the English language in connection with this Contract. All written communication shall be delivered either by hand delivery, by facsimile, or by first class, registered or certified mail, postage prepaid, addressed to the assigned DART Contracting Officer's Representative (COR). Telephone calls and/or emails may be used to expedite communications, but they shall not be considered "official" unless confirmed in writing.
b. A communication shall be deemed to have been "received" when it is in the actual possession of the person to whom it is addressed or that person’s designated agent. For purposes of fixing the date and time of actual receipt, that date and time shall be placed on the communication and become part of the communication for the record.

c. A Contractor whose principal language is other than English shall be required to utilize competent translators, specially skilled in the translation of technical language and shall assume the responsibility for all errors in translation. All correspondence and data transmitted to the Authority shall be prepared by or translated by such translators.

14. **Buy America Audits**

In addition to Buy America requirements of 49 CFR 661, this contract is subject to the provisions of 49 CFR Part 663, Pre-Award and Post-Delivery Audits of Rolling Stock Purchases. The Contractor shall provide such information and assistance as may be required to satisfy the requirements stated therein, to include the completion of Exhibit U, Buy America Certificate.

15. **Commercial Trade and Resale Authority**

During the performance of this contract, the Contractor must be authorized to engage in the commercial trade and resale of any item to be furnished under this contract by the manufacturer of that item.

16. **Delivery (D-200.04, JAN 02)**

   a. Milestones.

   The Contractor shall deliver to the Authority at the designated location Streetcars and all required manuals, test results completed, no later than the following dates.

   Milestone 1. Conditional or Final Acceptance of First Streetcar.
   Conditional Acceptance of first streetcar no later than May 8, 2014

   Milestone 2. Conditional or Final Acceptance of Second Streetcar.
   Conditional Acceptance of second streetcar no later than August 11, 2014

   Conditional Acceptance shall require the Streetcar to be ready for Authority Revenue Service with only minor cosmetic defects that do not impact revenue service in the manner intended by the Authority. Prior to Conditional Acceptance, the Contractor shall have approved successful test results, both static and dynamic, required by Contract, and shall have received approval for completed submittals of all required operations and maintenance manuals and training. Conditional Acceptance shall not be granted if there is any impact to Authority testing, training or revenue service as a result of Contractor’s failure to properly complete any contract requirement.

   b. Advanced Delivery Notification to the Authority (D-200.04B, AUG, 90)

      i. The Contractor shall notify the Authority ninety (90) days in advance of proposed shipment of each vehicle from the Contractor’s manufacturing facility, and provide updates on the shipment and date of delivery at least weekly thereafter until delivery is made to the location identified by the Contractor. Delivery to an Authority facility shall require prior approval of the Contracting Officer.

      ii. The Contractor shall not ship any vehicle without prior receipt of a Release for Shipment issued by the Contracting Officer.

      iii. Shipments of all other items required for delivery under this contract may be made as appropriate and without specific approval by the Contracting Officer.
iv. Neither the issuance of a Release for Shipment nor the Contractor's act of shipment of other items not requiring a Release for Shipment shall relieve the Contractor from full responsibility for compliance with all contract requirements.

c. Delivery F.O.B. Destination (D-200.04K, AUG 90)

All deliveries shall be made f.o.b. destination, within the Authority's premises. The term "FOB destination, within the Authority premises" as used in this clause, means free of expense to the Authority delivered and laid down within the doors of the Authority's premises, including delivery to specific room within a building if so specified. The Contractor shall -

i. Pack and mark the shipment to comply with specifications; or if the specifications do not contain specific packing or marking instruction, pack and mark the shipment in accordance with prevailing commercial practices and in such a manner to assure delivery in good condition and as required by this contract;

ii. Prepare and distribute commercial bills of lading;

iii. Deliver the shipment in good order and condition to the point of delivery specified in the contract;

iv. Be responsible for any loss of and/or damage to the goods occurring before receipt of the shipment by the Authority at the delivery point specified in the contract;

v. Furnish a delivery schedule and designate the mode of delivering carrier; and pay and bear all charges to the specified point of delivery.

17. Shipment

a. If shipped by sea, all vehicles or components thereof shall be suitably protected to protect against damage from handling and from exposure to the marine environment. After arrival and before manufacturing activities are initiated, all vehicles and components shall be thoroughly cleaned and inspected to insure removal of any corrosive elements and identification of any damage incurred during shipment.

b. The vehicles shall not be shipped by traveling on their own wheels. Trucks may be shipped resting on their own wheels, but the vehicle body must be blocked such that the weight is not on the trucks themselves. It is required that all sub-systems be protected from damage during shipment.

c. The vehicles shall be secured against unauthorized entry during transit by sealing closed all doors and exterior compartments. Any special temporary fittings such as straps, grab handles and locking devices required for shipment of the vehicles shall be provided and removed by the Contractor at its expense. Responsibility for the vehicles shall rest with the Contractor until delivery to an approved Authority facility.

d. Each vehicle, whether shipped by land or sea, will be equipped with an impact recorder as approved by the Contracting Officer and provided by the Contractor. The recorder shall record all handling impacts. All records shall become the property of the Authority and shall be appended to the vehicle history book. Excess impacts may be cause for rejection of a vehicle.

e. After completion of all assembly activities and incorporation of all outstanding approved modifications to the vehicle, the Contractor shall request approval for shipment of the vehicle to an approved DART facility location, or other designated destination approved by the Contracting Officer.

18. Final Acceptance
a. The Contractor shall submit for approval a minimum of 180 days prior to commencement of these scheduled activities, a "Testing and Vehicle Acceptance Plan" for each vehicle that shall include a schedule for completion and approval of all Contractor-required static and dynamic tests, and Authority acceptance activities, including Authority integrated testing, operator training and other pre-revenue activities. Contractor shall coordinate with the Authority in preparing the plan. Authority shall commence its acceptance activities for each vehicle only after successful completion of all prerequisite testing by the Contractor and approval of the Contracting Officer of all test reports and corrective actions taken by the Contractor as a result of those tests, in accordance with the Contract.

Final Acceptance of each vehicle will be deemed to have occurred when the Contracting Officer determines that all contract requirements have been fulfilled for that vehicle. At a minimum, the contract requirements for use of the Streetcar for Revenue Service in the manner intended by the Authority have been achieved, including but not limited to the following: (1) the all required vehicle technical submittals, operations and maintenance manuals have been submitted and approved; (2) vehicle has successfully completed all of the tests required for acceptance in accordance with the Contract; (3) all non-conformances and deficiencies have been resolved; (4) and all corrective actions taken by the Contractor in response to discrepancies identified during inspections of the vehicle have been approved by the Contracting Officer;

If at any time the number of delivered but unaccepted vehicles exceeds two (2) the Contracting Officer may refuse to permit delivery of additional vehicles until the number of unaccepted vehicles numbers two (2) or less.

19. Conditional Acceptance

a. The Contracting Officer, at his or her sole discretion, may Conditionally Accept any item(s) contained on the Schedule, which do not conform to the Contract requirements in all respects. If a vehicle is Conditionally Accepted, the Contracting Officer shall notify the contractor in writing of all outstanding deficiencies, which require correction prior to Final Acceptance.

b. Ownership of vehicle delivered to the Authority shall pass to the Authority at time of Final Acceptance. After Conditional Acceptance, the Contracting Officer may retain from the amount due an amount Contracting Officer determines is necessary to protect the Authority until Final Acceptance and completion of all Contract requirements... This retention shall not be released until correction of all outstanding discrepancies and Final Acceptance of the newly conformed vehicle.

c. Upon request, the Authority shall provide the Contractor reasonable access to any Conditionally Accepted vehicle for correction of outstanding discrepancies. Unless otherwise provided in writing by the Contracting Officer, the Contractor shall correct all outstanding discrepancies to achieve Acceptance no later than 90 days after date of Conditional Acceptance. After that period provided for Contractor correction of discrepancies, the Contracting Officer may obtain correction from other sources. The Contractor shall be liable for the costs incurred by the Authority for correction and for any impacts caused by failure of the Contractor to timely correct the discrepancies in a manner acceptable to the Contracting Officer...

d. Unless otherwise specified in the Contract, the Contract Warranty coverage shall begin at date of Final Acceptance.

20. Liquidated Damages (Feb 04)

(a) If the Contractor fails to deliver the supplies or perform the services within the time specified in this contract, or any extension, the Contractor shall, in place of actual damages, pay to the Authority as fixed, agreed, and liquidated damages, for each calendar day of delay, the sum set forth in the contract as "liquidated damages''.

(b) Alternatively, if delivery or performance is inexcusably delayed by the contractor, the Authority may terminate this contract in whole or in part under the Termination for Default Clause in this contract and
assess fixed, agreed, and liquidated damages accruing until the time the Authority may reasonably obtain delivery or performance of similar supplies or services. The liquidated damages shall be in addition to excess costs under the Termination Clause.

(c) The amount of liquidated damages provided in this contract is neither a penalty nor a forfeiture and shall compensate the Authority solely for the Authority’s inability to use the supplies or services and is not intended to, and does not, include: (i) any increases in financing costs resulting from the delay, or (ii) any additional services relating to, or arising as a result of, the delay. The Authority shall be entitled to claim against the Contractor for its actual damages and amounts not specifically included within the liquidated damages as set forth herein. Such costs shall be computed separately. Together with liquidated damages, they shall be either deducted from the contract price or billed to the Contractor.

(d) The Contractor shall not be charged with liquidated damages when the delay in delivery or performance arises out of causes beyond the control and without the fault or negligence of the Contractor as defined in the Termination for Default Clause in this contract.

(e) Liquidated Damages shall be assessed in the following amount for each day of delay in reaching the Milestones:

Milestone 1. Conditional Acceptance of first streetcar ordered: $3,500 per day

Milestone 2. Conditional Acceptance of second streetcar ordered $5,300 per day.

Upon exercise of any Option for additional vehicles, the Contracting Officer may establish milestones for performance of the scope of the Option and liquidated damages for the delay.

21. **Title (D-200.10B, AUG 90)**

   a) Upon delivery and prior to Final Acceptance of each vehicle to the Authority, the Contractor shall provide adequate documents for securing title in the name of the Dallas Area Rapid Transit Authority. Such transfer of title shall be required for Final Acceptance by the Authority.

   b) Following final assembly of each vehicle, delivery of the vehicle to the DART Facility identified by the Contracting Officer or other approved designated site, and Final Acceptance by the Authority, the Contractor warrants that the title of the vehicle shall pass to the Dallas Area Rapid Transit Authority. The title shall be free and clear of all liens, mortgages, and encumbrances, financing statements, security agreements, claims, and demands of any character.

22. **Invoicing and Payment**

   a. Invoices for Progress Payments may be submitted once per month to:

   **DART**
   Accounts Payable C-1021774-01
   P.O. Box 223805
   Dallas, Texas 75222-3805

   and shall conform to policies or regulations adopted from time to time by the Authority. Invoices shall be legible and shall contain, as a minimum, the following information:

   i. The contract and order number (if any);
   ii. A complete itemization of all costs including quantities ordered and delivery order numbers (if any);
   iii. Any discounts offered to the Authority under the terms of the contract
   iv. Evidence of the acceptance of the supplies or services by the Authority;
   v. Unique traceable invoice number(s); and
   vi. Any other information necessary to demonstrate entitlement to payment under the terms of the contract.
vii. Failure to provide the above critical information may result in the rejection and return of the invoice for resubmission with complete data.

b. Subject to the withholding provisions of the contract, payment shall be made within 30 days after the Authority's receipt of a properly prepared invoice.

23. **Payment Schedule (Reserved) – Will be included in subsequent amendment**

24. **Cost Principles**

Cost principles, Chapter 7 of the Authority's Procurement Regulations shall apply to this contract for pricing adjustments and/or any matter involving cost. If Chapter 7 is silent on a particular issue, then Part 31 of the Federal Acquisition Regulation shall apply. In no event shall imputed or other forms of interest be allowable for additional work or other costs or expenses.

25. **Price Reduction for Defective Cost or Pricing Data (6-203.20, JUN 86)**

   a. If any price, including profit or fee, negotiated in connection with this contract or any cost reimbursable under this contract (including any modifications thereto) was increased by any significant amount because (1) the Contractor or a subcontractor furnished cost or pricing data that were not complete, accurate, and current as certified in its respective Certificate of Current Cost or Pricing Data, (2) a subcontractor or prospective subcontractor furnished the Contractor cost or pricing data that were not complete, accurate, and current as certified in the Contractor's Certificate of Current Cost or Pricing Data, or (3) any of these parties furnished data of any description that were not accurate, the price or cost shall be reduced accordingly, and the contract shall be modified to reflect the reduction.

   b. Any reduction in the contract price under paragraph (a), above, due to defective data from a prospective subcontractor that was not subsequently awarded the subcontract shall be limited to the amount, plus applicable overhead and profit markup, by which (1) the actual subcontract or (2) the actual cost to the Contractor (if there was no subcontract) was less than the prospective subcontract cost estimate submitted by the Contractor; provided, that the actual subcontract price was not itself affected by defective cost or pricing data.

   c. Before awarding any subcontract expected to exceed $100,000 when entered into, or before pricing any subcontract modification involving a pricing adjustment expected to exceed $100,000, the Contractor shall require the subcontractor to submit cost or pricing data (actually or by specific identification in writing), unless the price of the subcontract or modification thereto is --

      i. Based on adequate price competition;
      ii. Based on established catalog or market prices of commercial items sold in substantial quantities to the general public; or
      iii. Set by law or regulation.

   d. The Contractor shall require the subcontractor to certify in substantially the form prescribed in section 3-505 of the Authority's Procurement Regulations that, to the best of its knowledge and belief, the data submitted under paragraph (a), above, were accurate, complete, and current as of the date of agreement on the negotiated price of the subcontract or subcontract modification.

   e. The substance of subparagraphs (c) and (d) and this subparagraph (e) of this clause shall be included in all subcontracts expected to exceed $100,000 when entered into.

26. **Price Reduction for Defective Cost or Pricing Data (Modifications) (6-203.21, JUN 86)**

   a. This clause shall become operative only for any modification to this contract involving aggregate increases and/or decreases in costs, plus applicable profits, of more than $100,000, except that this clause does not apply to any modification for which the price is:
i. Based on adequate price competition;
ii. Based on established catalog or market prices of commercial items sold in substantial quantities to the general public; or
iii. Set by law or regulation.

b. If any price (including profit) or fee negotiated in connection with any modification covered by this clause under paragraph (a), above, was increased by any significant amount because (1) the Contractor or subcontractor furnished cost or pricing data that were not complete, accurate, and current as certified in its respective Certificate of Current Cost or Pricing Data, (2) a subcontractor or prospective subcontractor furnished to the Contractor (in support of the subcontractor cost estimates) cost or pricing data that were not complete, accurate, and current as certified in the Contractor’s Certificate of Current Cost or Pricing Data, or (3) any of these parties furnished data of any description that were not accurate, the price shall be reduced accordingly and the contract shall be modified to reflect the reduction.

c. Any reduction in the contract price under paragraph (b), above, due to defective data from a prospective subcontractor that was not subsequently awarded the subcontract shall be limited to the amount, plus applicable overhead and profit markup, by which (1) the actual subcontract or (2) the actual cost to the Contractor (if there was no subcontract) was less than the prospective subcontract cost estimate submitted by the Contractor; provided, that the actual subcontract price was not itself affected by defective cost or pricing data.

d. Before awarding any subcontract expected to exceed $100,000 when entered into, or pricing any subcontract modification involving a pricing adjustment expected to exceed $100,000, the Contractor shall require the subcontractor to submit cost or pricing data (actually or by specific identification in writing), unless the price of the subcontract or modification thereto is --

   i. Based on adequate price competition;
   ii. Based on established catalog or market prices of commercial items sold in substantial quantities to the general public; or
   iii. Set by law or regulation.

e. The Contractor shall require the subcontractor to certify in substantially the form prescribed in section 3-505 of the Authority’s procurement regulations that, to the best of its knowledge and belief, the data submitted under paragraph (d), above, were accurate, complete, and current as of the date of agreement on the negotiated price of the subcontract or subcontract modification.

f. The Contractor shall insert the substance of subparagraphs (d) and (e) and this subparagraph (f) of this clause in each subcontract that exceeds $100,000 when entered into.

27. Technical Data Submittals

   a. Data required by this contract shall be delivered as specified in the Technical Specifications Contract Deliverable Requirements List (CDRL), or as otherwise specified. Any CDRL item which has not been scheduled in the Contract shall be included in the Contractor’s Schedule with a proposed submittal date. Any subsequent change in these scheduled submittal dates shall require prior written approval of the Contracting Officer

   b. All data submitted in accordance with the requirements of the CDRL shall be identified by the appropriate CDRL number. The CDRL identifier shall be included both on the data item and on the Contractor’s transmittal letter.

   c. All other data required by the Technical Specifications or otherwise by Contract shall be made available for review by the Contracting Officer.

   d. Failure to submit data in accordance with approved schedules shall be cause for withholding of payments.
e. Contractor data that has been approved by the Authority shall not be changed without prior approval of the Contracting Officer. Authority approval of data under this Contract shall not constitute approval for other contracts nor for other entities.

f. DART will provide any required comments or response to Contractor data submittals within the time period specified in the Contract, or, if no time is specified, within 30 days from date of receipt of the data.

g. The Contractor shall clearly mark on each page any document or information or data, in any format, that Contractor considers to contain proprietary, copyrighted or otherwise confidential information that should not be released by the Authority. DART is subject to open records requirements and cannot guarantee that information will not be released, however DART will, to the extent allowed by law, attempt to protect from public release proprietary information and trade secrets identified by the Contractor.

28. Testing

a. The Contractor shall include all testing in its Schedule, and shall also submit for approval a separate Testing and Acceptance Schedule identifying the final testing of the vehicles.

b. The Contractor shall provide reasonable notice to the Authority prior to performing all required system testing in accordance with the testing requirements provided in the Technical Specification and/or elsewhere in the contract to allow Authority representatives to witness any or all tests performed.

c. Failure of required tests may result in the necessity for retesting to demonstrate compliance with contract requirements, at the Contractor’s expense. Any costs incurred by the Authority as a result of repetition of testing may, at the election of the Contracting Officer, be deducted from the contract price. The Authority shall not be liable for cost or time of additional testing required by Contractor’s test failures.

29. Warranty (6-203.15, JUN 86)

a. Definitions. “Acceptance,” as used in this clause, means the act of an authorized representative of the Authority by which the Authority assumes for itself, or as an agent of another, ownership of existing supplies, or approves specific services as partial or complete performance of the contract.

“Correction,” as used in this clause, means the elimination of a defect.

“Supplies,” as used in this clause, means the end item furnished by the Contractor and related services required under the contract. The word does not include "data."

b. Contractor's Obligations.

i. Notwithstanding inspection and acceptance by the Authority of all supplies furnished under this contract, or any condition of this contract concerning the conclusiveness thereof, the Contractor warrants that for the periods defined in the Clause entitled “Warranty Period” of these Special Provisions:

1. All supplies furnished under this contract will be free from defects in material or workmanship and will conform with all requirements of this contract; and

2. The preservation, packaging, packing, and marking, and the preparation for and method of, shipment of such supplies will conform to the requirements of this contract.

ii. When return, correction, or replacement is required, transportation charges and responsibility for the supplies while in transit shall be borne by the Contractor. However,
the Contractor's liability for the transportation charges shall not exceed an amount equal to the cost of transportation by the usual commercial method of shipment between the place of delivery specified in this contract and the Contractor's plant, and return.

iii. Any supplies or parts thereof, corrected or furnished in replacement under this clause, shall also be subject to the terms of this clause to the same extent as supplies initially delivered. The warranty, with respect to supplies or parts thereof, shall be equal in duration to that in paragraph (b)(i) of this clause and shall run from the date of delivery of the corrected or replaced supplies.

iv. In no case shall the correction, under warranty or otherwise, of defects in design material or workmanship, result in an increase in maintenance requirements beyond those specified in the Contract Documents.

v. All implied warranties of merchantability and "fitness for a particular purpose" are excluded from any obligation contained in this contract.

vi. The contractor shall be liable for all costs associated with the removal of defective supplies or parts and reinstallation of replacement supplies or parts.

c. Remedies Available to the Authority.

i. The Contracting Officer shall give written notice to the Contractor of any breach of warranties in paragraph (b)(i) of this clause within 45 days after discovery of the defect.

ii. Within a reasonable time after the notice, the Contracting Officer may either –

1. Require, by written notice, the prompt correction or replacement of any supplies or parts thereof (including preservation, packaging, packing, and marking) that do not conform with the requirements of this contract within the meaning of paragraph (b)(1) of this clause; or

2. Retain such supplies and reduce the contract price by an amount equitable under the circumstances.

iii. If the contract provides for inspection of supplies by sampling procedures, conforming of supplies or components subject to warranty action shall be determined by the applicable sampling procedures in the contract. The Contracting Officer –

1. May, for sampling purposes, group any supplies delivered under this contract;

2. Shall require the size of the sample to be that required by sampling procedures specified in the contract for the quantity of supplies on which warranty action is proposed;

3. May project warranty sampling results over supplies in the same shipment or other supplies contained in other shipments even though all of such supplies are not present at the point of re-inspection; provided, that the supplies remaining are reasonably representative of the quantity on which warranty action is proposed; and

4. Need not use the same lot size as on original inspection or reconstitute the original inspection lots.

iv. Notwithstanding the foregoing, in the event of any emergency constituting an immediate hazard to the health or safety of the public, Authority employees or property, the Contracting Officer may undertake at the Contractor's expense and without prior notice, all work necessary to correct such hazardous conditions when it was caused by the fault of the Contractor.
v. Within a reasonable time after notice of any breach of the warranties specified in paragraph (b)(1) of this clause, the Contracting Officer may exercise one or more of the following options:

1. Require an equitable adjustment in the contract price for any group of supplies;

2. Screen the supplies grouped for warranty action under this clause at the Contractor's expense and return all nonconforming supplies to the Contractor for correction or replacement;

3. Require the Contractor to screen the supplies at locations designated by the Authority within the continental United States and to correct or replace all nonconforming supplies; or

4. Return the supplies grouped for warranty action under this clause to the Contractor (irrespective of the f.o.b. point or the point of acceptance) for screening and correction or replacement.

vi. The Contracting Officer may, by contract or otherwise, correct or replace the nonconforming supplies with similar supplies from another source and charge to the Contractor the cost occasioned to the Authority thereby if the Contractor –

1. Fails to make redelivery of the corrected or replaced supplies within the time established for their return; or

2. Fails either to accept return of the nonconforming supplies or fails to make progress after their return to correct or replace them so as to endanger performance of the delivery schedule, and in either of these circumstances does not cure such failure within a period of 10 days (or such longer period as the Contracting Officer may authorize in writing) after receipt of notice from the Contracting Officer specifying such failure.

vii. Instead of correction or replacement by the Authority, the Contracting Officer may require an equitable adjustment of the contract price. In addition, if the Contractor fails to furnish timely disposition instructions, the Contracting Officer may dispose of the nonconforming supplies for the Contractor's account in a reasonable manner. The Authority is entitled to reimbursement from the Contractor, or from the proceeds of such disposal, for the reasonable expenses of the care and disposition of the nonconforming supplies, as well as for excess costs incurred or to be incurred.

viii. The rights and remedies of the Authority provided in this clause are in addition to and do not limit any rights afforded to the Authority by law, equity, or any other clause of this contract.

30. Warranty Period – Additional Requirements

a. The warranty period of the structure of the Car body, under frame, support brackets, truck frames, axles, and the exterior painting for a period of five (5) years after the date of Final Acceptance.

b. The warranty period for all other vehicle components and systems for the vehicle which are procured under this contract will be two (2) years for each vehicle starting on the date of Final Acceptance.

c. Spare parts and extra parts/materials delivered under this contract for a period of two (2) years from acceptance of the parts/materials if not installed on a vehicle. If installed on a vehicle the spare or extra parts shall adopt the remaining warranty of the vehicle.
d. Any existing parts and materials from DART stock (not supplied under this contract) that are installed on a vehicle as part of the warranty program shall adopt the warranty life of the vehicle. In the event of failure of these existing parts during the warranty period, the Contractor will be invoiced for DART's cost to repair, rebuild or replace the item, as applicable, plus a handling charge of $100.00, for each instance.

e. Special tools and test equipment ordered under this contract for a period of two (2) years.

31. **Use of DART Property During Warranty Period**

a. With prior arrangement, the Contractor shall be allowed to use DART facilities and equipment to perform warranty work, if such work is conducted during normal hours, does not interfere with other DART activities, and is performed in accordance with DART policies and directives. Any damages to DART property resulting from use by the Contractor or its representatives shall be the sole responsibility of the Contractor and shall be corrected at the Contractor's expense.

b. When approved by the Contracting Officer, DART owned spare parts may be used for warranty purposes. The Contractor shall replenish, at its own cost, any parts so used on an item-for-item basis within sixty (60) calendar days after such use, or as approved by the Contracting Officer.

c. During the warranty period, the Contractor shall assure the replacement of all spares, whether from Contractor warranty inventory or from DART inventory, within sixty (60) calendar days of withdrawal from inventory.

32. **Certificate of Conformance (6-203.13, JUN 86)**

a. When authorized in writing by the Contracting Officer, the Contractor shall ship with a Certificate of Conformance any supplies for which the contract would otherwise require inspection at source. In no case shall the Authority's right to inspect supplies under the inspection provisions of this contract be prejudiced. Shipments of such supplies will not be made under this contract until use of the Certificate of Conformance has been authorized in writing by the Contracting Officer or inspection and acceptance have occurred.

b. The Contractor's signed certificate shall be attached to or included on the top copy of the inspection or receiving report distributed to the Authority. In addition, a copy of the signed certificate shall be attached to or entered on copies of the inspection or receiving report accompanying the shipment.

c. The Authority has the right to reject defective supplies or services within a reasonable time after delivery by written notification to the Contractor. The Contractor shall in such event promptly replace, correct, or repair the rejected supplies or services at the Contractor's expense.

d. The certificate shall read as follows:

I certify that on <___[a]___>, the <___[b]___> [insert Contractor's name] furnished the supplies or services called for by Contract No. <___[c]___> via <___[d]___> on <___[e]___> in accordance with all applicable requirements. I further certify that the supplies or services are of the quality specified and conform in all respects with the contract requirements, including specifications, drawings, testing, preservation, packaging, packing, marking requirements, and physical item identification (part number), and are in the quantity shown on this or on the attached acceptance document."

Date of Execution:<___[f]___>
Signature: <___[g]___>
Title: <___[h]___>

33. **Spare Parts Requirements**
The Contractor shall guarantee the availability of Spare Parts in accordance with the requirements of Exhibit I Specifications. All spare parts provided under this contract shall be identical in manufacturer model and part number to those installed on the vehicles accepted under this contract or as identified in the most recent approved engineering design or specification change, whichever is most current.

34. First Article Approval

All First Article approvals shall be in accordance with the Technical Specification, Exhibit I.
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The Contract clauses and provisions in this Exhibit apply to all Federally-assisted supply and service contracts. These provisions supersede and take precedence over any other clause or provision contained within this contract that may be in conflict therewith.

1. **Access Requirements for Individuals with Disabilities (F-112, JAN 94)**

   The Contractor shall comply with all applicable requirements of the Americans with Disabilities Act of 1990 (ADA), 42 U.S.C. 12101 *et seq.* and 49 U.S.C. 322; Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. 794; Section 16 of the Federal Transit Act, as amended, 49 U.S.C. app. 1612; and the following regulations and any amendments thereto:

   (1) US. DOT regulations, "Transportation Services for Individuals with Disabilities (ADA)," 49 CFR. Part 37;

   (2) US. DOT regulations, "Nondiscrimination on the Basis of Handicap in Programs and Activities Receiving or Benefiting from Federal Financial Assistance," 49 CFR. Part 27;

   (3) US. DOT regulations, "Americans with Disabilities (ADA) Accessibility Specifications for Transportation Vehicles," 49 CFR. Part 38;

   (4) Department of Justice (DOJ) regulations, "Nondiscrimination on the Basis of Disability in State and Local Government Services," 28 CFR. Part 35;

   (5) DOJ regulations, "Nondiscrimination on the Basis of Disability by Public Accommodations and in Commercial Facilities," 28 CFR. Part 36;


   (8) Federal Communications Commission regulations, "Telecommunications Relay Services and Related Customer Premises Equipment for the Hearing and Speech Disabled," 47 CFR. Part 64, Subpart F; and

   (9) FTA regulations, "Transportation for Elderly and Handicapped Persons," 49 CFR Part 609.
2. **Audit and Inspection of Records (F-110, JAN 94)**

   (a) This clause is applicable if this contract was entered into by means of negotiation and shall become operative with respect to any modification to this contract whether this contract was initially entered into by means of negotiation or by means of formal advertising.

   (b) The Contractor shall maintain records, and the Contracting Officer, the U.S. Department of Transportation, and the Comptroller General of the United States or any of their duly authorized representatives shall, until the expiration of three years after final payment under this contract, have access to and the right to examine any directly pertinent books, documents, papers and records of such Contractor, involving transactions related to the contract, for the purpose of making audit, examination, excerpts and transcriptions.

   (c) The Contractor further agrees to include in all his subcontracts hereunder a provision to the effect that the subcontractor agrees that the Contracting Officer, the US. Department of Transportation, and the Comptroller General of the United States or any of their duly authorized representatives shall, until the expiration of three years after final payment under this contract, have access to and the right to examine any directly pertinent books, documents, papers and records of such subcontractor, involving transactions related to the subcontract, for the purpose of making audit, examination, excerpts and transcriptions.

3. **Cargo Preference - Use of United States-Flag Vessels (F-109, AUG 04)**

   This clause applies to contracts involving materials, equipment, or commodities that may be transported by ocean vessel in carrying out the terms of the contract. As required by 46 C.F.R. Part 381, the Contractor agrees:

   (a) To utilize privately owned United States-Flag commercial vessels to ship at least fifty percent (50%) of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners and tankers) involved, whenever shipping any equipment, materials, or commodities pursuant to this section, to the extent such vessels are available at fair and reasonable rates for United States-Flag commercial vessels.

   (b) To furnish within twenty (20) working days following the date of loading for shipments originating with the United States, or within thirty (30) working days following the date of loading for shipments originating outside the United States, a legible copy of a rated, "on-board" commercial ocean bill-of-lading, in English, for each shipment of cargo described in paragraph (a) above to the Authority (through the Prime Contractor in the case of subcontractor bills-of-lading), to the Division of National Cargo, Office of Market Development, Maritime Administration, Washington, D.C. 20590, and to the FTA recipient, marked with appropriate identification of the Project.

   (c) To insert the substance of the provisions of this clause in all subcontracts issued pursuant to this contract that may involve the transport of equipment, material, or commodities by ocean vessel.

4. **Clean Air and Water Act (F-105, JAN 94)**

   (a) Definitions:

   (1) "Air Act," as used in this clause, means the Clean Air Act (42 U.S.C. 7401 et seq.).

   (2) "Clean air standards," as used in this clause, means:

   (i) Any enforceable rules, regulations, guidelines, standards, limitations, orders, controls, prohibitions, work practices, or other requirements contained in, issued under, or otherwise adopted under the Air Act or Executive Order 11738;

   (ii) An applicable implementation plan as described in Section 110(d) of the Air Act [42 U.S.C. 7410(d)];

   (iii) An approved implementation procedure or plan under Section 110(c) or Section 111(d) of the Air Act [42 U.S.C. 7411(c) or (d)]; or

   (iv) An approved implementation procedure under Section 112(d) of the Air Act [42 U.S.C. 7412(d)].

   (3) "Clean water standards," as used in this clause, means any enforceable limitation, control, condition, prohibition, standard, or other requirement promulgated under the Water Act or contained in a permit
issued to a discharger by the Environmental Protection Agency or by a State under an approved program, as authorized by Section 402 of the Water Act (33 U.S.C. 1342), or by local government to ensure compliance with pre-treatment regulations as required by Section 307 of the Water Act (33 U.S.C. 1317).

(4) "Compliance," as used in this clause, means compliance with:

(i) Clean air or water standards; or

(ii) A schedule or plan ordered or approved by a court of competent jurisdiction, the Environmental Protection Agency, or an air or water pollution control agency under the requirements of the Air Act or Water Act and related regulations.

(5) "Facility," as used in this clause, means any building, plant, installation, structure, mine, vessel or other floating craft, location, or site of operations, owned, leased, or supervised, by a Contractor or subcontractor, used in the performance of a contract or subcontract. When a location or site of operations includes more than one building, plant, installation, or structure, the entire location or site shall be deemed a facility except when the Administrator, or a designee of the Environmental Protection Agency, determines that independent facilities are co-located in one geographical area.

(6) "Water Act," as used in this clause, means Clean Water Act (33 U.S.C. 1251 et seq.).

(b) The Contractor agrees:

(1) To comply with all the requirements of Section 114 of the Clean Air Act (42 U.S.C. 7414) and Section 308 of the Clean Water Act (33 U.S.C. 1318) relating to inspection, monitoring, entry, reports, and information, as well as other requirements specified in Section 114 and Section 308 of the Air Act and the Water Act, and all regulations and guidelines issued to implement those acts before the award of this contract;

(2) That no portion of the work required by this prime contract will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date when this contract was awarded unless and until the EPA eliminates the name of the facility from the listing;

(3) To use best effort to comply with clean air standards and clean water standards at the facility in which the contract is being performed; and

(4) To insert the substance of this clause into any nonexempt subcontract, including this paragraph (b)(4).

5. Contract Work Hours and Safety Standards Act- Overtime Compensation-Nonconstruction (F-103, APR 12)

(a) Overtime Requirements. No Contractor or subcontractor employing laborers or mechanics for any part of the contract work shall require or permit them to work in excess of forty (40) hours in any workweek, unless they are paid at least one and one-half (1-1/2) times the basic rate of pay for all hours worked in excess of forty (40) hours in such workweek.

(b) Violation; Liability for Unpaid Wages; Liquidated Damages. In the event of any violation of the provisions set forth in paragraph (a) of this clause, the Contractor and any subcontractor responsible therefore shall be liable for the unpaid wages. In addition, such Contractor and subcontractor shall be liable to the United States (in the case of work done under contract for the District of Columbia or a territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic, including watchmen and guards, employed in violation of the provisions set forth in paragraph (a) of this clause in the sum of $10 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty (40) hours without payment of the overtime wages required by the provisions set forth in paragraph (a) of this clause.

(c) Withholding for Unpaid Wages and Liquidated Damages. The Contracting Officer shall withhold from payments due under the contract, sufficient funds required to satisfy any Contractor or subcontractor liabilities for unpaid wages and liquidated damages. If amounts withheld under the contract are insufficient to satisfy Contractor and subcontractor liabilities, the Contracting Officer shall withhold payments from other Federal or Federally-assisted contracts held by the same Contractor that are subject to the Contract Work Hours and Safety Standards Act.
(d) Payrolls and Basic Records.

(1) The Contractor or subcontractor shall maintain payrolls and basic payroll records during the course of contract work, and shall preserve them and make them available for a period of three (3) years after completion of the contract for all laborers and mechanics working on the contract. The records shall contain the name and address of each such employee, social security number, labor classification, hourly rates of wages paid, daily and weekly number of hours worked, deductions made, and actual wages paid. The records need not duplicate those required for construction work by Department of Labor regulations at 29 CFR. 5.5(a)(3) implementing the Davis-Bacon Act.

(2) The records maintained under paragraph (d)(1) of this clause shall be made available by the Contractor and its subcontractors for inspection, copying, or transcription by authorized representatives of the Contracting Officer or the Department of Labor. The Contractor or subcontractor shall allow the authorized representatives to interview employees in the workplace during working hours.

(e) Subcontracts. The Contractor or subcontractors shall insert the provisions set forth in paragraphs (a) through (e) of this clause in any subcontracts, and also require their subcontractors to include these provisions in any lower tier subcontracts. The Prime Contractor shall be responsible for compliance by any subcontractor or lower tier subcontractor with the provisions set forth in paragraphs (a) through (e) of this clause.

6. **Disadvantaged Business Enterprise (DBE) Program (F-102, NOV 99)**

   It is the policy of the Authority and the Department of Transportation that Disadvantaged Business Enterprises (DBEs) as defined in 49 CFR Part 26 shall have a level playing field and an opportunity to participate in the performance of contracts financed in whole or in part with Federal funds. Consequently, the DBE requirements of 49 CFR Part 26 apply to this contract.


8. **Equal Employment Opportunity (F-101, JAN 94)**

   This clause applies to all contracts, except contracts for standard commercial supplies or raw materials and construction. During the performance of this contract, the Contractor agrees as follows:

   (a) The Contractor shall not discriminate against any employee or applicant for employment because of race, color, creed, sex, disability, age or national origin.

   (b) The Contractor shall take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, creed, sex, disability, age, or national origin. This shall include, but not be limited to: employment; upgrading; demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship.

   (c) The Contractor shall include the provisions of paragraphs (a) and (b) of this clause in every subcontract or purchase order except for standard commercial supplies or raw materials and construction.

9. **Federal Changes (F-177, MAR 12)**

   (a) Federal Laws, Regulations, and Directives. The Authority understands and agrees that Federal laws, regulations, and directives applicable to the Project and to the Grant Agreement may be modified from time to time. In particular, new Federal laws, regulations, and directives may become effective after the Authority executes the underlying Grant Agreement for the Project, and might apply to that Agreement. The most recent of Federal laws, regulations, and directives will apply to the Agreement at any specific time, except as FTA determines otherwise in writing.
(b) The Contractor shall at all times comply with all applicable FTA regulations, policies, procedures and directives, including without limitation those listed directly or by reference in the Master Agreement between the Authority and FTA, as they may be amended or promulgated from time to time during the term of this Contract. The Contractor's failure to so comply shall constitute a material breach of this Contract.

10. **Fly America Requirements (F-130, JUL01)**

The Contractor agrees to comply with 49 U.S.C. 40118 (the "Fly America" Act) in accordance with the General Services Administration's regulations at 41 CFR Part 301-10, which provide that recipients and subrecipients of Federal funds and their contractors are required to use U.S. Flag air carriers for U.S Government-financed international air travel and transportation of their personal effects or property, to the extent such service is available, unless travel by foreign air carrier is a matter of necessity, as defined by the Fly America Act. The Contractor shall submit, if a foreign air carrier was used, an appropriate certification or memorandum adequately explaining why service by a U.S. flag air carrier was not available or why it was necessary to use a foreign air carrier and shall, in any event, provide a certificate of compliance with the Fly America requirements. The Contractor agrees to include the requirements of this section in all subcontracts that may involve international air transportation.

11. **Incorporation of Federal Transit Administration (FTA) Terms (F-133, APR 12)**

These provisions include, in part, certain Standard Terms and Conditions required by the U.S. DOT, whether or not expressly set forth herein. All contractual provisions required by DOT, as set forth in the most recent edition of FTA Circular 4220.1F, and any revisions thereto, are hereby incorporated by reference. All FTA mandated terms shall be deemed to control in the event of a conflict with other provisions contained in this contract. The Contractor shall not perform any act, fail to perform any act, or refuse to comply with any Authority requests that would cause the Authority to be in violation of the FTA terms and conditions.

12. **No Federal Government Obligations to Third Parties (F-174, MAR 12)**

Except as the Federal Government expressly consents in writing, the Authority agrees that:

(a) The Federal Government shall not be subject to any obligations or liabilities related to:

(1) The Project,

(2) Any third party participant at any tier, or

(3) Any other person or entity that is not a party (Authority or FTA) to the underlying Agreement.

(b) Notwithstanding that the Federal Government may have concurred in or approved any solicitation or third party contract at any tier that has affected the Project, the Federal Government has no obligations or liabilities to any:

(1) Third party participant, or

(2) Any other person or entity that is not a party (Authority or FTA) to the underlying Agreement.

13. **Non-Discrimination Assurance (F-128, NOV 99)**

The Contractor or subcontractor agrees that it will not discriminate on the basis of race, color, national origin or sex in the performance of this contract. The Contractor shall carry out the applicable requirements of 49 CFR Part 26 in the award and administration of DOT assisted contracts. Failure by the Contractor to carry out these requirements is a material breach of this Contract, which may result in the termination of this Contract or such other remedy as the Authority deems appropriate. The Contractor understands that it is required to insert the substance of this clause in all subcontracts and purchase orders.

14. **Notice of Federal Requirements (F-113, JAN 94)**

The Contractor is advised that Federal requirements applicable to this contract as set forth in federal law, regulations, policies, and related administrative practices may change during the performance of this contract. Any such changes shall also apply to this contract.
15. **Officials Not to Benefit (F-107, JAN 94)**

No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this contract or to any benefit arising from it. However, this clause does not apply to this contract to the extent that this contract is made with a corporation for the corporation's general benefit.

16. **Preference for Recycled Products (F-178, MAR 12)**

Except as the Federal Government determines otherwise in writing, the Contractor agrees to provide a competitive preference for products and services that conserve natural resources, protect the environment, and are energy efficient by:

(a) Complying and facilitating compliance with Section 6002 of the Resource Conservation and Recovery Act, as amended, 42 U.S.C. § 6962; and


17. **Program Fraud and False or Fraudulent Statements or Related Acts (F-132, JUL 01)**

(a) The Contractor acknowledges that the provisions of the Program Fraud Civil Remedies Act of 1986, as amended, 31 U.S.C. § 3801, et seq., and U.S. DOT regulations, "Program Fraud Civil Remedies," 49 C.F.R. Part 31, apply to its actions pertaining to this contract. Upon execution of the underlying contract, the Contractor certifies or affirms the truthfulness and accuracy of any statement it has made, it makes, it may make, or causes to be made, pertaining to the underlying contract or the FTA assisted project for which this contract work is being performed. In addition to other penalties that may be applicable, the Contractor further acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification, the Federal Government reserves the right to impose the penalties of the Program Fraud Civil Remedies Act of 1986 on the Contractor to the extent the Federal Government deems appropriate.

(b) The Contractor also acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification to the Federal Government under a contract connected with a project that is financed in whole or in part with Federal assistance originally awarded by FTA under the authority of 49 U.S.C. § 5307, the Government reserves the right to impose the penalties of 18 U.S.C. § 1001 and 49 U.S.C. § 5307(n)(1) on the Contractor, to the extent the Federal Government deems appropriate.

(c) The Contractor agrees to include the above two clauses in each subcontract financed in whole or in part with Federal assistance provided by FTA. It is further agreed that the clauses shall not be modified, except to identify the subcontractor who will be subject to the provisions.

18. **Restrictions on Lobbying (F-111, APR 12)**

Contractors that submit an offer of $100,000 or more shall file the certification required by 49 CFR Part 20, "New Restrictions on Lobbying." Each tier certifies to the tier above that it will not and has not used Federal appropriated funds to pay any person or organization for influencing or attempting to influence an officer or employee of any agency, a member of Congress, officer or employee of Congress, or an employee of a member of Congress in connection with obtaining any Federal contract, grant, or any other award covered by 31 U.S.C. § 1352. Each tier shall also disclose the name of any registrant under the Lobbying Disclosure Act of 1995 who has made lobbying contacts on its behalf with non-Federal funds with respect to that Federal contract, grant, or award covered by 31 U.S.C. § 1352. Such disclosure forms shall be forwarded from tier to tier and furnished to the Contracting Officer.

19. **Title VI Civil Rights Act of 1964 (F-104, APR 12)**

**Civil Rights** - The following requirements apply to the underlying contract:

that it will not discriminate against any employee or applicant for employment because of race, color, creed, national origin, sex, age, or disability. In addition, the Contractor agrees to comply with applicable Federal implementing regulations and other implementing requirements FTA may issue.

(b) **Equal Employment Opportunity** - The following equal employment opportunity requirements apply to the underlying contract:

1. **Race, Color, Creed, National Origin, Sex** - In accordance with Title VII of the Civil Rights Act, as amended; 42 U.S.C. § 2000e; and Federal transit laws at 49 U.S.C. § 5332, the Contractor agrees to comply with all applicable equal employment opportunity requirements of U.S. Department of Labor (U.S. DOL) regulations, "Office of Federal Contract Compliance Programs, Equal Employment Opportunity, Department of Labor," 41 C.F.R. Parts 60, et seq., (which implement Executive Order No. 11246, "Equal Employment Opportunity," as amended by Executive Order No. 11375, "Amending Executive Order 11246 Relating to Equal Employment Opportunity"; 42 U.S.C. § 2000e note; and with any applicable Federal statutes, executive orders, regulations, and Federal policies that may in the future affect construction activities undertaken in the course of the Project. The Contractor agrees to take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, creed, national origin, sex, or age. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer, recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

2. **Age** - In accordance with section 4 of the Age Discrimination in Employment Act of 1967, as amended, 29 U.S.C. § 623, and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees to refrain from discrimination against present and prospective employees for reason of age. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

3. **Disabilities** - In accordance with section 102 of the Americans with Disabilities Act, as amended, 42 U.S.C. § 12112, the Contractor agrees that it will comply with the requirements of U.S. Equal Employment Opportunity Commission, "Regulations to Implement the Equal Employment Provisions of the Americans with Disabilities Act," 29 C.F.R. Part 1630, pertaining to employment of persons with disabilities. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

(c) The Contractor also agrees to include these requirements in each subcontract financed in whole or in part with Federal assistance provided by FTA, modified only if necessary to identify the affected parties.
EXHIBIT F

GENERAL PROVISIONS
(SUPPLY CONTRACT)

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1. **Definitions (6-202.01, JUL 91)**
   
   As used throughout this contract, the following terms shall have the meaning set forth below:
   
   (a) The term "the Authority" means the Dallas Area Rapid Transit Authority; and the term "duly authorized representative" means any person or persons or board (other than the Contracting Officer) authorized in writing to act for the Authority.
   
   (b) The term "Contracting Officer" means the person executing this contract on behalf of the Authority or his duly appointed successor; and the term includes, except as otherwise provided in this contract, the authorized representative of the Contracting Officer acting within the limits of his authority.
   
   (c) Except as otherwise provided in this contract, the term "subcontracts" includes purchase orders under this contract.
   
   (d) In computing any period of time established under this contract, "days" means calendar days, and the day of the event from which the designated period of time begins to run shall not be included, but the last day shall be included unless it is a Saturday, Sunday, or Federal or State of Texas holiday, in which event the period shall run to the end of the next business day.

2. **Additional Bond Security (6-202.08, JUN 86)**
   
   The Contractor shall promptly furnish additional security required to protect the Authority and persons supplying labor or materials under this contract if --
   
   (a) any surety upon any bond furnished with this contract becomes unacceptable to the Authority;
   
   (b) any surety fails to furnish reports on its financial condition as required by the Authority; or
(c) the contract price is increased so that the penal sum of any bond becomes inadequate in the opinion of the Contracting Officer.

3. **Assignment (6-202.14, JUN 86)**

The Contractor shall not assign the whole or any part of this contract or any monies due or to become due hereunder without the prior written consent of the Contracting Officer.

4. **Authority Designated Holidays (D-200.11E, NOV 05)**

The Authority designated holidays are: New Year’s Day (January 1); Martin Luther King, Jr., Day (third Monday in January); Presidents' Day (third Monday in February); Memorial Day (last Monday in May); Independence Day (July 4); Labor Day (first Monday in September); Thanksgiving Day (fourth Thursday in November); the day after Thanksgiving (fourth Friday in November); and Christmas Day (December 25). Holidays that fall on a Saturday are observed on the Friday before the holiday. Holidays that fall on a Sunday are observed the following Monday.

5. **Changes (6-202.02, JUN 86)**

(a) The Contracting Officer may at any time, and without notice to the sureties, if any, by a written order, make changes within the general scope of this contract in any one or more of the following: (i) drawings, designs, or specifications, where the supplies to be furnished are to be specially manufactured for the Authority in accordance therewith; (ii) method of shipment or packing; and (iii) place of delivery. If any such change causes an increase or decrease in the Contractor's cost of, or the time required for, the performance of any part of the work under this contract, whether changed or not changed by the order, an equitable adjustment shall be made in the contract price or delivery schedule, or both, and the contract shall be modified in writing accordingly.

(b) Any notice of intent to assert a claim for adjustment under this clause must be asserted by the Contractor within 30 days from the date of receipt of the Contracting Officer's written order; provided, however, that later notice shall not bar the Contractor's claim if the Contractor can demonstrate that the Authority was not prejudiced by the delay in notification. In no event shall any claim be asserted after final payment.

(c) Failure to agree to any adjustment under this clause shall be a dispute concerning a question of fact within the meaning of the Disputes Clause of this contract. However, nothing in this clause shall excuse the Contractor from proceeding with the contract as changed pending resolution of the dispute.

6. **Disputes (6-202.11, MAR 90)**

(a) Except as otherwise provided in this contract, any dispute concerning a question of fact or law arising under or related to this contract which is not disposed of by agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail or otherwise furnish a copy thereof to the Contractor. The decision of the Contracting Officer shall be final and conclusive unless, on or before the 90th day from the date of receipt of such copy, the Contractor mails or otherwise furnishes a written appeal addressed to the Authority. The decision of the Authority or its duly authorized representative on such appeal shall be final and conclusive as to questions of fact unless determined by a court of competent jurisdiction to have been fraudulent, capricious, arbitrary, so grossly erroneous as necessarily to imply bad faith, or not supported by substantial evidence. The decision of the Authority or its duly authorized representative shall not be final and conclusive as to questions of law. No action challenging such decision shall be brought more than two years from the date of the Contractor's receipt of such decision. In connection with any appeal of the Contracting Officer's decision, the Contractor shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. Pending the final resolution of a dispute hereunder, the Contractor shall proceed diligently with the performance of the contract and in accordance with the Contracting Officer's decision.

(b) If it is determined, on appeal, that the Contracting Officer's interpretation of the contract, direction to the Contractor, or any other action required by the Contracting Officer's decision was an erroneous determination of the rights and obligations of the parties under the contract, the Contractor's remedy shall be the same as if such action were a change order under the Changes Clause of this contract.

7. **Equal Opportunity (6-202.15, JUN 86)**

During the performance of this contract, the Contractor agrees that it will, in good faith, afford equal opportunity required by applicable federal, state, or local law to all employees and applicants for employment without regard to race, color, religion, sex, handicapping conditions, or national origin. The Contractor further agrees to afford equal opportunity required by applicable federal, state, or local law to subcontractors and vendors which are "disadvantaged business
enterprises" or "women owned enterprises" (both as defined by federal law or regulation in effect on the date of this contract). The Contractor agrees to insert the substance of this clause in all subcontracts and purchase orders.

8. **Examination and Retention of Records (6-203.19, JUN 86)**

   (a) The Contracting Officer and his representatives shall have the audit and inspection rights described in the applicable paragraphs (b) and (c), below.

   (b) If this is a cost-reimbursement type, incentive, time and materials, labor hour, or price redeterminable contract, or any combination thereof, the Contractor shall maintain, and the Contracting Officer and his representatives shall have the right to examine, all books, records, documents, and other evidence and accounting procedures and practices sufficient to reflect properly all direct and indirect costs of whatever nature claimed to have been incurred and anticipated to be incurred for the performance of this contract. Such right of examination shall include inspection at all reasonable times at the Contractor's plants, or such parts thereof, as may be engaged in or maintain records in connection with the performance of this contract.

   (c) If the Contractor submitted certified cost or pricing data in connection with the pricing of this contract or if the Contractor's cost of performance is relevant to any change or modification to this contract, the Contracting Officer and his representatives shall have the right to examine all books, records, documents, and other data of the Contractor related to the negotiation, pricing, or performance of such contract, change, or modification for the purpose of evaluating the costs incurred and the accuracy, completeness, and currency of the cost or pricing data submitted. The right of examination shall extend to all documents necessary to permit adequate evaluation of the costs incurred and the cost or pricing data submitted, along with the computations and projections used therein.

   (d) The materials described in (b) and (c), above, shall be made available at the office of the Contractor at all reasonable times for inspection, audit, or reproduction until the expiration of three (3) years from the date of final payment under this contract, except that:

      (1) if this contract is completely or partially terminated, the records relating to the work terminated shall be made available for a period of three (3) years from the date of any final settlement; and

      (2) records which relate to appeals under the Disputes Clause of this contract or litigation, or the settlement of claims arising out of the performance of this contract, shall be made available until such appeals, litigation, or claims have been resolved.

   (e) The Contractor shall insert a clause containing all the provisions of this clause, including this paragraph (e), in all subcontracts exceeding $10,000 hereunder, altered to reflect the proper identification of the contracting parties and the Contracting Officer under the prime contract.

9. **Extras (6-202.03, JUN 86)**

   Except as otherwise provided in this contract, no payment for extras shall be made unless such extras and the prices thereof have been authorized in writing by the Contracting Officer.


    The contract price includes all applicable federal, state, and local taxes and duties. The Authority is exempt from Texas state and local sales and use taxes, and any such taxes included on any invoice or voucher received by the Authority shall be deducted from the amount of the invoice or voucher for purposes of payment.

11. **Governing Law (6-202.18, JUN 86)**

    The rights, obligations, and remedies of the parties shall be governed by the laws of the State of Texas. Whenever there is no applicable state statute or decisional precedent governing the interpretation of, or disputes arising under or related to, this contract, then federal common law, including the law developed by federal boards of contract appeals, the United States Claims Court (formerly the Court of Claims), and the Comptroller General of the United States, shall govern. Venue for any action shall lie exclusively in Dallas County, Texas. This is the complete agreement between the parties. If any provision of the contract is found to be invalid or unenforceable, the remaining provisions shall not be impaired.

12. **Indemnification (NOV 05)**
The Contractor shall fully indemnify and hold harmless the Authority and all of its directors, officers, employees, and agents from any and all contractual and negligence claims, demands, causes of action, damages, losses, and expenses (including attorney's fees) of whatsoever nature, character, or description that any person or entity has or may have arising out of or related to the breach of or failure to perform the contract or any subagreements thereunder or resulting from any negligent act, omission, misconduct, or fault of the Contractor or subcontractors and their employees and agents.

13. **Inspection (6-202.05, JUN 86)**

(a) All supplies (which term throughout this clause includes without limitation raw materials, components, intermediate assemblies, and end products) shall be subject to inspection and test by the Authority or its authorized representative, to the extent practicable, at all times (including the period of manufacture) and places and, in any event, prior to acceptance.

(b) In the event any supplies or lots of supplies are defective in material or workmanship or otherwise not in conformity with the requirements of this contract, the Authority shall have the right either to reject those supplies (with or without instructions as to their disposition) or to require their correction. Supplies or lots of supplies which have been rejected or required to be corrected shall be removed or, if permitted or required by the Contracting Officer, corrected in place by and at the expense of the Contractor promptly after notice and shall not thereafter be tendered for acceptance unless the former rejection or requirement of correction is disclosed. If the Contractor fails promptly to remove such supplies or lots of supplies which are required to be removed, or promptly to replace or correct such supplies or lots of supplies, the Authority either (i) may by contract or otherwise replace or correct such supplies and charge to the Contractor the cost occasioned the Authority thereby, or (ii) may terminate this contract for default as provided in the Termination for Default Clause of this contract. Unless the Contractor corrects or replaces such supplies within the delivery schedule, the Contracting Officer may require the delivery of such supplies at a reduction in price which is equitable under the circumstances. Failure to agree to such reduction of price shall be a dispute concerning a question of fact within the meaning of the Disputes Clause of this contract.

(c) If any inspection or test is made by the Authority or its authorized representative on the premises of the Contractor or a subcontractor, the Contractor without additional charge shall provide all reasonable facilities and assistance for the safety and convenience of the Authority's inspectors in the performance of their duties. If the Authority's inspection or test is made at a point other than the premises of the Contractor or a subcontractor, it shall be at the expense of the Authority, except as otherwise provided in this contract; provided, that in case of rejection, the Authority shall not be liable for any reduction in value of samples used in connection with such inspection or test. All inspections and tests by the Authority shall be performed in such a manner as not to unduly delay the work. The Authority reserves the right to charge to the Contractor any additional cost of the Authority's inspection and test when supplies are not ready at the time such inspection and test is required by the contract or when reinspection or retest is necessitated by prior rejection. Acceptance or rejection of the supplies shall be made as promptly as practicable after delivery, except as otherwise provided in this contract; but failure to inspect and accept or reject supplies shall neither relieve the Contractor from responsibility for such supplies as are not in accordance with the contract requirements nor impose liability on the Authority therefor.

(d) The inspection and test by the Authority of any supplies or lots thereof does not relieve the Contractor from any responsibility regarding defects or other failures to meet the contract requirements which may be discovered prior to acceptance. Except as otherwise provided in this contract, acceptance shall be conclusive except for latent defects, fraud, or such gross mistakes as amount to fraud.

14. **Interest of Public Officials (6-202.16, JUN 86)**

The Contractor represents and warrants that no employee, official, or member of the Board (Executive Committee) of the Authority is or will be pecuniarily interested or benefited directly or indirectly in this contract. The Contractor further represents and warrants that it has not offered or given gratuities (in the form of entertainment, gifts, or otherwise) to any employee, official, or member of the Board (Executive Committee) of the Authority with a view toward securing favorable treatment in the awarding, amending, or evaluating the performance of this contract. For breach of any representation or warranty in this clause, the Authority shall have the right to annul this contract without liability and/or have recourse to any other remedy it may have at law.

15. **Licenses and Permits (D-200.18A, FEB 91)**

The Contractor shall, without additional expense to the Authority, be responsible for obtaining any necessary licenses, permits, and approvals for complying with any federal, state, county, municipal, and other laws, codes, and regulations applicable to the performance of the work or to the products or services to be provided under this contract including, but
16. **Manufacturer’s Warranty (D-200.12A, JAN 02)**

Any and all standard manufacturer’s warranties shall accrue to the benefit of the Authority. The manufacturer’s warranties referenced herein shall be in addition to any contractual remedies set forth in this contract, and in addition to any and all other statutory remedies or warranties imposed on the Contractor for the benefit of the Authority.

17. **New Material (6-203.03, JUN 86)**

Unless this contract specifies otherwise, the Contractor represents that the supplies and components (including any former property of the Authority identified in this contract) are new, including recycled (not used or reconditioned) and are not of such age or so deteriorated as to impair their usefulness or safety. If the Contractor believes that furnishing used or reconditioned supplies or components will be in the Authority's interest, the Contractor shall so notify the Contracting Officer in writing. The Contractor's notice shall include the reasons for the request along with a proposal for any consideration to the Authority if the Contracting Officer authorizes the use of used or reconditioned supplies or components.

18. **Notice of Labor Disputes (6-203.06, JUN 86)**

(a) If the Contractor has knowledge that any actual or potential labor dispute is delaying or threatens to delay the timely performance of this contract, the Contractor immediately shall give notice, including all relevant information, to the Contracting Officer.

(b) The Contractor agrees to insert the substance of this clause, including this paragraph (b), in any subcontract under which a labor dispute may delay the timely performance of this contract; except that each subcontract shall provide that in the event its timely performance is delayed or threatened by delay by any actual or potential labor dispute, the subcontractor shall immediately notify the next higher tier subcontractor or the Contractor, as the case may be, of all relevant information concerning the dispute.

19. **Order of Precedence (3-802.10, JUN 86)**

In the event of any inconsistency between the provisions of the solicitation (including any resulting contract), the inconsistency shall be resolved by giving precedence in the following order: (a) the Schedule; (b) Special Solicitation Instructions and Conditions; (c) Solicitation Instructions and Conditions; (d) Special Provisions; (e) General Provisions; (f) other provisions of the contract whether incorporated by reference or otherwise; and (g) the specifications or statement of work.

20. **Payments (6-202.07, JUN 86)**

The Contractor shall be paid, upon the submission of proper invoices or vouchers, the prices stipulated herein for supplies delivered and accepted or services rendered and accepted, less deductions, if any, as herein provided. Unless otherwise specified, payment will be made on partial deliveries accepted by the Authority when the amount due on such deliveries so warrants; or, when requested by the Contractor, payment for accepted partial deliveries shall be made whenever such payment would equal or exceed either $1,000 or 50% of the total amount of this contract.

21. **Payment of Interest on Contractor's Claims (6-202.12, JUN 86)**

(a) If an appeal is filed by the Contractor from a final decision of the Contracting Officer under the Disputes Clause of this contract, denying a claim arising under the contract, simple interest on the amount of the claim finally determined to be owed by the Authority shall be payable to the Contractor. Such interest shall be at the rates determined by the United States Secretary of the Treasury from time to time pursuant to Public Law 92-41, 85 Stat. 97, from the date the Contractor furnishes to the Contracting Officer his written appeal under the Disputes Clause of this contract, to the date of (1) a final judgment by a court of competent jurisdiction, or (2) mailing to the Contractor of a supplemental agreement for execution either confirming completed negotiations between the parties or carrying out a decision of the Authority or its duly authorized representative. In no event shall the interest charged or payable hereunder exceed that allowable under Texas law.

(b) Notwithstanding (a), above, (1) interest shall be applied only from the date payment was due, if such date is later than the filing of appeal, and (2) interest shall not be paid for any period of time that the Contracting Officer determines the Contractor has unduly delayed in pursuing his remedies under this contract or before a court of competent jurisdiction.
22. **Pricing of Adjustments (6-203.01, JUN 86)**

When costs are a factor in any determination of a contract price adjustment pursuant to the Changes Clause or any other provision of this contract, such costs shall be in accordance with Chapter 7 (Cost Principles) of the Authority's Procurement Regulations in effect on the date of this contract.

23. **Prompt Payment (F-129, NOV 99)**

The Contractor agrees to pay each subcontractor under this Contract for satisfactory performance of its contract no later than 10 (ten) calendar days from receipt of each payment the prime receives from the Authority. The Contractor agrees further to release retainage payments (if applicable) to each subcontractor within ten (10) calendar days after the subcontractor's work is satisfactorily completed and final payment has been made to the subcontractor. Any delay or postponement of payment from the above referenced time frame may occur only for good cause following written approval from the Contracting Officer.

24. **Publicity Releases (6-203.16, JUN 86)**

All publicity releases or releases of reports, papers, articles, maps, or other documents in any way concerning this contract or the work hereunder which the Contractor or any of its subcontractors desires to make for purposes of publication in whole or in part, shall be subject to approval by the Contracting Officer prior to release.

25. **Risk of Loss or Damage (6-202.06, JUN 86)**

Except as otherwise provided in this contract, the Contractor shall be responsible for the supplies covered by this contract until they are delivered at the designated delivery point, regardless of the point of inspection. After delivery to the Authority at the designated point and prior to acceptance by the Authority or rejection and giving notice thereof by the Authority, the Authority shall be responsible for the loss, destruction of, or damage to the supplies only if such loss, destruction, or damage results from the negligence of officers, agents, or employees of the Authority acting within the scope of their employment. The Contractor shall bear all risks as to rejected supplies after notice of rejection, except that the Authority shall be responsible for the loss, destruction of, or damage to the supplies only if such loss, destruction, or damage results from the gross negligence of officers, agents, or employees of the Authority acting within the scope of their employment.

26. **Royalties and Patents (6-203.17, JUN 86)**

The Contractor shall pay all royalties and license fees. The Contractor shall defend all suits or claims for infringement of any patent rights and shall save the Authority harmless from loss on account thereof, except when a particular design, process, or product of a particular manufacturer is specified by the Authority; provided, that, if the Contractor has reason to believe that the design, process, or product specified infringes a patent, the Contractor shall be responsible for such loss unless it promptly gives such information to the Contracting Officer.

27. **Termination for Default (6-202.09, JUN 86)**

(a) The Authority may, subject to the provisions of paragraph (c) below, by written notice of default to the Contractor, terminate the whole or any part of this contract in either one of the following circumstances:

   (1) if the Contractor fails to make delivery of the supplies or to perform the service within the time specified herein or any extension thereof; or

   (2) if the Contractor fails to perform any of the other provisions of this contract, or so fails to make progress as to endanger performance of this contract in accordance with its terms, and in either of these two circumstances does not cure such failure within a period of 10 days (or such longer period as the Contracting Officer may authorize in writing) after receipt of notice from the Contracting Officer specifying such failure.

(b) In the event the Authority terminates this contract in whole or in part as provided in paragraph (a) of this clause, the Authority may procure, upon such terms and in such manner as the Contracting Officer may deem appropriate, supplies or services similar to those so terminated, and the Contractor shall be liable to the Authority for any excess costs for such similar supplies or services; provided, that the Contractor shall continue the performance of this contract to the extent, if any, it has not been terminated under the provisions of this clause.
(c) Except with respect to defaults of subcontractors, the Contractor shall not be liable for any excess costs if the failure to perform the contract arises out of causes beyond the control and without the fault or negligence of the Contractor. Such causes may include, but are not restricted to, the following: acts of God or of the public enemy, acts of the Authority, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, and unusually severe weather; provided, however, in every case the failure to perform must be beyond the control and without the fault or negligence of the Contractor. If the failure to perform is caused by the default of a subcontractor and if such default arises out of causes beyond the control of both the Contractor and subcontractor and without the fault or negligence of either of them, the Contractor shall not be liable for any excess costs for failure to perform, unless the supplies or services to be furnished by the subcontractor were obtainable from other sources in sufficient time to permit the Contractor to meet the required delivery schedule.

(d) If this contract is terminated as provided in paragraph (a) of this clause, the Authority, in addition to any other rights provided in this clause, may require the Contractor to transfer title and deliver to the Authority in the manner and to the extent directed by the Contracting Officer (i) any completed supplies and (ii) such partially completed supplies and materials, parts, tools, dies, jigs, fixtures, plans, drawings, information, and contract rights (hereinafter called "manufacturing materials") as the Contractor has specifically produced or specifically acquired for the performance of such part of this contract as has been terminated; and the Contractor shall, upon direction of the Contracting Officer, protect and preserve property in possession of the Contractor in which the Authority has an interest. Payment for completed supplies delivered to and accepted by the Authority shall be at the contract price. Payment for manufacturing materials delivered to and accepted by the Authority and for the protection and preservation of property shall be in an amount agreed upon by the Contractor and Contracting Officer. Failure to agree to such amount shall be a dispute concerning a question of fact within the meaning of the Disputes Clause of this contract. The Authority may withhold from amounts otherwise due the Contractor for such completed supplies or manufacturing materials such sum as the Contracting Officer determines to be necessary to protect the Authority against loss because of outstanding liens or claims of former lien holders.

(e) If, after notice of termination of this contract under the provisions of this clause, it is determined for any reason that the Contractor was not in default or that the default was excusable under the provisions of this clause, the rights and obligations of the parties shall be those provided in the Termination for the Convenience of the Authority Clause hereof. Failure to agree to any such adjustment shall be a dispute concerning a question of fact within the meaning of the Disputes Clause of this contract.

(f) The rights and remedies of the Authority provided in this clause shall not be exclusive and are in addition to any other rights and remedies provided by law or under this contract. Time is of the essence for all delivery, performance, submittal, and completion dates in this contract.

(g) As used in paragraph (c) of this clause, the terms "subcontractor" and "subcontractors" mean subcontractor(s) at any tier.

28. Termination for the Convenience of the Authority (6-202.10, JUN 86)

The Contracting Officer may, whenever the interests of the Authority so require, terminate this contract, in whole or in part, for the convenience of the Authority. The Contracting Officer shall give written notice of the termination to the Contractor specifying the part of the contract terminated and when termination becomes effective.

(a) The Contractor shall incur no further obligations in connection with the terminated work, and, on the date set forth in the notice of termination, the Contractor will stop work to the extent specified. The Contractor also shall terminate outstanding orders and subcontracts as they relate to the terminated work. The Contractor shall settle the liabilities and claims arising out of the termination of subcontracts and orders connected with the terminated work. The Contracting Officer may direct the Contractor to assign the Contractor's right, title, and interest under terminated orders or subcontracts to the Authority. The Contractor must still complete the work not terminated by the notice of termination and may incur such obligations as are necessary to do so.

(b) The Contracting Officer may require the Contractor to transfer title and deliver to the Authority in the manner and to the extent directed by the Contracting Officer: (i) any completed supplies; and (ii) such partially completed supplies and materials, parts, tools, dies, jigs, fixtures, plans, drawings, information and contract rights (hereinafter called "manufacturing materials") as the Contractor has specifically produced or specially acquired for the performance of the terminated part of this contract. The Contractor shall, upon direction of the Contracting Officer, protect and preserve property in the possession of the Contractor in which the Authority has an interest. If the Contracting Officer does not exercise this right, the Contractor shall use its best efforts to sell such supplies and manufacturing materials.

(c) The Authority shall pay the Contractor the following amounts:
(1) contract prices for supplies or services accepted under the contract;

(2) costs incurred in preparing to perform and performing the terminated portion of the work plus a fair and reasonable profit on such portion of the work (such profit shall not include anticipatory profit or consequential damages), less amounts paid or to be paid for accepted supplies or services; provided, however, that if it appears that the Contractor would have sustained a loss if the entire contract would have been completed, no profit shall be allowed or included, and the amount of compensation shall be reduced to reflect the anticipated rate of loss;

(3) costs of settling and paying claims arising out of the termination of subcontracts (these costs must not include costs paid in accordance with subparagraph (2) of this paragraph); and

(4) the reasonable settlement costs of the Contractor including accounting, legal, clerical, and other expenses reasonably necessary for the preparation of settlement claims and supporting data with respect to the terminated portion of the contract and for the termination and settlement of subcontracts thereunder, together with reasonable storage, transportation, and other costs incurred in connection with the protection or disposition of property allocable to the terminated portion of this contract.

The total sum to be paid the Contractor under this section shall not exceed the total contract price plus the reasonable settlement costs of the Contractor reduced by the amount of payments otherwise made, the proceeds of any sales of supplies and manufacturing materials under this paragraph, and the contract price of work not terminated.

29. Variation in Quantity (6-202.04, JUN 86)

No variation in the quantity of any item called for by this contract will be accepted unless such variation has been caused by conditions of loading, shipping, or packing, or allowances in manufacturing processes, and then only to the extent, if any, specified elsewhere in this contract.
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1. Definitions and Interpretations (M-101, NOV 99)

The Authority will utilize the following definitions to identify Disadvantaged Business Enterprise (DBE) Program eligibility standards. The following definitions and any other definitions related to the DBE program have the same meaning as defined in 49 CFR Part 26.

(a) "Disadvantaged Business Enterprise" or "DBE" means a for profit small business concern: (1) which is at least 51 percent owned by one or more socially or economically disadvantaged individuals, or in the case of a corporation in which 51 percent of the stock is owned by one or more such individuals; and (2) whose management and daily business operation are controlled by one or more of the socially and economically disadvantaged individuals who own it.

(b) "Small Business Concern" means, with respect to firms seeking to participate as DBEs in DOT-assisted contracts, a small business as defined pursuant to Section 3 of the Small Business Act and Small Business Administration regulations implementing it (13 CFR Part 121) that also does not exceed the cap on average annual gross receipts specified in section 26.65(b).

(c) "Socially and Economically Disadvantaged Individual" means any individual who is a citizen (or lawfully admitted permanent resident) of the United States and includes any individual in the following groups, members of which are rebuttably presumed to be socially and economically disadvantaged:

1. "Black Americans," which includes persons having origins in any of the Black racial groups of Africa;

2. "Hispanic Americans," which includes persons of Mexican, Puerto Rican, Cuban, Dominican, Central or South American, or other Spanish or Portuguese cultures or origin, regardless of race;

3. "Native Americans," which includes persons who are American Indians, Eskimos, Aleuts, or Native Hawaiians;

4. "Asian-Pacific Americans," which includes persons whose origins are from Japan, China, Taiwan, Korea, Burma (Myanmar), Vietnam, Laos, Cambodia (Kampuchea), Thailand, Malaysia, Indonesia, the Philippines, Brunei, Samoa, Guam, the U.S. Trust Territories of the Pacific Islands, Republic of Palau, the Commonwealth of the Northern Mariana Islands, Macao, Fiji, Tonga, Kiribati, Tuvalu, Nauru, Federated States of Micronesia, or Hong Kong;

5. "Subcontinent Asian Americans," which includes persons whose origins are from India, Pakistan, Bangladesh, Bhutan, the Maldives Islands, Nepal, or Sri Lanka;
(6) Women;

(7) "Tribally-owned concern" means any concern at least 51 percent owned by an Indian tribe;

(8) "Any individual groups whose members are designated as socially and economically disadvantaged by the Small Business Administration (SBA) at such times as the SBA designation becomes effective; and

(9) Any individual who the Authority finds to be socially and economically disadvantaged on a case-by-case basis.

(d) "DOT" means the U.S. Department of Transportation including the Federal Transit Administration (FTA).

(e) "Good Faith Efforts" means efforts to achieve a DBE goal or other requirement that, by their scope, intensity and appropriateness to the objective, can reasonably be expected to fulfill the DBE program requirement.

2. **Banks and Financial Institutions (M-109, JUL 01)**

The Contractor is encouraged to utilize the services of disadvantaged, minority and woman-owned banks and financial institutions. The identity of such banks is available, upon request, from the Authority's DEO Department.

3. **Certification of DBEs (M-106, JUN 03)**

(a) All prospective DBEs must submit the certification application and the appropriate forms to the North Central Texas Regional Certification Agency (NCTRCA). Application forms may be obtained from the Authority's DEO Department or the NCTRCA at www.nctrca.org. All such firms shall cooperate in supplying additional information as requested by the NCTRCA or the Authority's DEO Department. NCTRCA is a regional certification agency that was created to perform centralized certification services for DBEs in the Dallas/Fort Worth area. The Authority will rely upon the certification of the NCTRCA to determine the eligibility of the DBE firms. With the advent of the Texas Unified Certification Program (TUCP), the NCTRCA will also accept DBE certifications from other DBE certification agencies within the State (South Central Texas Regional Certification Agency, TX DOT, City of Austin, Corpus Christi Regional Transportation Authority and the City of Houston). However, the Authority's DEO Department reserves the right to certify eligible DBEs.

(b) The DBE firm should be prepared to provide, upon request, appropriate documentation, e.g., tribal roll, birth certificates, visa, passport, etc., necessary to clearly support its claim of "disadvantaged" status.

(c) The eligibility of a DBE certified joint venture will be determined on a project-by-project basis by the Authority's DEO Department. Appropriate forms to apply for DBE certification are available from the Authority's DEO Department or the NCTRCA.

(d) Information concerning DBEs currently certified through the local centralized DBE Certification Program may be obtained from the Authority's DEO Department. Notwithstanding other DBE certification or registration, firms identified to participate as DBEs on Authority contracts are subject to the certification review process. Offerors are reminded that only certified DBEs may participate in Authority contracts in such capacities. If Offerors propose using a DBE not currently certified, it is strongly urged that the Authority's DEO Department be contacted well in advance of the date set for receipt of offers in order to enable review of the proposed DBE’s eligibility.

4. **Credit Toward Goals (M-104, NOV 99)**

The Authority will count DBE participation toward the overall and contract goals as provided in 49 CFR 26.55.

5. **DBE Modifications or Substitutions (M-107, JUL 01)**

This Provision applies to all modifications and substitutions under this Contract. The Contractor will be required to comply with this Provision to the extent needed to achieve the DBE goals agreed to at the time of contract award.

(a) If a prime contractor wishes to terminate or substitute a DBE subcontractor listed as fulfilling its contract goal, and then performs the work of the terminated DBE subcontractor with its own forces, an affiliate, a non-DBE subcontractor or with another DBE subcontractor, it must submit written documentation prior to the termination or substitution of the DBE subcontractor to the Contracting Officer. This will include any changes to items of work, material, services, or DBE firms that differ from those identified on the Intent to Perform As A Subcontractor form(s) on file with the
Contracting Officer. The Offeror/Contractor must provide any and all documentation and information as may be requested with respect to the requested change.

(b) The Offeror's/Contractor's documentation shall include the specific reasons for the proposed change. Specific reasons that are acceptable include, but are not limited to: the DBE was not able to perform; the DBE was unable to produce acceptable work; and/or the DBE has submitted an unreasonable escalation in price. In the case of a DBE subcontractor being substituted by another DBE subcontractor, the Contractor should include the name, address, certification number and principal office of the proposed DBE firm. After providing an opportunity to the DEO Department to make a recommendation, the Contracting Officer will approve or disapprove the change.

(c) If the change involves a subcontractor substitution, the Offeror/Contractor must make good faith effort to replace one DBE with another DBE. The substitute DBE firm must be certified by the NCTRCA or the DEO Department in order for the Offeror/Contractor to receive credit toward fulfilling its DBE participation goal for the contract. In the event that the Offeror/Contractor is unable to contract with another DBE firm, good faith effort documentation must be provided to the Contracting Officer describing the unsuccessful attempts to locate a substitute DBE. In all situations, the Contractor may not terminate or substitute a DBE subcontractor without the prior written consent of the Contracting Officer.

(d) The Offeror/Contractor must submit a new Intent to Perform as a Subcontractor form for the substitute DBE firm(s) with the request for change, to verify that the new DBE firm(s) is certified by NCTRCA or the DEO Department. The Contracting Officer shall notify the Offeror/Contractor in writing of his decision as expeditiously as possible. If the contract has been awarded and the Contracting Officer approves the proposed substitution in writing, the Contractor shall provide a copy of the executed subcontract agreement with the proposed DBE firm to the Contracting Officer within ten (10) business days of its receipt of the substitution approval.

(e) If the change involves a modification, the Contractor must submit, if applicable, the Intent to Perform as a Subcontractor form specified for contract modifications for any DBE subcontractor affected by this change. This form may be obtained from the Contracting Officer.

(f) If the Contractor does not comply with this Provision, the Authority may elect to apply contract remedies as defined in 49 CFR Part 26, or other contract remedies, as appropriate. Additionally, the Contracting Officer may order that the profits from the terminated portion of the DBE subcontract be forfeited by the Contractor.

6. Demonstration of Good Faith Effort (M-105, NOV 99)

(a) If an Offeror does not meet the DBE goal, it shall nevertheless be eligible for award of the contract if it can demonstrate to the Contracting Officer that it has made a good faith effort to meet the DBE goal. This good faith efforts documentation should be submitted when the initial response to the Authority's solicitation is due. All contractors, including DBE prime contractors, are required to submit good faith efforts documentation, if necessary. In evaluating an Offeror's good faith effort submission, the Authority will only consider those documented efforts that occurred prior to the good faith efforts determination.

(b) In the event that a firm submitted by an Offeror in accordance with the requirements of the Submission of DBE Utilization Forms and Related Documentation (M-103, NOV 99) provision cannot be certified, the Offeror will be notified and given an opportunity to substitute that firm with a certified DBE firm. The Offeror will have ten (10) calendar days from the date of notification to accomplish the substitution. In the event the Offeror is unable to contract with another substitute DBE firm, the good faith efforts that the Offeror made in attempting to contract with a substitute DBE firm must be documented to the Contracting Officer at the end of the same ten (10) calendar day period.

(c) In making a determination that the Offeror has made a good faith effort to meet the DBE goal, the Offeror shall furnish to the Authority, as part of its DBE utilization information provided under the Submission of DBE Utilization Forms and Related Documentation (M-103, NOV 99) provision, such specific documentation concerning the steps it has taken to obtain DBE participation. By way of illustration and not limitation, the Authority will consider the following information:

1. Whether the Offeror attended any pre-bid or pre-proposal meetings scheduled by the Authority to discuss, among other matters, DBE participation opportunities and acknowledged receipt of DBE certified vendor lists;

2. Whether the Offeror advertised in general circulation, trade association, and/or minority/women-focus media concerning subcontracting opportunities;
(3) Whether the Offeror provided written notice to a reasonable number of DBEs that their interest in the contract was being solicited in sufficient time to allow DBEs to participate effectively;

(4) Whether the Offeror followed up initial solicitations of interest by contacting DBEs to determine with certainty whether the DBEs were interested;

(5) Whether the Offeror selected portions of the work to be performed by DBEs in order to increase the likelihood of meeting the DBE goals (including, where appropriate, breaking down the contract into economically feasible subcontracts to facilitate DBE participation);

(6) Whether the Offeror provided interested DBEs with adequate information about the plans, specifications, scope of work and requirements of the contract;

(7) Whether the Offeror negotiated in good faith with interested DBEs regarding their capabilities, not rejecting DBEs as unqualified without sound reasons based on a thorough investigation;

(8) Whether the Offeror negotiated in good faith with interested DBEs regarding price, using good business judgment and not rejecting reasonable quotes from interested DBE firms;

(9) Whether the Offeror made efforts to assist interested DBEs in obtaining bonding, lines of credit, insurance, etc., as required by the Authority or the Offeror;

(10) Whether the Offeror made efforts to assist interested DBEs in obtaining necessary equipment, supplies, materials, or related assistance or services;

(11) Whether the Offeror effectively used the services of available minority and women community organizations; contractor groups; local, State, and Federal business assistance offices; and other organizations that provide assistance in the identification of DBEs;

(12) Whether the Offeror obtained written documentation from the Authority Surety Support Program Consultant or a bona fide surety company indicating that bonding was denied and for what reason(s), prior to the DBE being rejected as a potential subcontractor for failing to obtain Offeror-required bonding. Documentation furnished by a surety company will be subject to verification by the Authority; and

(13) Whether other Offerors have attained a sufficient level of DBE participation to meet the contract goals.

(d) The Authority will look not only at the different kinds of efforts that the Offeror has made, but also the quantity and intensity of those efforts. Efforts that are merely pro forma are not good faith efforts to meet the goal (even if they are sincerely motivated) if, given all relevant circumstances, the Offeror's efforts could not reasonably be expected to produce a level of DBE participation sufficient to meet the goal.

(e) Offerors are reminded that the issue of whether or not the Offeror has met or exceeded the established goal and/or demonstrated good faith efforts is considered a matter of the Offeror's responsibility. The Authority will only award contracts to Offerors determined to be responsible. The Contracting Officer, after affording the Authority's DEO Department an opportunity to make a recommendation, shall be responsible for determining the sufficiency of an Offeror's good faith effort to meet contract goals.

(f) An Offeror that the Contracting Officer determines is not responsible may request administrative review and reconsideration under the Authority’s Procurement Regulations. As part of any reconsideration, if requested, the Offeror may elect to meet in person with the Reconsideration Official (President/Executive Director of the Authority) to discuss credit toward meeting the DBE goal or whether the Offeror made adequate good faith efforts.

7. Offeror's DBE Obligation (M-102, NOV 99)

The Offeror’s DBE Obligation is outlined in an Exhibit C provision entitled Disadvantaged Business Enterprise (DBE) Participation, and the provision entitled Non-Discrimination Assurance found in Exhibit E of this Contract.

8. Payment Documentation (M-108, MAY 04)

Concurrently with the submission of each invoice or request for a progress payment under this contract, the Contractor shall provide a breakdown of the amounts paid to DBEs identified by the Contractor to participate in this contract. The
breakdown shall be provided on the DEO Vendor Payment Report form which is available at http://www.dart.org/deo.asp?, or a photocopy of the attached Vendor Payment Report. As provided elsewhere in this Contract, the Authority may withhold all or part of any payment otherwise due the Contractor if the Contractor fails to submit the Vendor Payment Report form and/or make prompt payments to its subcontractors, suppliers, materialmen or laborers.

9. **Sanctions for Noncompliance with the Authority's DBE Program Provisions (M-110, NOV 99)**

Failure of the Contractor to carry out the Authority's DBE program provisions shall constitute a breach of contract and may result in termination of the Contractor for default or such remedy as the Authority may deem appropriate. The Authority reserves the right to apply legal and contract remedies available under Federal, state and local law, including but not limited to, responsibility determinations in future contracts, suspension and debarment procedures as outlined in 49 CFR Part 29, and forfeiture of profits as provided elsewhere. The Authority will bring to the attention of the Department of Transportation any false, fraudulent, or dishonest conduct in connection with the program, so that DOT can take steps provided in 49 CFR Section 26.107.

10. **Submission of DBE Utilization Forms and Related Documentation (M-103, NOV 99)**

(a) Each Offeror should submit to the Authority an executed Intent to Perform As a Subcontractor form (Attachment 1) for each proposed DBE subcontractor when the initial response to the Authority's solicitation is due. Good faith documentation (if necessary) should also be submitted at this time. The submission of this information is considered an issue of responsibility, and the Authority will not award a contract to any Offeror who has not supplied this documentation.

(b) The Intent to Perform As A Subcontractor form for each proposed DBE subcontractor shall constitute a representation by the Offeror to the Authority that it believes such firm is certified as a DBE, and is ready, willing, and able to perform the work indicated. It shall also represent a commitment by the Offeror that if it is awarded the contract, it will enter into a subcontract with such DBE firm for the work described at the approximate price set forth in the Intent to Perform As A Subcontractor form.

(c) If the DBE Subcontractor participation changes after the forms have been submitted, but prior to award of the contract, the Offeror will be required to immediately notify the Contracting Officer of the changed amount and the reason(s) for the change. The modification and substitutions of DBE firms that occur shall be governed by DBE Modification or Substitutions (M-107, JUL 01) provision of this Exhibit.

(d) Except as authorized by the Contracting Officer, the successful Offeror shall enter into formal agreements with the DBE firms shown in the submitted Intent to Perform As A Subcontractor form(s) within ten(10) business days after receipt of a contract executed by the Authority. The successful offeror (Contractor) shall provide the Contracting Officer two copies of each agreement within three (3) business days of execution.

(e) If an Offeror is a DBE and lists itself on the Intent to Perform As A Subcontractor form, it is required to perform the work indicated with its own work force.
ATTACHMENT 1 TO EXHIBIT G

DALLAS AREA RAPID TRANSIT - D/M/WBE FORM

SOLICITATION NUMBER: P-1021774

INTENT TO PERFORM AS A SUBCONTRACTOR
FOR A CONTRACT AWARD

Pursuant to DART Board policy, DBE firms participating in the Authority’s DBE Program must have “current” certification status with the Authority prior to award of this contract. The Authority’s DBE certification of any firm is effective for three (3) years from the date of written notification of certification. If the Authority determines that the firm is not an eligible DBE firm for DART contracts and subcontracts, such firms must immediately submit a completed and signed Certification Affidavit to the North Central Texas Regional Certification Agency, 616 Six Flags Drive, Suite 128, Arlington, TX 76011; or if a joint venture, submit a Joint Venture Certification Application to the DART Diversity & Economic Opportunity Department, P.O. Box 660163, Dallas, Texas 75266-7217.

1. Name of Offeror / Prime Contractor ________________________________________.

2. The undersigned has been certified by DART via NCTRCA Certification #______________.

3. The undersigned is prepared to perform the following described work and/or supply the material listed in connection with the above project (where applicable specify “supply” or “install” or both):

____________________________________________________________________________

and at the following price $ ________________.

With respect to the proposed subcontract described above, _________% of the dollar value of such subcontract will be sublet and/or awarded to non-DBE contractors.

NOTICE: If the DBE firm is not sub-subcontracting any of the work described above, a zero (0) must be shown in the blank above.

____________________ BY: _____________________________ DATE: _____/_____/_____
(Name of DBE Firm) (Signature of Owner, President or Authorized Agent)

PHONE: ________________
(Print or Type - Name of Signature of Owner, President or Authorized Agent of DBE firm)

DECLARATION OF PRIME CONTRACTOR

I HEREBY DECLARE AND AFFIRM that I am the ______________________________

and a duly authorized representative of ______________________________________________

(Name of Declarant) (Name of Prime Contractor)

to make this declaration and that I have personally reviewed the material and facts set forth in this Intent to Perform form. To the best of my knowledge, information and belief, the facts and representations contained in this form are true, the owner or authorized agent of the DBE firm signed this form in the place indicated, and no material facts have been omitted.

Except as authorized by the Contracting Officer, the undersigned will enter into a formal agreement with the listed DBE firm for work as indicated by this form within ten (10) business days after receipt of the contract executed by the Dallas Area Rapid Transit Authority. The undersigned will provide the Contracting Officer a copy of that agreement within three (3) business days of execution.

The Prime contractor designated the following person as their DBE Liaison Officer:

___________________________________________________ ______________________
(Name-Please Print) (Phone)

Pursuant to 49 CFR Section 26.107, any person [entity] who makes a false or fraudulent statement in connection with participation of a DBE in any DOT-assisted program or otherwise violates applicable Federal statutes and may be referred to the Department of Transportation, and possibly the Department of Justice, for prosecution.

____________________________

(Name of Declarant)

___________________________

(Signature) (Date)
ATTACHMENT 2 TO EXHIBIT G

DALLAS AREA RAPID TRANSIT - D/M/WBE FORM
INSTRUCTIONS FOR CONTRACTORS
"HOW TO FILL OUT VENDOR PAYMENT REPORT"

The Vendor Payment Report is to be filled out by the Contractor and submitted with each invoice. The instructions below correspond to each item on the reverse side of the report. Please follow the instructions.

1. **Invoice No.**
   Fill in the invoice number accompanying this report.

2. **Report No.**
   Fill in the number of the report you are sending in sequence. For example: If this is the second invoice you are submitting, you are sending in Report No. 2.

3. **Reporting Period**
   This is to be filled in to state the period of time you are reporting. Example: From: April 1, 1991 To: April 30, 1991.

4. **DART Contract Number**
   Fill in the contract number assigned to your project by DART.

5. **Type of Contract**
   Designate the type of contract that has been awarded your company by DART.

6. **Contractor's Business Name, Address and Telephone Number**
   Fill in your company's name, address, and telephone number.

7. **Date of Contract Award**
   Fill in the date contract was executed by both you and DART.

8. **Scheduled Date of Completion**
   Fill in completion date of contract as written in contract.

9. **Original Contract Amount**
   Fill in dollar amount of original contract agreed upon by you and DART.

10. **Current Amended Contract Amount and Date**
    Fill in dollar amount of original contract plus/minus the dollar amount agreed upon at a later date as a result of contract modifications, if applicable. Include date modification was executed.

11. **Total Amount Received to Date**
    Fill in the dollar amount you have received from DART to-date.

12. **Total Amount Owed**
    Fill in the dollar amount of the contract minus amount paid to you by DART.

13. **Committed Disadvantaged/Minority/Women-Owned Participation**
    Fill in the percentage of D/M/WBE participation you committed to obtain in the contract.

14. **Instructions for Calculation of Disadvantaged/Minority/Women-Owned Business Enterprise Percentage**

15. **Actual Disadvantaged/Minority/Women-Owned Business Enterprise Percent Paid-to-Date**
    Fill in the calculated dollar amount paid to the D/M/WBE divided by the dollar amount you received from DART.

16. **Name of Subcontractors**
    Name all D/M/WBE subcontractors. (Use additional sheets as necessary.)

17. **Disadvantaged/Minority/Women-Owned Business Enterprise**
    State whether the subcontractor is a DBE/MBE/WBE.

18. **Description of Work**
    State the work performed by the D/M/WBE subcontractor.

19. **Amount and Date of Last Payment**
    State the amount and date of last payment made to each D/M/WBE subcontractor. Submit evidence of payment, i.e., cancelled check, check register, etc.

20. **Subcontract Value (Dollars)**
    State the committed dollar value to the D/M/WBE subcontractor for the duration of the contract.

21. **Total Amount Paid-to-Date (Dollars)**
    Add all amounts paid to each D/M/WBE subcontractor to date.

22. **Percent of Earned Progress to Date**
    State dollar amount paid to the D/M/WBE subcontractor divided by the amount committed to them.

23. **Amount of This Invoice Allocated to the Subcontractor**
    Fill in how much of this invoice will be paid to each D/M/WBE subcontractor.
# VENDOR PAYMENT REPORT

**Dallas Area Rapid Transit**
Department of Diversity & Economic Opportunity
P.O. Box 660163
Dallas, Texas 75266-7217
(214) 749-2507

Instructions: All prime contractors are required to complete and submit this report as specified in the contract, or as requested by the Contracts Specialist, until final payment of the contract. Note: Failure to comply with DART's Disadvantaged, Minority, and Women-Owned Business enterprise provisions may result in contract termination, or the suspension or debarment of the contractor from doing business with DART in the future in accordance with the procedures set forth in DART's Procurement Regulations. To complete this report, see detailed instructions on the proceeding page of Exhibit G. **This report must be submitted with invoice.**

## 4) DART Contract Number

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<th>5) Type of Contract (X)</th>
<th>6) Contractor's Business Name, Address and Telephone Number</th>
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## 7) Date of Contract Award

| 8) Schedule Date of Completion | 9) Original Contract Amount | 10) Current Contract Amount, Including Modifications ($ and date)
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## 11) Total Amount Received To Date

| 12) Total Amount Owed | 13) Committed Disadvantaged, Minority, and Women | 14) D/M/WBE Instruction for Calculation of Percentage:
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<td>Disadvantaged-Minority-Women ($)</td>
<td>Dollar amount paid to D/M/WBE divided by dollar amount received by Contractor from DART.</td>
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## 16) Name of Subcontractor

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<th>19) Amount &amp; Date of Payment(s) Made During Current Invoice Period</th>
<th>20) Subcontract Dollars</th>
<th>21) Amount Paid to Date (Dollars)</th>
<th>22) % Paid to Date</th>
<th>23) Amount of This Invoice Allocated to Subcontractor</th>
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## Company Official's Signature & Title

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<tr>
<th>Date Signed</th>
<th>Name &amp; Title of Individual Completing Report</th>
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Form 33.212 (05/95)  
Page 8 of 9  
Exhibit G
Dallas Area Rapid Transit

Attachment 3 to EXHIBIT G

DBE GOAL COMPLIANCE for TRANSIT VEHICLE MANUFACTURERS (TVM)

The offeror shall complete the below certification and submit with the offeror’s proposal.

11. DISADVANTAGED BUSINESS ENTERPRISE APPROVAL CERTIFICATION

The offeror hereby certifies that it has compiled with requirements of Title 49, Code of Federal Regulations, part 26.49, Participation by Disadvantaged Business Enterprises in DOT Programs, and that the Federal Transportation Administration (FTA) has approved its goals program.

______________________________, a TVM, hereby certifies that it has compiled with the (Name of Firm) requirements of Section 26.49 of 49 CFR Part 26, by submitting a current annual DBE goal to the FTA. The goals apply to Federal Fiscal Year _______ ( ) and the offeror certifies that its annual Disadvantaged Business Enterprise Goals have either been approved, or not disapproved by the Federal Transportation Administration.

Executed on: ____________________________ at ____________________________
(Month, Date, Year) (City, State)

By: __________________________________
(Typewritten or Printed Name) (Title of Signature Authority)

Signature: __________________________________________
DALLAS STREETCAR

TECHNICAL SPECIFICATIONS

RFP: P-1021774
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<table>
<thead>
<tr>
<th>Section No</th>
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<tr>
<td>1</td>
<td>General Topics and Definitions</td>
</tr>
<tr>
<td>2</td>
<td>Design and Performance Criteria</td>
</tr>
<tr>
<td>3</td>
<td>Carbody Structure</td>
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<td>Coupler</td>
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<td>Propulsion System and Control</td>
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<td>Vehicle Communications</td>
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<tr>
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<td>ATP, TSS, TWC and Event Recorder</td>
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<td>Interior and Exterior Appointments</td>
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<td>17</td>
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<td>18</td>
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<tr>
<td>19</td>
<td>Program Control and Quality Assurance</td>
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SECTION 1
GENERAL TOPICS AND DEFINITIONS

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  1.2.1 Contract Deliverables...................................................................................................................... 1
1.3 Definitions.................................................................................................................................................. 2
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SECTION 1
GENERAL TOPICS AND DEFINITIONS

1.1 Introduction
These technical specifications shall define the functional, performance, and interface design requirements for the procurement of modern articulated, low floor streetcars, with the ability to operate off-wire for significant distances, for the Dallas Streetcar project. The vehicles shall be safe, reliable and maintainable.

The Contractor shall design, manufacture, test and deliver the products as described by this specification. Deviations from these requirements are permitted only with specific approval of DART.

The Contractor is responsible for the design and integration of all vehicle systems such that all specified requirements are achieved without conflict or error within or between systems. The Contractor shall insure that all designers, suppliers, and subcontractors are informed of all specified requirements and that appropriate engineering management tools are utilized to insure that coordination and communication occurs between the designers of inter-related systems.

Name brands, specific equipment, or specific materials may be referenced in this specification. Such equipment has been shown to be successful in previous applications, where correctly applied and integrated with other equipment; however, such references shall not be interpreted as pre-approval of any Contractor designs or applications. The Contractor is responsible for the selection, application, and integration of equipment and materials as necessary to conform to the specified requirements.

All equipment provided under this Contract shall be new. Rebuilt or refurbished equipment is prohibited. New equipment damaged during execution of this Contract may be restored to new condition only where approved in writing by DART on a case-by-case basis, and all restorations shall be performed by the original equipment manufacturer.

1.2 Specification Organization
This Specification is divided into sections according to technical discipline and traditional supplier arrangements. This format is for convenience only and does not imply or suggest a preferred system integration approach or level of importance.

Explicit references may appear within sections linking requirements appearing in other sections. Such references shall, in no way, be assumed to limit the range or applicability of any requirements in this document, whether referenced or not.

1.2.1 Contract Deliverables
This specification requires the submittal of drawings, documents, analyses, test results, manuals and similar information for review by DART to verify compliance with specified requirements, and for after-delivery support of the vehicles. Specific submittal requirements are listed at the conclusion of each section under the heading Contract Deliverables Requirements List or CDRL. Typically, the CDRL submittals in each section relate to the design requirements in that section. Those design drawings requiring submittal and approval are identified in Sections 2 through 14. Final drawings requiring submittal are discussed in
Section 18. Other documents requiring submittal and approval are identified in the CDRL requirements in Sections 2 through 18.

Regardless, if noted as submittals in the text, the Contractor is obligated to forward them for review and approval even though they may not appear in the CDRL section.

### 1.3 Definitions

The following terms may appear in this document. They are defined as indicated:

- **Adhesion, Coefficient of**: During rolling contact, the ratio between the tangential force at the wheel-rail interface and the normal force.
- **Approval**: Acceptance in writing by DART’s Project Manager.
- **Approved or Approved Type**: Design, type material, procedure, or method given approval by DART’s Project Manager.
- **Assembly**: A collection of subassemblies and components performing various functions within a larger system.
- **AW0**: Weight of empty vehicle.
- **AW1**: Weight of vehicle with full seated load.
- **AW2**: Weight of vehicle with a full seated load plus standees at 4 passengers/m².
- **AW3**: Weight of vehicle with a full seated load plus standees at 6 passengers/m².
- **AW4**: Weight of vehicle with a full seated load plus standees at 8 passengers/m².
- **Blending**: In braking, the simultaneous control of dynamic (rheostatic and regenerative) and friction braking, with the effort of each continuously proportioned to achieve the required total braking effort within the specified tolerances.
- **City, the**: The City of Dallas, Texas
- **Coast**: The mode of operation in which no propulsion (positive traction) or braking effort is in effect, except for normal drive train losses.
- **Contract Drawings**: Drawings and specifications provided by DART as part of this procurement.
- **Contractor**: The person or persons, firm, partnership, corporation, or combination thereof which has entered into a procurement contract with DART to supply the vehicles.
- **Contractor's Drawings**: Items such as general drawings, detail drawings, graphs, diagrams, sketches, calculations, and catalog cuts prepared by the Contractor for use in its manufacturing facility, assembly facility, or shop, to fabricate, assemble, and install parts of the vehicle whether manufactured by it from raw materials or purchased from others in a ready-to-use condition.
- **DART**: The Dallas Area Rapid Transit, and its successors, the Party of the First Part to the Contract.
- **Data**: Written presentations, plans, reports, schedules, forms, drawings, calculations, analyses, samples, photos and other items prepared by the Contractor, it subcontractors or suppliers in response to requests from DART or its authorized representative or to otherwise meet the requirements of the contract documents.
Days: Unless otherwise designated, days shall be understood to mean calendar days; that is, including weekends and holidays.

Days, Working: Those calendar days during which regular business is conducted excluding Saturdays and Sundays and all Federal, State, and municipal holidays that are observed by DART.

Defect(s), Defective: A condition which: does not meet the requirements of the Contract Documents; causes a vehicle of a portion of the work to cease operation or to operate in a degraded mode; or inflicts injury or damage to a vehicle, the work, other property or persons.

Drive: A system consisting of one or several motors or actuators, their direct control equipment (power circuits), and the associated mechanical devices required to produce a useful output.

Equal: Providing the same function, performance, and reliability.

Failsafe: A system is "failsafe" when it is designed such that any malfunction will not cause the system to achieve an unsafe state.

Failure: A condition in which equipment does not function as specified, designed, or expected.

Failure Rate: The frequency of failure, expressed as failures per hour or failures per mile. Failure rate is the mathematical reciprocal of Mean Time Between Failures (MTBF) or Mean Distance Between Failures (MDBF).

First Article: The first item of production that fixes and defines all subsequent production items. First articles are production units intended for review by DART.

Inspector: The person(s) or firm designated by DART as its quality control representative.

Interface: The points where two or more systems, subsystems, or structures come into physical or functional contact, and transfer energy and/or information.

Jerk: Time rate of change of acceleration and deceleration, equal to the second derivative of velocity and expressed in units of distance per cubed unit of time (e.g., m/s\(^3\)).

Light: The transparent portion of a window.

Liner (as in interior liner): The visible covering material for the walls, ceiling, and other interior surfaces.

Load Weighing: The measurement of passenger load for the purpose of adjusting tractive effort to produce a constant acceleration or braking rate regardless of load.

Mask, Window: Interior liner that surrounds the windows, often molded to include the sill and other portions of the sash.

Mean Distance Between Failures (MDBF): The mean operating mileage between independent failures.

Mean Time Between Failures (MTBF): The mean operating time between independent failures.

No Motion Speed: The lowest speed detectable by the vehicle control systems.

Normal: As in, example, "normal operating conditions" or "operating normally". A condition in which relevant vehicle equipment is not in a failure mode and the environment is functioning as specified.
**Project Manager:** Person designated by DART as its representative in matters pertaining to vehicle design, schedule, change orders, and other aspects of the Contract.

**Proof (used as a suffix):** As in splashproof, dustproof. The device and contents are impervious to, or unharmed by, application of the indicated action or material.

**Reliability:** The probability of performing a specified function, without failure and within design parameters, for the period of time indicated.

**Safe:** Secure from liability to harm, injury, danger, or risk; free from danger or risk.

**Safety:** The condition in which persons are free from threat or danger, harm, or loss arising from improper design, manufacture, assembly, malfunction, or failure of the car or any of its components or systems.

**Service, as in Service Use, Service Braking:** The operation of the cars under normal conditions.

**Slide, Wheel:** During braking, the condition existing when the rotational speed of the wheel is less than that for pure rolling contact between tread and rail.

**Speed, Balancing:** The speed attained by the vehicle or train when resisting forces exactly equal to the maximum available tractive forces.

**Speed, Base:** The speed to which the maximum constant acceleration can be maintained at the nominal line voltage.

**Speed, Schedule:** The average speed of a vehicle or train, from terminal-to-terminal, obtained by dividing the distance between these points by the time taken to make the trip, including time for intermediate station stops.

**Spin, Wheel:** During acceleration, the condition existing when the rotational speed of the wheel is greater than that for pure rolling contact between tread and rail.

**Stop, Emergency:** The stopping of a vehicle or train by an emergency brake application.

**Stop, Service:** The stopping of a vehicle or train by application of service braking.

**Streetcar:** See “Vehicle”.

**Tight (used as a suffix):** As in watertight, airtight, enclosed or protected as to completely exclude the indicated material from passage.

**Time, Build-Up:** In response to a step-forcing function, time interval from 10% of the total change in value to the attainment of 90% of the total change in value of the controlled variable. Build-up time is equal to response time minus dead time.

**Time Constant:** Slope of controlled variable build-up curve in units of controlled variable per unit of time, measured during the build-up time interval.

**Time, Dead (also Time, Reaction):** Time from the occurrence of a step change of the control signal to the attainment of 10% of the total change in value of the controlled variable.

**Time, Response:** Time from the occurrence of a step change of control signal to the attainment of 90% of the total change in value of the controlled variable.

**Time, Warm-Up:** The elapsed time from the application of power to an operable device until it is capable of performing its intended function.

**Tram:** "In tram" is the condition of ideal truck geometry in which the axles are perfectly parallel and the wheels are in perfect longitudinal alignment. The centers of the journal...
bearings represent the corners of a perfect rectangle. Verification that a truck is "in tram" is determined by measuring the diagonal and longitudinal distance between reference points on the axle bearing housings.

**Truck:** An assembly of structural frame, with axles and four wheels, associated motors, gear units, friction brake components, magnetic track brakes, safety bars and suspension elements that supports a portion of the car weight. Also know as a Bogie.

**Vehicle:** A complete streetcar assembly as described by this specification, ready to operate.

**Vital:** A term applied to a device or circuit which has known failure modes, certain of which occur with extreme rarity

**Wainscot:** The lower portion of a wall, especially if finished differently from the upper portion.

**Warp, Track:** The vertical distance between the plane of any three of four rail head contact points (two on each rail) forming a rectangle and the remaining point.

### 1.4 Acronyms and Abbreviations

The following acronyms and abbreviations appear in this document. They are defined as indicated:

- **AAR**  Association of American Railroads
- **ADA**  American Disabilities Act
- **AFI**  Air Filter Institute
- **AISC**  American Institute of Steel Construction
- **AISI**  American Iron and Steel Institute
- **ANSI**  American National Standard Institute
- **APS**  Auxiliary Power Supply
- **APTA**  American Public Transit Association
- **AREA**  American Railway Engineering Association
- **ARI**  Air Conditioning and Refrigeration Institute
- **ASA**  Acoustical Society of America
- **ASCII**  American Standard Code for Information Interchange
- **ASHRAE**  American Society of Heating, Refrigeration and Air Conditioning Engineers
- **ASIC**  Application Specific Integrated Circuit
- **ASME**  American Society of Mechanical Engineers
- **ASTM**  American Society for Testing and Materials
- **AWG**  American Wire Gauge
- **AWS**  American Welding Society
- **CDA**  Copper Development Association
- **CDRL**  Contract Deliverables Requirements List
- **CFE**  Customer Furnished Equipment
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<tr>
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<td>Mean Time to Repair</td>
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<tr>
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<td>National Bureau of Standards</td>
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<td>NEC</td>
<td>National Electrical Code</td>
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<tr>
<td>NEMA</td>
<td>National Electrical Manufacturer's Association</td>
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<td>NFL</td>
<td>No Field Lubrication</td>
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<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>NTP</td>
<td>Notice to Proceed</td>
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<td>OCS</td>
<td>Overhead Contact System</td>
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<td>Root Mean Square</td>
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<td>Safety Hazards Analysis</td>
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<td>SI</td>
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<td>System Safety Program</td>
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<td>TIG</td>
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<td>Total Indicated Runout</td>
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<td>USASI</td>
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<td>v</td>
<td>Velocity</td>
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<tr>
<td>VPI</td>
<td>Vacuum Pressure Impregnation</td>
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<td>VSWR</td>
<td>Voltage Standing Wave Ratio</td>
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1.5 Units of Measure

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<td>A</td>
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<td>British thermal unit</td>
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<td>Decibel milliwatt</td>
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<td>ft</td>
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<td>ft/min</td>
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<td>ft³/min</td>
<td>Cubic feet per minute</td>
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<td>g</td>
<td>Acceleration due to gravity (32.2 ft/s² = 9.81 m/s²)</td>
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<td>g</td>
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<tr>
<td>h</td>
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<tr>
<td>Hz</td>
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<td>Joule</td>
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</table>
μV  Microvolt
N  Newton
oz  Ounce
psi  Pounds force per square inch
Pa  Pascal
s  Second
V  Volt
Vac  Volt alternating current
Vdc  Volt direct current
°C  Degree Celsius
°F  Degree Fahrenheit

1.6 CDRL

No submittals are required for this Section.

END OF SECTION
# SECTION 2

## DESIGN AND PERFORMANCE CRITERIA

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SECTION 2
DESIGN AND PERFORMANCE CRITERIA

2.1 General

This section establishes system performance, environmental, and general design criteria for the Dallas Streetcar. Included topics are configuration, capacity, dimensional, performance, environmental, noise and vibration, weight, safety, reliability, and other requirements which affect vehicle system and subsystem design. These requirements apply to all aspects of vehicle and equipment design as well as associated off-vehicle equipment.

Subject to the maintenance intervals specified in Section 2.11.3, and the Contractor’s recommended maintenance practices and normal industry accepted operating procedures, the streetcars shall be designed for a normal revenue service maximum speed of 42 mph (70 km/h) and a minimum service life of 30 years in the Dallas environment. Annual average mileage is estimated to be 40,000 miles (67,000 km) per vehicle.

2.2 General Vehicle Configuration

2.2.1 Vehicle Type

The vehicle shall be an articulated, modern urban streetcar with contemporary styling, with the following characteristics:

- There shall be not less than three body sections including at least one low floor section.
- Not less than 50% of the vehicle shall be low floor.
- There shall be at least one double wide doorway per side in the low floor section.
- The vehicle shall be capable of bi-directional operation, with a fully functional cab at each end. Operating control and performance shall be equal from both cabs.
- The vehicle shall be designed for single unit operation with provisions for towing a non-operable vehicle.
- The vehicle shall be heated and air conditioned consistent with the Dallas, Texas environment and these Technical Specifications.
- The vehicle shall be provided with an Energy Storage System (ESS) to permit operation without an overhead wire on the segments defined in these Technical Specifications.

Within 90 days after NTP, the Contractor shall submit for DART’s approval general arrangement drawings of the vehicle as described in CDRL 2-1.

2.2.2 Elderly and Handicapped Accessibility

The vehicle shall comply with all requirements of the Architectural and Transportation Barriers Compliance Board contained in 36 CFR Part 1192; “Americans With Disabilities Act (ADA), Accessibility Guidelines for Transportation Vehicles; Final Guidelines” and 49 CFR Parts 27, 37, and 38; “Transportation for Individuals With Disabilities; Final Rule.” Other ADA
requirements (as they apply to transit applications), such as signage and information displays, shall be incorporated.

Space for at least four wheelchairs shall be provided in each vehicle. Seats which flip up to allow space for wheelchairs shall be provided at two locations, one per vehicle side. At two locations, one per side, hanging type bicycle stowing racks shall be provided. Stanchions, grab bars, and handrails shall be provided to permit safe use of this area by standees when no wheelchairs are present.

Suitable graphics shall be provided at each wheelchair area to indicate that the primary use of the area is for wheelchairs and to provide instructions for operating the flip up seats where provided.

2.2.3 Identification

Streetcars shall be sequentially numbered. The numbering scheme shall utilize numbers with up to four digits as approved by DART. Vehicle numbers shall be applied on the exterior on each end of the vehicle and on both sides of the center section. In addition, vehicle numbers and body end identification letters (A or B) shall be installed on the side wall above the left side cab window in each cab, and in the passenger compartment on the upper part of each cab and articulation bulkhead. Numbering locations, font, and size shall be submitted to DART for review and approval. (CDRL 2-2)

2.3 Operating Environment

2.3.1 Right of Way Description

The streetcar shall operate successfully over the entire initial alignment as described in this Section. The vehicles will be operated on city streets in mixed traffic with maximum speeds of 40 mph (67 km/h). The track bed design will be primarily level, without cross slope for drainage, though at limited locations track bed cross slopes of up to 2% may be required by wayside conditions

The initial line of the Dallas Streetcar system consists of an approximate 1.6-mile, single at-grade, dedicated streetcar track extending from near Union Station in downtown Dallas to the Colorado Boulevard and Beckley Avenue intersection in Oak Cliff. The streetcar track would be contained within existing roadway right-of-way along Houston Street, crossing the Trinity River via the Houston Street Viaduct, then transitioning to Zang Boulevard, and finally turning west on Colorado Boulevard before terminating at the Beckley Avenue Intersection. Operation on the Houston Street Viaduct shall be using an on-board energy storage system (ESS). Refer to Figure 2-3 for the alignment profile.

Operation across the historic Houston Street Viaduct shall be without an overhead traction power distribution system. Operation shall include the all vehicle auxiliary systems including heating and air conditioning.

In addition to the Dallas Streetcar alignment the vehicle shall be capable of operating on the DART alignment from Houston Street immediately south of Young Street and connecting with the DART alignment underneath the Houston Viaduct. Movements on the DART alignment will be during non-revenue service hours.
2.3.2 Right of Way Design Constraints

The physical constraints of the track, yard and wayside are included below. No warranty is made by DART of Dallas that track will be maintained in its new condition.

- Rail Types: 115 RE
- Rail Cant: 1:40, except for special trackwork sections
- Minimum horizontal curve radius: 65.62 ft (20 m)
- Minimum vertical curve radius, crest: 820 ft (250 m)
- Minimum vertical curve radius, sag: 1,150 ft (350 m)
- Minimum frog number: 4
- Track gage: 56-1/2 in (1435 mm)
- Nominal track cross-slope: 0 in (0 mm)
- Maximum track cross-slope: 3 in (75 mm)
- Maximum sustained gradient: 7.0%
- Maximum gradient for 328 ft (100 m): 8.25%
- Reverse vertical curves: Either a crest curve of 820 ft (250 m) and a sag of 1150 ft (350 m) separated by a tangent section of 43 ft (13 m) or a crest and sag of 1640 ft (500 m) separated by no tangent track.
- Compound curves: An 66 ft (20 m) horizontal curve and a 1640 ft (500 m) radius vertical curve, either crest or sag.
- Platform heights: 14 in (355 mm) above TOR

2.3.3 Clearance and Fordability Requirements

Vertical under-car clearance is defined from Top of Rail (TOR) with the maximum suspension deflection and carbody roll, minimum vertical curve radius, maximum track superelevation, and fully worn wheels. Minimum vertical clearance shall be 2 in (50 mm).

Clearances between truck components and the carbody shall be as specified in Section 11.2.4.

The Contractor shall submit for review the dynamic vertical and horizontal excursions of the vehicle under normal and worst case conditions of truck and suspension motion, and carbody roll. The clearance envelope shall be limited to that shown on Figures 2-1 and 2-2. The Contractor shall submit the actual clearance requirements (CDRL 2-3 and 2-4) within 60 days after NTP.

The vehicle shall operate without impairment or damage in standing water of depths up to 3 inches (75 mm).

2.3.4 Station Platform Interface

The nominal horizontal gap between the platform edge and the edge of vehicle floor at the doorway shall be 2.0 in (51 mm) and in no case shall be greater than 3.0 in (76 mm) nor
less than 1.5 in (38 mm), including platform tolerance. On tangent track, the platform edge is located at 55.25 in (1,403 mm) from track centerline.

The nominal vertical gap between the platform horizontal surface at the platform edge and the vehicle floor surface at the doorway shall be 0 in (0 mm) and in no case shall be greater than 0.625 in (15 mm), including platform tolerance. Station platforms are at a height of 14.0 in (355 mm), ±0.25 in (± 6.4 mm) above top of rail.

The Contractor shall communicate and cooperate with the Dallas Streetcar wayside construction contractors on platform interface issues to assure that the wayside/vehicle system complies with ADA requirements.

2.3.5 Climatic Conditions

The vehicle shall operate as specified, and be stored and maintained without impairment, under all climatic conditions of the City of Dallas.

The following climatic factors shall be used as design guidelines and shall be considered as operational requirements. Actual localized temperatures and conditions within and under the car body may be more severe than the ambient climatic conditions and the Contractor shall be responsible for evaluating these during its design effort. Additionally, the Contractor shall be responsible for advising DART if there are any special environmental factors to which its equipment may be sensitive that are not listed below. The Contractor shall ensure that no equipment damage occurs during manufacture, storage, and shipment as a result of climatic conditions which differ from those below:

- Temperature and Solar Load:
  - Minimum ambient air temperature, external to equipment: 4°F (-15°C)
  - Maximum ambient air temperature, external to equipment: 115°F (46°C)
  - Maximum solar radiation: 275 BTU/hr·ft² (866.9 w/hr·m²)
  - Maximum daily temperature range: 50°F (10°C)

- Precipitation:
  - Maximum rainfall rate (may occur simultaneously with worst case wind): 7 inches (178 mm) per hour
  - Maximum snowfall: 12 inches (305 mm) in 24 hours
  - Ice: Measurable quantities infrequently

- Fordability
  - The vehicles must be able to operate in water up to 3 inches (75 mm) above the TOR for a distance of 400 feet (121.9 m) at speeds up to 10 mph (16.1 km/h).

- Wind
  - Average speed: 11 mph (17.7 km/h)
- Maximum sustained for 1 minute: 73 mph (117.5 km/h)
- Maximum gusting: 81 mph (130.4 km/h)

### 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:

- **Particulates:**
  - Average: 0.175 mg/m³
  - Maximum: 0.324 mg/m³
- **Ozone:** 0.200 ppm, maximum
- **NO₂:** 0.25 ppm, maximum
- **SO₂:** 262 μg/m³, maximum
- **CO:** 20 ppm, maximum
- **Chloride Content:** 13.9 mg/m³
- **Moisture Acidity:** pH 4.41

### 2.4 Supply Voltages

#### 2.4.1 Wayside Primary Power Voltage

The vehicle shall operate at a nominal OCS voltage of 750 Vdc, generated by 6-pulse rectification, with an operating range of 525 Vdc to 925 Vdc.

#### 2.4.2 Low Voltage Dc

A low voltage dc system, with battery back-up, shall be provided for vehicle controls and other specified equipment.

The low voltage dc system shall be 24 Vdc nominal with the operating range at the load apparatus considered to be 17 Vdc to 34 Vdc. All equipment operating from the low voltage power system shall function normally, without failure or degradation in serviceable life, at equipment terminal voltages between 17 Vdc and 34 Vdc. The minimum pick-up voltage for relays and contactors may be based on 77°F (25°C) ambient operation.

#### 2.4.3 Ac Supply Voltage

A source of 3 phase ac and single phase ac power shall be provided for general loads. The 3 phase ac system source voltage shall be 208 or 460 Vac rms, 4 wire, 60 Hz. All ac loads shall be designed for the voltage at the load point. The single phase ac source shall be 120 Vac, 60 Hz.

#### 2.4.4 Transients and Abnormal Electrical Conditions

The vehicle shall provide protection against, and withstand without damage, all transients and voltage surges typical of rail transit, and as specified in IEC 60850 and IEC 61287.
All equipment on the vehicle shall be protected from damage or continued shutdown caused by random interruptions of the overhead contact wire system power due to isolation gaps, pantograph bounce, or other conditions.

All propulsion equipment shall be designed and tested for rated performance as described elsewhere in this section. The equipment shall operate over the voltage range of the primary power system without damage, failure of the equipment to function as specified, or reduction of required service life.

All auxiliary equipment operated directly from the line voltage shall be rated for full performance at line voltages specified in Section 2.4.1.

2.5 Vehicle Weights and Dimensions

The dimensions shall be as indicated below. Construction tolerances of dimensions shall be as stated on the Contractor’s drawings unless specifically stated in this specification.

2.5.1 Weights

The weight of each vehicle, including passengers at 154 lb (70 kg) each, shall be defined as follows:

- **AW0**: Empty vehicle operating weight, maximum of 97,500 lb (44,225 kg)
- **AW1**: Full seated load (passengers plus operator), plus AW0
- **AW2**: Standees at 4 persons per m² of suitable standing space per passenger, plus AW1
- **AW3**: Standees at 6 persons per m² of suitable standing space per passenger, plus AW1
- **AW4**: Standees at 8 persons per m² of suitable standing space per passenger, plus AW1

All weights above are based on a ready-to-run vehicle, complete in all respects with all equipment, materials and fluids. Suitable standing space shall include all areas of the aisles where it is possible for passengers to stand, including wheelchair areas, excluding step areas and an area 12 inches (300 mm) wide in front of the longitudinal seats for the legs of passengers. The ratings of vehicle equipment and systems shall be based on the actual weight and passenger capacity of the vehicle. The Contractor shall provide a report on vehicle weight, passenger load calculations, and weight unbalance. (CDRL 2-5)

2.5.2 Weight Balance

All equipment shall be arranged so that its weight is distributed to maximize adhesion and preclude the tendency to derail. The equipment shall be so arranged that each vehicle, complete with all necessary apparatus and for all passenger loading conditions specified, shall meet the following balancing requirements:

- The difference in vehicle weight supported at the rail by the A-end and B-end trucks shall not exceed 2,000 lb (900 kg) for all loading conditions from AW0 to AW3. Greater imbalances resulting from the ESS may be proposed for DART approval.
- The lateral imbalance shall not exceed 25,000 in-lb (290 kg-m) for all loading conditions from AW0 to AW3
2.5.3 Carbody Dimensions

Allowed vehicle lengths: 65 ft to 82 ft (19.8 m to 25 m)
Vehicle width Up to 8.7 ft (Up to 2.65 m)
Low floor height above TOR, from AW0 to AW3 14 in (356 mm)
Maximum roof-mounted equipment height, exclusive of pantograph, above TOR with new wheels and vehicle at AW0: 12.5 ft (3810 mm)
Minimum interior ceiling height 6.5 ft (1980 mm)
Minimum side door opening width
  Single leaf doors 27.5 in (700 mm)
  Double leaf doors 48 in (1220 mm)
Minimum side door opening height 6.3 ft (1930 mm)

2.5.4 Pantograph Dimensions

Maximum height above TOR in the lockdown position, new wheels, vehicle at AW0: 13 ft (3960 mm)
Pantograph operating height under dynamic conditions, vehicle weight from AW0 to AW3, and with new to fully worn wheels
  Max Minimum Operating Height 13.3 ft (4065 mm)
  Minimum Max Operating Height 22.5 ft (6860 mm)
Maximum collector width over horns 6.5 ft (1980 mm)
Minimum carbon shoe length 3.5 ft (1067 mm)
Maximum longitudinal distance from vehicle pivot point centerline to center of pantograph shoe, locked down 4.2 ft (1275 mm)

2.5.5 Wheel Dimensions

Nominal Diameter, new 20 in to 26 in (510 mm to 660 mm)
Minimum allowable wear on diameter 2 in (50 mm)
Wheel Profile Section 2.5.6
Back-to-Back Dimension Section 2.5.6

2.5.6 Wheel to Rail Interface Study

Within 90 days of NTP, the Contractor shall submit its Wheel to Rail Interface Study (WRIS) Plan and Schedule to DART for review. (CDRL 2-6)

Upon receipt of DART’s written approval, the Contractor shall conduct the WRIS in conjunction with the wayside construction contractor, DART, and DART’s Project Office. The
WRIS shall include determination of wheelset back-to-back dimension, wheel dimensions, track gauge under varying conditions on tangent track, curved track, and in special trackwork, for both the streetcar and DART alignments, and rail head and wheel profiles. The report of the WRIS shall be submitted to DART for review upon completion of the study, and, upon approval of the report by DART, the recommendations of the study shall become part of the Contract Documents and the vehicle design requirements. (CDRL 2-7)

The WRIS shall, as a major goal, ensure the compatibility among the chosen rail sections, track design, the car truck design, and the wheels. It shall optimize the combined design of the wheel to rail interface for long term wheel and rail wear, minimum propensity to derail, wheel/rail noise reduction, and ride quality enhancement. Consideration of the necessary modifications to DART wheel-truing equipment and capability to maintain the wheel profile shall be addressed in the WRIS.

The Contractor shall be responsible for coordination among the various parties to the wheel to rail interface in the conduct of the study, and shall implement the results of the WRIS on the vehicle elements.

2.6 Performance Requirements

The following establishes the performance required of the streetcar. Performance requirements are modified when operating with on the ESS (off-wire).

Within 180 days after NTP, the Contractor shall submit for DART’s approval performance data for the vehicle as described in CDRL 2-8.

2.6.1 Propulsion and Braking Assumptions

All propulsion and braking equipment shall be designed to interface properly and produce the required performance values. The basis for performance calculations, designs and evaluation shall be as follows:

- All acceleration, braking and jerk rates shall be based on level tangent dry track in still air except when otherwise noted.
- Propulsion equipment shall provide required performance at nominal 750 Vdc catenary voltage except as described below.
- Initial acceleration rates shall be as required by this section over a 525 Vdc to 925 Vdc range at the OCS.
- Braking rates shall be independent of the primary power voltage and once initiated, full dynamic braking capabilities shall be available without primary power voltage present.
- All specified performance capabilities shall be provided over the specified full range of the following:
  - Wheel wear
  - Ambient temperatures
  - Low voltage power supply voltage
2.6.2 Acceleration Requirements

When operating from the wayside primary power system, full acceleration average rate at the maximum power position of 3.0 mphps (1.34 m/s$^2$) ±5% at all vehicle weights from AW0 to AW2. The full acceleration rate may decrease linearly from AW2 to AW4 down to a value determined by the multiplication of 3.0 mphps (1.34 m/s$^2$) times the ratio of AW2 to AW4. The full acceleration rate shall be available in the speed range of 0 to 20 mph (32 km/h). During acceleration, with any requested rate, the instantaneous acceleration rate shall not vary from the average rate by more than 0.20 mphps (0.09 m/s$^2$).

When operating from the ESS, the minimum full acceleration average rate at the maximum power position shall be 2.0 mphps (0.89 m/s$^2$) ±5% at all vehicle weights from AW0 to AW2. The full acceleration rate may decrease linearly from AW2 to AW4 down to a value determined by the multiplication of 2.0 mphps (0.89 m/s$^2$) times the ratio of AW2 to AW4. The full acceleration rate shall be available in the speed range of 0 to 15 mph (25 km/h). During acceleration, with any requested rate, the instantaneous acceleration rate shall not vary from the average rate by more than 0.20 mphps (0.09 m/s$^2$).

Specified acceleration performance shall be available at the nominal line voltage and higher, and at AW2 or lower.

Acceleration requirements are:

- Acceleration rate at Master Controller Max Power: 3.0 mphps, ± 5% from 0 to 18 mph
- 1.34 m/s$^2$, ± 5% from 0 to 30 km/h
- Time to reach 20 mph (33 km/h) from stop: less than 8 seconds
- Time to reach 40 mph (67 km/h) from stop: less than 25 seconds

At weights greater than AW2, acceleration may be reduced in direct proportion to the ratio of AW2 weight/actual vehicle weight.

For line voltages less than nominal, the specified acceleration shall be provided except that the speed to which the acceleration is maintained may be reduced in direct proportion to line voltage/nominal voltage.

2.6.3 Speed Requirements

The vehicle shall have a minimum balancing speed of 42 mph (70 km/h) on level tangent track, over the specified range of wheel wear, at nominal line voltage, AW2 weight, still air. Minimum safe operating speed for all equipment with fully worn wheels shall be at least 48 mph (80 km/h).

2.6.4 Braking Requirements

Full service braking effort shall be provided by dynamic braking. Dynamic braking shall be blended regenerative and rheostatic. Friction braking shall be capable of covering the loss of dynamic braking in the event of dynamic failure, and provide continued service braking at a reduced speed.

At all vehicle weights, service braking shall be 100% dynamic braking down to the dynamic brake fade point.

In the event of dynamic brake failure on a truck, friction brakes shall automatically provide the necessary braking efforts to achieve the requested rate.
The full service average braking rate requirements, as measured by the entry speed divided by stopping time, are:

- 3.0 mphps (1.34 m/s²) + 5%, with all dynamic brakes functional, from any entry speed to zero.
- 3.0 mphps (1.34 m/s²) +10%, with one or more dynamic brake units inoperative, from any entry speed to zero. After the initial stop with a dynamic brake failure, the system may automatically reduce vehicle maximum speed to conform to friction brake thermal limitations.

The instantaneous variation in braking rate shall not exceed ±10% of the command value in blended braking and ±20% in friction brake only braking, at any speed.

Dynamic brake fade shall occur at 3 mph (5 km/h) or lower.

2.6.5 Maximum Braking

Application of maximum braking shall be from the master controller.

Maximum braking shall be a combination of full service brake plus track brake. Sand shall be automatically applied and the wheel slip system shall be operational. Maximum braking shall be retrievable.

2.6.6 Emergency Braking Requirements

Application of emergency braking shall be from the console emergency push button switch.

Emergency braking shall be a combination of, friction disc brakes, track brakes, dynamic brakes, and the application of sand. The minimum emergency brake rate at AW0 shall be achieved independently of dynamic braking, using friction disc brakes, track brakes and the application of sand. At vehicle weights above AW0, dynamic brakes shall supplement the friction disc brakes, track brakes and application of sand, so the minimum emergency brake rate can be achieved. The spin/slide system shall be cut out during emergency braking.

For brake entry speeds greater than 15 mph (25 km/h), the average emergency brake rate shall be a minimum of 5.0 mphps (2.23 m/s²) and shall not exceed this rate by more than 30%.

For brake entry speeds of less than 15 mph (25 km/h), the instantaneous emergency brake rate after the rate has built up shall be a minimum of 5.0 mph (2.23 m/s²) and the maximum rate shall follow the characteristics of the magnetic track brake.

Emergency braking shall not be jerk limited, and shall not be inhibited by the state of any other vehicle systems.

An emergency brake command shall be irretrievable to the no motion detection speed. Track brakes shall be released and sanding terminated when the vehicle achieves no-motion.

Emergency brake is considered a safety system. Emergency braking shall be controlled by a double wire double break control line (separate positive and negative control wires with duplicate switching contacts for each control function in the positive and negative control lines).

See Section 5.3.3 for additional emergency brake control requirements.
2.6.7 Wheel Spin Slide Correction

A system shall be provided to detect and correct wheel spin and slide on all wheels of the vehicle, both in acceleration and braking. The spin/slide system shall be designed for safe operation such that a spin/slide system failure must not prevent the application of braking at any level less than desired, in any braking mode.

- Spin/slide protection shall be active in all motoring and braking modes except for emergency braking.
- The spin/slide system shall minimize damage to the wheel treads caused by wheel slide or spin and provide the shortest possible stopping distance under adverse rail conditions.
- The spin/slide system shall detect slides or spins by evaluation of axle or wheel speed differences and acceleration/deceleration rate levels.
- Spin/slide correction shall use modern methods of tractive effort modulation that are in the same proportion to the magnitude of the detected spin or slide.
- The system shall modify the deceleration detection level during track brake applications.
- Sanding shall be applied automatically during correction of major spins and slides. Sanding shall be cancelled at no-motion or if the spin/slide condition is corrected.
- Removal of effort shall not be jerk limited during spin/slide corrections.
- The wheel spin/slide correction system shall function properly with differences of up to 2 inches (50 mm) in diameter among the wheels of one truck compared to the wheels of the any other truck of a vehicle.
- A separate safety timing function shall be provided to trip and override brake release on each truck after 3 seconds from slide detection if the slide is not corrected in that time period. The timer shall be reset, once tripped, by sensing no motion and application of acceleration power. If not tripped the timer shall be reset by correction of the slide.
- Spin/slide efficiency shall be at least 90%, as measured by an inertial accelerometer on artificially wetted rails. Efficiency shall be calculated as the ratio of actual acceleration to achievable acceleration, using an approved calculation method. Measurements shall be taken only during periods of actual spin/slide activity when wheels are spinning or sliding.

2.6.8 Jerk Limits

The rate of change in acceleration during all requested changes in power and brake efforts shall be between 2.5 mph/s$^2$ and 3.0 mph/s$^2$ ($1.1 \text{ m/s}^3$ and $2.0 \text{ m/s}^3$) for maximum power and full service brake.

Where the rate of change request is less than the jerk limit, the system shall follow the command signal rate of change within specified accuracy limits.

- The jerk limits specified shall apply to all normal power and service braking applications and to re-applications of power and braking when controlled by the spin/slide system.
• Release of power when traversing overhead primary power isolation gaps need not be jerk limited; however, reapplication of power shall be jerk limited. Overhead line power isolation gaps will not exceed 12 inches (300 mm).

• Emergency brake applications shall not be jerk limited.

• Release of power, when the master controller is moved directly from a power position to a brake position without stopping in the coast position, shall not be jerk limited; however, the application of the service braking portion of the mode transition shall be jerk limited.

• Friction brake release at less than 3 mph (5 km/h) shall not be jerk limited.

2.6.9 Mode Change Dead Times

The mode change dead time (MCDT) shall be less than 400 ms for the following direct mode changes:

- Power to Brake
- Power to Coast
- Coast to Brake
- Coast to Power
- Brake to Coast
- Brake to Power below 3 mph (5 km/h)

For the direct mode change Brake to Power, above 3 mph (5 km/h), the mode change dead time shall be less than 800 ms.

Mode change dead times for emergency brake applications shall be 400 ms or less, regardless of the original mode.

Mode change dead time shall be measured from the time that the control line(s) change(s) state until the vehicle acceleration or deceleration is reduced to 90% of the previously commanded value, or 10% of the new commanded value, respectively, for mode changes to or from coast, and until it reaches 10% of the new commanded value for mode changes between brake and power.

2.6.10 No Motion Detection

Equipment shall be provided to detect all vehicle motions down to, and including, 3 mph (5 km/h).

The speed detection system shall generate a safe signal, indicating that no-motion has been detected, for other vehicle systems that require such information.

The no-motion detection system shall monitor all axles, and shall include at least 2 independent circuits to generate the no-motion state.

2.6.11 Load Weighing

The tractive efforts produced by the propulsion and braking systems shall be apportioned on a per truck basis according to the vertical load on each truck, such that tractive efforts are optimized for available adhesion.
The load compensation signal shall be generated by the friction brake control system. The propulsion system shall use this load compensation signal.

2.6.12 Rollback Prevention

When moving the master controller to a power position from a brake position a rollback prevention measure shall be employed to set the brakes in the event the vehicle moves more than 6 inches (150 mm) in the direction opposite from the selected direction of travel. The brake will remain applied until the master controller is returned to a braking position.

2.6.13 Parking Brake

A parking brake shall be provided on all powered trucks. The parking brake shall automatically apply when the vehicle is powered-down from the cab, or when the friction brake system loses system pressure or the ability to stop the train normally.

The parking brake shall be capable of stopping and holding a vehicle at all weights up to AW4 on a maximum grade of 9% indefinitely.

2.6.14 Duty Cycle Rating

The vehicle shall operate on the intended alignment, under worst case ambient conditions, without exceeding the thermal ratings of any equipment, as follows:

- The vehicle shall be capable of operating continuously at AW3 passenger loading on a duty cycle comprised of full power acceleration to the maximum speed limit for each track segment, except as noted below, maintaining that speed until brake, full service deceleration to a stop, and 8 second dwell time at each station, over the specified alignment, in all directions, with a 2 minute layover at each end of the line.

- An operating vehicle shall be capable of towing or pushing an inoperative vehicle with the brakes released (not functional). Full acceleration and braking tractive effort shall be available on the operative vehicle. An operative vehicle at AW0 weight shall have the capability to tow an inoperative vehicle at AW3 weight to the next available unloading location, and then moving the empty vehicle to the shop via the worst case (most severe duty cycle) routing.

- If dynamic braking on a vehicle or truck becomes inoperative, the vehicle may have a speed restriction imposed based on the thermal capacity of the friction brake system. A vehicle in this state shall have the capacity to perform a full round trip at restricted speed and AW2 load weight.

2.6.15 System Redundancy and Recovery

The vehicle shall be configured such that it can continue to operate under failure conditions. Devices and procedures shall be provided to disable the failed system and allow the remaining systems to continue operation. Performance may be limited, except where specifically indicated otherwise.

The following systems shall be physically and functionally redundant and share no components except where specifically permitted:

- Propulsion
- Friction braking
2.7 Noise and Vibration

2.7.1 General

All sound measurements shall be performed using Type 1 sound level meters meeting current IEC or ANSI standards. Sound levels shall be measured on the A scale (dBA), with slow meter response for stationary vehicle measurements, and with fast meter response for moving car measurements.

The maximum allowable noise level shall be reduced by at least 3 dB if significant pure tones in the range from 250 Hz to 8,000 Hz are present in the noise. Pure tone noise shall be considered significant in this context if any one-third octave band sound pressure level is 5 dB, or more, higher than the arithmetic average of the 2 adjacent bands containing no pure tones.

Unless otherwise noted, specified noise limits shall be for equipment which operates on a regular basis and shall not apply to equipment which operates infrequently, such as a circuit breaker or pneumatic pressure relief device.

2.7.2 Interior Noise

Measurements of interior noise levels shall be taken in accordance with ISO 3381.

With the vehicle stationary with windows and doors closed, with all auxiliary equipment operating simultaneously under normal operating conditions, the interior noise level shall not exceed 68 dBA.

With the vehicle operating on the City of Dallas alignment, on smooth rail, at any speed up to 48 km/h and under any acceleration or deceleration condition, interior noise shall not exceed 75 dBA.

Noise generated by lamps, fixtures, and ballasts installed and energized at rated voltage and frequency, measured 1 foot (300 mm) from any lighting fixture, shall not exceed 48 dBA.

2.7.3 Wayside Noise Limits

All measurements of exterior noise levels shall be made in accordance with ISO 3095, with microphones placed 25 ft (7.5 m) from the track centerline, and 5 ft (1.5 m) above the track.

With vehicle stationary and empty, and all auxiliary equipment operating simultaneously under normal conditions, exterior noise shall not exceed 70 dBA.

With the vehicle operating on DART’s alignment, on smooth rail, at any speed up to 70 km/h (42 mph), under any acceleration or deceleration condition, exterior noise shall not exceed 78 dBA.

2.7.4 Vibration Generation
Vehicle equipment operation shall not cause visible or audible vibrations anywhere on the vehicle floor, walls, ceiling panels and seat frames, at any specified operating speed, and under any acceleration or braking condition except emergency braking.

Interior vibration limits are as follows:

- Below 1.4 Hz: Maximum deflection (peak-to-peak) of 0.1 inch (2.5 mm)
- 1.4 Hz to 20 Hz: Peak acceleration of 0.001 g (0.01 m/s²)
- Above 20 Hz: Peak velocity of 0.03 in/s (0.75 mm/s)

2.7.5 Vibration and Impact Loads

All vehicle equipment shall operate without damage or degradation of performance when subjected to vibration and impacts encountered during normal service, and shall be compliant with and tested per IEC 61373 standard, including all functional and durability requirements.

2.8 Electromagnetic Interference and Compatibility

The vehicle equipment shall not create electrical interference with other equipment on the vehicle, nor with equipment on the wayside. Of particular concern, in this regard, is the requirement the streetcar operate on the DART alignment to the DART maintenance facility during non-revenue hours. The streetcar shall not interfere with the safe and proper operation of the existing DART signal and TWC systems. See Section 14 for additional details on the Automatic Train Protection (ATP) and train-to-wayside communication (TWC) systems.

The Contractor shall coordinate with DART to determine all applicable signaling and communications frequencies currently used or reserved for future use. A report listing all frequencies of concern, the DART acceptable limits, and the vehicle limits for each frequency identified within 90 days of NTP. (CDRL 2-9)

2.8.1 Emission Limits

To help avoid undesirable effects upon external equipment or other installations along the right-of-way caused by on-board vehicle subsystems, the electromagnetic emission limits specified below shall not be exceeded for each individual car. Meeting these emission limit requirements is the first level of defining the interface between the vehicles and their intended environment. The Contractor shall be responsible for reducing the emission limits, if necessary, to prevent interference with any existing DART equipment, and shall work jointly with DART, DART, and others designated by DART to insure compatibility between the streetcars and the DART equipment.

2.8.2 Radiated Emission Limits

The vehicle, in the configuration proposed to DART, shall comply with EN 50121 for railway applications. Radiated emissions shall be in accordance with EN 5021-3-1 for urban environments.

2.8.3 Conductive Emission Limits

Conductive emissions, as measured by the procedures of "Conductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures, UMTA-MA-06-0153-85-
6, Method RT/CE02A, Conductive Emission Test, Vehicle", shall have a current limit (amperes rms) defined as follows:

- From 0 Hz to 80 Hz, 10 A maximum.
- From 80 Hz to 90 Hz, 10 A decreasing linearly to 1A maximum.
- From 90 Hz to 120 Hz, 1 A maximum.
- From 120 Hz to 600 Hz, 10 A maximum.
- From 600 Hz to 1,500 Hz, 1 A maximum.
- From 1,500 Hz to 4,000 Hz, 0.20 A maximum.
- From 4,000 Hz to 20,000 Hz, 0.030 A maximum.

DART will consider allowing higher currents at some frequencies, provided that the currents are limited in the track circuit and communication system passbands to values that will not cause interference with the operation of the signal and communications systems. The specific values shall be based upon Contractor demonstrating that the higher values do not interfere under the worst case wayside and vehicle combinations.

The limits above shall be individually met by each power equipment apparatus as well as during the simultaneous operation of all equipment.

2.8.4 Inductive Emission Limits

The inductive emissions, as measured by the procedures of "Inductive Interference in Rapid Transit Signaling Systems, Volume II: Suggested Test Procedures, UMTA-MA-06-0153-85-8, method RT/IE01A", shall be limited to a maximum of 20 mV, rms, rail-to-rail, at all frequencies between 0 Hz and 1 kHz and a maximum of 10 mV, rms, rail-to-rail, at frequencies from 1 kHz to 20 kHz. This condition shall be met by each individual power equipment as well as the simultaneous operation of all equipment.

DART will consider allowing higher rail-to-rail voltages at some frequencies, provided that the currents are limited in the track circuit and communication system passbands to values that will not cause interference with the operation of the signal and communications system. The specific values shall be based upon Contractor demonstrating that the higher values do not interfere under the worst case wayside and vehicle combinations.

2.9 Vehicle Safety Analysis

2.9.1 General

The streetcar shall be designed and constructed to be safe to passengers, persons nearby, and streetcar employees, both under normal operating conditions, and in the event of equipment failure. Contractor shall insure that all systems' safety aspects have been considered for each individual system, and for systems integrated to complete the vehicle design.

2.9.2 System Safety Program

The Contractor shall develop, implement, and maintain a comprehensive system safety program (SSP) conforming to the guidelines and requirements of MIL-STD-882D, Section 4. DART will use the implementation guidelines of Appendix A of MIL-STD-882D as the basis for determining acceptability of the Contractor's SSP.
The SSP shall identify all hazards related to the streetcar and impose design requirements and management controls which prevent mishaps by eliminating hazards or reducing risk to levels acceptable to DART. The SSP shall be developed in the earliest phases of the Contract and shall be continuously maintained throughout as design and construction evolves. (CDRL 2-10)

Safety requirements defined in this Section 2.9 and elsewhere in this Specification shall be incorporated into the SSP and the Contractor’s designs.

### 2.9.3 General Safety Design Requirements

The term ‘hazard’ describes any event or condition which may result in injury to a person or damage to the streetcar or other physical property. Hazards shall be resolved such that the likelihood of any such injury or damage shall be remote or improbable.

The following guidelines, listed below, shall be incorporated into the design of all vehicle systems affecting safety:

- Only components with high reliability and predictable failure modes, and which have been proven in conditions similar to the projected service, shall be utilized.
- All electronic circuits shall be assumed capable of failing in permissive modes.
- Software shall be considered unsafe unless it is verified as safe by an approved methodology. Approved methodologies shall comply with the requirements of IEEE 1483 and EN 50128.
- Systems shall be based on closed circuit principles in which energized circuits result in permissive conditions, while interrupted or de-energized circuits result in restrictive conditions.
- All vital circuits not wholly within the system apparatus enclosure shall be double-wire, double-break, with the exception of connections to non-vital circuits, which may be single-wire, single-break.
- Any component or wire becoming grounded shall not cause a permissive condition. Safety circuits shall be kept free of any combination of grounds that will permit a flow of current equal to, or in excess of, 75% of the release value of any safety device in the circuit.
- Circuit impedances, signal encoding, shielding, layout, and isolation shall be selected to reduce the effects of interference to the extent that safety is maintained under all conditions.
- Commands that result in permissive conditions shall be propagated by no less than two independent signals, both of which must be present before the permissive condition can occur. The lack of either signal shall be interpreted as a restrictive command.
- Systems controlled by variable level signals shall be arranged such that zero signal level results in the most restrictive condition. At least one enabling signal, however, independent from the variable control signal, shall be present before the control signal can modulate the system to a more permissive level.
- Circuit breakers and fuses shall be guaranteed by the manufacturer to successfully interrupt rated currents. Circuit breakers and fuses shall be applied
such that the maximum circuit fault currents cannot exceed the manufacturer’s guaranteed operating ranges.

- Systems that rely on structural integrity for safety shall have sufficient safety factors such that failures are not possible within the life of the vehicle under all possible normal conditions.
- Systems and devices subject to wear shall not wear to permissive states within a period no less than three times the recommended and approved overhaul period under the worst-case combination of duty cycle, environment, and all other influences. Such systems and devices shall be clearly indicated as SAFETY CRITICAL in the maintenance manuals.
- Mechanical systems which apply force to achieve safe states shall not depend upon the application of fluid pressure or electrical energy, unless specifically approved.
- All locks, catches, and similar devices affecting safety shall be either self-engaging without application of power or, if engaged by application of power, shall remain fully and safely engaged in the absence of power.
- All systems shall function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation, and the Dallas environment.
- All safety related systems, and devices within those systems, shall be clearly identified as SAFETY CRITICAL in all operation and maintenance manuals, procedures, and training materials.

2.9.4 Failure Induced Hazards

Vehicle equipment and systems shall be designed and constructed to revert to safe modes under failure conditions. Contractor shall employ high quality components, proven systems, redundancy, checking devices, and other techniques to accomplish this goal.

Vehicle systems, the failure of which could result in injury to a person or damage to the streetcar, shall conform to both of the following design principles:

- The failure of a single device shall not result in a permissive condition
- An undetected failure of any device shall not permit a subsequent device failure to result in a permissive condition

The term ‘failure’ includes both the initial device failure and all consequential device failures caused by the initial failure.

The term ‘device’ includes any component, subsystem, or system, whether electrical or mechanical, pneumatic or hydraulic.

The terms ‘restrictive’ and ‘permissive’ relate to potential system responses, which result in either a more safe or less safe condition, respectively, such as: stop versus proceed, a lower speed versus a higher speed, deceleration versus acceleration, brakes applied versus brakes released, actuation of alarm versus no actuation of alarm, etc.

Systems shall conform to the safety design principals by one or both of the following methods:
• The utilization of vital devices, that is, devices with known, guaranteed-by-the-
manufacturer failure modes, such as signal grade relays, combined in circuits in
such a way that the requirements of this section are met.

• Independent channels with independent checking of each. All channels shall
indicate a permissive state in order for the controlled system to achieve a
permissive state. Failure in any channel shall not affect any other channel, or
force the system into a permissive state, unless other actions are required by
other parts of this Specification. Differences in state between channels shall be
alarmed and shall force a restrictive state on the system.

Failures in equipment which result in an indication of danger, whether or not actual danger
exists, shall be considered to have occurred in a safe manner. Conversely, a failure which
results in an indication of safety when, in fact, a dangerous condition may exist, shall not be
considered safe.

2.9.5 Fire and Life Safety

All vehicle components, subsystems, and systems shall be designed for the prevention of
fire and protection of the public, employees, and emergency response personnel from injury
due to fire, smoke, explosion, or panic due to these occurrences and protection of system
elements from damage by fire or explosion.

The vehicle design shall provide for equipment to be located outside of the passenger
compartment, whenever practical, unless specified otherwise, to isolate potential ignition
sources from combustible materials. The articulation, floor, sides, and roof shall be
designed to retard propagation of an underfloor and/or roof fire to the vehicle interior. Fire-
stops shall be provided at floor and roof penetrations. Enclosures for control and other
critical equipment shall be located to provide protection against environmental
contamination and mechanical damage.

2.9.6 Safety Under Normal Operating and Maintenance Conditions

Passengers and operators shall not be exposed to tripping hazards, sharp points and
edges, lethal or injurious voltages, toxic materials, abrupt or unexpected accelerations, or
similar hazards. Location, illumination levels, colors, graphics, and surface finishes shall be
selected to enhance visibility of step edges, windscreens, controls, and other objects with
which the passengers and operators must interface.

Normal and emergency equipment and controls which the passengers or operators may
operate shall be clearly identified, and where required, operating procedures shall be
presented in both printed and graphic formats.

Maintenance manuals, procedures, and training shall indicate the proper handling, storage,
and disposal of hazardous materials. Exposure of maintenance personnel to lethal or
injurious voltages shall be reduced through compartmentalization, interlocks, and similar
measures. All equipment shall be free from sharp points and edges. All equipment
containing hazardous materials, lethal or injurious voltages, or other risks shall be clearly
labeled on both the outside and inside of the equipment.

Maintenance, operating, training, and other manuals shall clearly identify all hazardous
materials and equipment. All maintenance procedures involving hazards shall contain clear
identification of the hazard and instructions to reduce or eliminate the hazards during the
procedure.
2.9.7 Human Error and Other External Influences

All systems shall protect against unsafe conditions resulting from human error. No sequence of operations, or the simultaneous activation of any controls, shall result in unsafe conditions. Where conflicting commands, such as simultaneous power and brake, are requested, the more restrictive shall result.

Maintenance of safety-related equipment shall be arranged such that the effects of errors are minimized. Methods such as limitation of adjustment ranges, unalterable software, non-interchangeable parts, and visible wear indicators shall be employed.

2.9.8 Hazard Identification

Contractor shall identify all failure-induced and normal operating (non-failure condition) hazards falling into severity categories I, II, and III of MIL-STD-882D. The identification of hazards shall include all sub-system suppliers. Hazards shall be compiled into lists and submitted to DART within 180 days after NTP. (CDRL 2-11)

In addition to those hazards identified by the Contractor, the following hazards shall be included in the listings and shall be considered hazards:

- Emergency brake fails to apply when requested
- Service brakes fail to apply when requested
- Propulsion fails to cease when requested
- No-motion detection system indicates no-motion when vehicle is moving
- Door opens spontaneously when not commanded
- Door opens on the wrong side of the vehicle
- Door closes on person's limb and indicates door closed and locked to control system
- Door interlocks erroneously indicate door is closed and locked
- Excessive currents or overheated equipment cause fire
- Vehicle moves in wrong direction

2.9.9 Hazard Analyses

Contractor shall perform a preliminary hazard analyses on all hazards identified in the hazard lists. The hazard analyses shall identify all potential causes of each identified hazard and provide a system of tracking each potential cause to ensure the final hazard analysis includes each potential cause. Analyses shall demonstrate that the vehicle conforms to the requirements of this Specification and that all identified hazards are either eliminated, or reduced to levels of risk acceptable to DART. A preliminary hazard analysis complying with MIL-STD-882D shall be submitted for DART’s review and approval within 180 days after NTP. (CDRL 2-12)

All hazard analyses shall be adjusted or amended as the vehicle design and construction progresses. A final hazard analysis, including Failure Modes Effects and Criticality Analyses, shall be submitted for DART’s review and approval with the delivery of the first streetcar. (CDRL 2-13) For each hazard identified the potential causes identified in the preliminary hazard analysis shall be traceable to the specific resolution in the final analysis. The final
analysis shall be updated for any modifications made to the streetcar during commissioning or revenue operation during the warranty period.

The analysis methods shall be selected by the Contractor as appropriate for the system under evaluation and the hazard severity, subject to approval by DART. Contractor shall be prepared to and shall demonstrate, by test at no additional cost to DART, the validity of any portion of all analyses, as requested by DART.

Standard failure and safety analysis methods, and published failure rates for components, shall be utilized wherever possible.

Existing hazard analyses of like equipment operating under like conditions may be offered in lieu of performing a complete analysis of proposed equipment, subject to DART’s approval.

2.10 Reliability

Streetcar systems shall meet the Mean Time Between Failure (MTBF) requirements listed below, assuming maintenance, preventive and corrective, is performed as recommended by the Contractor. Additional reliability requirements for specific equipment may appear elsewhere in this document.

The requirements apply to all unscheduled maintenance activities resulting from equipment failures, whether occurring in revenue service or not. The time periods used for determining MTBF compliance will be based on actual car mileage divided by an average schedule speed of 5 mph (8 km/h).

Reliability shall be demonstrated in actual revenue service during the warranty period. Systems which fail to meet reliability goals, after an agreed initial time period, shall be redesigned and retrofitted by the Contractor, at the Contractor’s expense, prior to the end of the warranty period.

All equipment furnished by the Contractor shall be considered as belonging to one of the systems listed below.

<table>
<thead>
<tr>
<th>System</th>
<th>MTBF (hours per car)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbody &amp; Appointments, including seating, windows,</td>
<td>100,000</td>
</tr>
<tr>
<td>cab equipment</td>
<td></td>
</tr>
<tr>
<td>Propulsion, Dynamic Brake &amp; Controls including gear</td>
<td>20,000</td>
</tr>
<tr>
<td>box</td>
<td></td>
</tr>
<tr>
<td>Friction Braking, including track brake and sanders</td>
<td>17,000</td>
</tr>
<tr>
<td>Communications and passenger information</td>
<td>40,000</td>
</tr>
<tr>
<td>Passenger Doors &amp; Controls, including bridgeplates</td>
<td>17,000</td>
</tr>
<tr>
<td>Lighting</td>
<td>100,000</td>
</tr>
<tr>
<td>Electrical, including the vehicle network and cab</td>
<td>20,000</td>
</tr>
<tr>
<td>controls, and apparatus not included in other</td>
<td></td>
</tr>
<tr>
<td>systems. Excludes equipment internal to other</td>
<td></td>
</tr>
<tr>
<td>systems.</td>
<td></td>
</tr>
<tr>
<td>HVAC</td>
<td>30,000</td>
</tr>
<tr>
<td>Trucks &amp; Suspension</td>
<td>50,000</td>
</tr>
</tbody>
</table>

The Contractor shall submit a report with the predicted reliability of the components to be utilized within each system prior to beginning manufacturing of the vehicle for approval by
DART. The report shall be updated after the beginning of revenue service with the MTBFs achieved. (CDRL 2-14)

2.11 Maintainability

The vehicle shall incorporate design standards which minimize Mean Time To Repair (MTTR) and costs throughout its intended useful life.

The quantitative MTTR requirements for the car shall consist of the following subsystem requirements:

<table>
<thead>
<tr>
<th>System Element</th>
<th>MTTR (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbody &amp; Appointments</td>
<td>2.0</td>
</tr>
<tr>
<td>Propulsion, Dynamic Brake &amp; Controls</td>
<td>2.0</td>
</tr>
<tr>
<td>Friction Braking</td>
<td>2.0</td>
</tr>
<tr>
<td>Electrical</td>
<td>1.5</td>
</tr>
<tr>
<td>HVAC</td>
<td>2.0</td>
</tr>
<tr>
<td>Communications</td>
<td>1.0</td>
</tr>
<tr>
<td>Passenger Doors &amp; Controls</td>
<td>1.0</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.5</td>
</tr>
<tr>
<td>Trucks &amp; Suspension</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The MTTR for each element shall be derived from Predicted Mean Time To Repair (PMTTR) analyses as required. DART may approve subsystem MTTRs which take more time than specified, provided the average for any system element is not changed significantly and total MTTR hours for the vehicle are not exceeded.

2.11.1 Maintenance Plan

The Contractor shall submit a maintenance program detailing all schedules and activities for the car's corrective and preventive maintenance.

This plan shall be submitted to DART for review. The plan shall outline each maintenance task, time schedules, recommended tools, personnel, and skill levels required. These recommendations shall be based upon those of the Contractor and of the equipment suppliers. Periodic updates shall be submitted as required. (CDRL 2-15)

2.11.2 Maintainability Demonstration

As part of the training program for maintenance personnel, selected servicing, scheduled and preventive maintenance, troubleshooting, change-out of components, corrective maintenance, and use of special tools shall be demonstrated where special emphasis, instruction, or proficiency is needed. Vehicle movement under disabling conditions shall also be demonstrated. The Contractor's demonstration shall verify that durations of these tasks fall within the times established by the Maintenance Plan.
2.11.3 Scheduled and Preventive Maintenance

Scheduled and preventive maintenance are comprised of all tasks necessary to service the car, to defer or prevent failures, and to maximize equipment life.

The Contractor's reliability or maintainability demonstrations shall assume these service levels, with no augmentation.

The total of scheduled maintenance tasks shall be defined in the maintenance manual, and shall be no more frequent or take more time than the following schedule:

<table>
<thead>
<tr>
<th>Operating Miles</th>
<th>Scheduled Maintenance Person (in Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>6</td>
</tr>
<tr>
<td>10,000</td>
<td>8</td>
</tr>
<tr>
<td>25,000</td>
<td>24</td>
</tr>
<tr>
<td>50,000</td>
<td>36</td>
</tr>
<tr>
<td>250,000</td>
<td>50</td>
</tr>
<tr>
<td>500,000</td>
<td>1200 (First Major Overhaul)</td>
</tr>
</tbody>
</table>

An exception is made for HVAC filter maintenance, which may occur at 5000 mile intervals, or greater.

Scheduled activities during the 10,000 mile cycle shall be limited to inspection, filter cleaning or replacement, and replacement of consumables.

DART will verify that the above schedule can be achieved 3 months after the acceptance of the first vehicle. This delay period is to enable the Contractor to ensure that all maintenance requirements for the car equipment have been effectively established by its operating and maintenance training programs and manual publications.

2.12 Service Proven Design

Vehicle, system, and subsystem designs shall be service proven, unless otherwise approved by DART. DART will assess the definition of "service proven" according to the risk associated with each particular design. For systems and subsystems, a service proven design will meet all the following criteria:

- Used in revenue rail operation for at least 2 years
- Used in revenue rail operation for at least 600,000 vehicle miles (1 million vehicle kilometers) with at least 50,000 miles (80,000 kilometers) per vehicle
- Has a minimum fleet size of 12 vehicles

For the Energy Storage System DART will evaluate compliance with the service proven requirements by Contractor documentation of supplier experience, operational or demonstration testing, or other Contractor substantiation of their capabilities to meet the requirements.

For a complete car, a service proven design shall meet the following criteria:
- Used in revenue rail operation or operational testing for at least 1 year
- Has a minimum operating fleet size of 6 vehicles

To establish a design’s service proven history, the Contractor shall submit specific details of the application history, certified by current users of the equipment. Equipment, which does not meet the above criteria, may be proposed for DART’s approval if the Contractor has successfully supplied fleets of similar streetcars or light rail vehicles which otherwise complies with the above requirements.

The Contractor may offer, for approval, a design that is basically unchanged from a service proven design, but which must be varied slightly in design or manufacture to meet DART’s requirements. The Contractor shall show, in detail, what has been changed in the equipment and why such changes will not adversely affect operation in the Dallas environment.

2.13 CDRL

The following submittals are required.

2-1 Scaled general arrangement drawings (Section 2.2.1), including:
- Plan, profile, and front elevation drawings of the vehicle exterior, showing all visible features, with dimensions
- Plan view of seating arrangement, including seat dimensions and spacings, aisle widths, wheelchair and bicycle areas, doorway dimensions, etc.
- Longitudinal section drawings of the vehicle, showing seating arrangements, stanchions, interior steps, cab, etc.
- Plan view drawing of all roof equipment, with dimensions
- Plan view drawing of under-floor equipment, including trucks, with dimensions

2-2 Vehicle numbering locations (Section 2.2.3)

2-3 Vehicle clearance dimensions on level tangent track showing effects of maximum suspension deflection and maximum body roll. Identify the location of the roll center(s). (Section 2.3.3)

2-4 Vehicle clearance dimensions on curves with cross-slope from 0% to 2% in 0.5% increments showing clearance requirements for both the inside and outside of curves, ranging from 82 ft (25 m) to tangent in a minimum of 20 DART approved increments. The data points on the carbody shall include the upper corner, lower corner, rear view cameras, and pantograph at lock-down, maximum extension, and mid-point of range. (Section 2.3.3)

2-5 Vehicle weight, passenger load, and weight unbalance report (Section 2.5.1)

2-6 Wheel to rail interface study plan (Section 2.5.6)

2-7 Wheel to rail interface study report (Section 2.5.6)

2-8 Performance data (Section 2.6), including:
- Tractive effort curves for motoring from zero to 48 km/h, at AW0, AW1, and AW2, for line voltages of 525, 600, 750, and 900 Vdc on the primary
power supply and for AW0, AW1, AW2 and AW3 for operation on the ESS.

- Braking performance curves, including emergency braking, from 48 km/h to zero, at AW0, AW1, AW2, and AW3 showing apportionment between dynamic, friction braking, and track brakes.
- Description of regenerative braking, voltage ranges, maximum currents, etc.
- Speed / time / distance curves for motoring and braking at with 750 vdc primary power and with the ESS and at AW0, AW1, AW2, AW3.
- Verification of the thermal capacity of the propulsion and braking equipment under the conditions described in Section 2.6.14. Submittal shall include all input assumptions, ambient temperature assumptions, speed/time/distance plots of the vehicle on the Dallas alignment (Figure 2-3), temperature predictions (or actual test results) for all equipment, including motor windings, brake resistors, brake discs, inverter and brake chopper device junction temperatures, and similar.

2-9 Emission Limits Report (Section 2.8.1)
2-10 System Safety Program (Section 2.9.2)
2-11 Hazard Lists (Section 2.9.8)
2-12 Preliminary Hazard Analyses (Section 2.9.9)
2-13 Final Hazard Analyses (Section 2.9.9)
2-14 Reliability Report (Section 2.10)
2-15 Maintainability Plan (Section 2.11.1)
NOTES:
1. ALL HEIGHT DIMENSIONS FROM TOP OF RAIL.
NOTES:
1. DIMENSIONS SHOWN ARE INCHES.
FIGURE 2-3
ALIGNMENT PROFILE
SHEET 3 OF 5

DALLAS STREETCAR
FEBRUARY 14, 2012
SECTION 3
CARBODY STRUCTURE

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SECTION 3
CARBODY STRUCTURE

3.1 General
The carbody shall consist of three articulated sections. As a minimum the inboard portion of
the main body sections and the center section shall have a low floor. All sections shall be
semi-permanently coupled together to form a single operating vehicle. The carbody
information and requirements discussed in this section refer to the structural elements
interior to the composite body cladding panels, if used, except as noted.

Each body section shall consist of a roof, side frames, underframe, and end frames. The
underframe of the main body sections shall consist of end underframe units, side sills, body
bolsters at truck connection points, and floor beams. Body sills located inboard the side sills
may be used, if necessary. Portions of the roof, side frame, and underframe shall be
designed to form a girder to carry the shear and bending loads resulting from the specified
loads. In the selection of the type and thickness of material to be used, the Contractor's
design shall maximize strength and reliability, minimize weight, and produce the desired
appearance.

The carbody and attached equipment shall be designed to provide clearances for the truck
and track profiles as specified in Sections 11 and 2 of this Specification, except for any
stops attached to the carbody for limiting truck movement.

The structural design shall be based on the specified loads, load factors, deflections,
and crashworthiness requirements.

The finished carbody shall be load tested to verify that it is in conformance with Specification
requirements and the requirements of the Contractor's design, and to validate the design
analysis.

The front end shall permit the use of a wide single-piece windshield complimentary to the
approved appearance, to maximize operator field of view.

The carbody structure, including end underframe with attached anticlimber, end frames, and
articulation assemblies, assembled with tow bars and trucks, shall be arranged to minimize
the propensity to telescope in the event of collision with a highway vehicle or another
streetcar.

Tie down points shall be incorporated into the car in order to secure the vehicle for shipment
and for body straightening after an accident.

3.2 Materials
The carbody structure shall be constructed of aluminum, high strength low-alloy (HSLA)
steel, stainless steel, or a combination thereof. Non-structural carbody exterior elements
may be of glass fiber reinforced plastic or similar service-proven materials. The Contractor
shall submit drawings showing materials used for all structural members including outside
sheathing. Refer to Sections 17.3, 17.4, 17.5 and 17.6 for specific material requirements.
3.3 Structural Arrangements, General Requirements

The streetcar structure shall be unitized for each sub-body and may utilize the exterior skin as a stressed structural element. All portions of the carbody shall be provided with adequate venting and drainage to prevent the build-up of condensation. Enclosed structural cavities shall be vented and, if required, be treated with a rust proofing coating suitable for the vehicle design life.

The vehicle shall include anticlimbers and a front end frame structure consisting of partial height collision posts at the approximate one-third points (horizontal plane) of the end frame (but in any case not more than 36 inches (915 mm apart)), structural corner posts at each extreme carbody corner, and a horizontal beam ("structural shelf") at the bottom of the windshield tying the tops of the collision posts to each other and to the corner posts, all securely welded to the end frame sheathing to resist telescoping in collisions. Equivalent anti-telescoping and crashworthy elements shall be provided at the articulation joint and support structure. Alternative structural arrangements with equal or better performance may be proposed for DART’s approval.

3.3.1 Anticlimber

An anticlimber shall extend laterally over the full width of the vehicle front end frame and shall be welded or bolted to the end sill. The anticlimber shall be wide enough to engage the anticlimber of an opposing vehicle under the worst horizontal track curves.

A jacking pad shall be provided under the center of each anticlimber.

A frangible plastic cover shall be provided to cover the anticlimber ribs and provide a visual impression similar to an automotive bumper. The cover shall not deter engagement of the anticlimbers in the event of a collision.

3.3.2 Jacking Pads and Hoists

Each carbody section shall be provided with non-slip, easy to reach jacking pads at structural points to sustain jacking loads. Jacking pads shall be located considering jack placement, derailment clearances, and similar factors arising when jacking the vehicles in the shop and in the field with modern portable rerailing equipment. Jacking pad locations and their supporting structure shall permit asymmetrical jacking of any body section without cosmetic damage, deformation, or dislocation. The Contractor shall submit the locations of jacking pads for both maintenance and re-railing equipment to DART for review and approval. (CDRL 3-1) If carbody inserts are provided, the details of the inserts shall be provided to enable DART to procure adapters for portable jacks.

3.3.3 Floor Construction

The floor shall be constructed so that all applicable noise, vibration, strength and fire requirements in this specification are met. The floor design shall meet the fire requirements per NFPA 130 for 30 minute testing. In the event a floor construction design to another standard is proposed, the Contractor shall submit a detailed design of the proposed floor, a detailed description of the standard used, evidence of compliance to the proposed standard, and justification as to how the proposed floor design provides safety equal to that provided by compliance to NFPA 130 to passengers and the operator in the event of car fire.

A stainless steel sub-floor (floor pans) shall be provided below the floor beams throughout the length of the car. The sub-floor pan shall not be less than 0.020 in (0.5mm) thick. The sub-floor shall be welded to the bottom flanges of the floor beams and to the draft sills, end
sills, side sills, and body bolsters. Riveting of the floor pans will be allowed only if sealing of
the pan can be guaranteed for the life of the vehicle. All seams and edges shall be
permanently watertight and fire proof as required by Section 17. The space between the
floor and subfloor shall be filled with insulation. The design of all panels shall preclude the
movement of water along the panels in a manner that will increase the potential for water
ingestion into the carbody. If clearances prohibit the application of the subfloor pan at
particular locations, or require less than normal separation between the subfloor and floor
panels, alternative designs which provide the specified thermal and acoustic insulation
requirements and fire barrier properties may be proposed for DART’s approval.

3.3.4 Roof Construction

The roof shall be constructed of carlines, purlines, and roof sheathing covering the entire
roof area. Framing members and structural wells shall be provided for support of roof-
mounted equipment. Equipment wells shall be provided with adequate drainage for the
worst case environmental conditions described in Section 2.3.5. The roof design shall meet
the fire requirements per NFPA 130 for 30 minute testing. In the event a roof construction
design to another standard is proposed, the Contractor shall submit a detailed design of the
proposed roof, a detailed description of the standard used, evidence of compliance to the
proposed standard, and justification as to how the proposed roof design provides safety
equal to that provided by compliance to NFPA 130 to passengers and the operator in the
event of car fire.

The roof equipment installation, including all wiring and pipe work, shall be designed and
installed in such a way so as to present a clean and simple appearance when viewed from
above. The entire roof area shall be painted the same color, including all roof mounted
equipment cases, pantograph, mounting brackets or rails, wiring covers, piping, access
steps, and walkways.

3.3.5 Articulated Section

Articulation section shall be considered as an integral part of the carbody, including during
testing as required by this specification.

Articulation section shall provide stable connection between carbody sections and maintain
each body section up-right on level tangent track.

Articulation bellows shall be covered on the inside and be integral to the interior finish.

Articulation components which require periodic service, inspection, and maintenance shall
be easily accessible either from the passenger compartment, side of the car, or bottom of
the car at inspection pit. If the articulation section uses friction material for rotation, such
material shall have adequate life over a scheduled heavy maintenance interval but not
shorter than 12 months. Such material shall provide coefficient of friction as constant as
possible so that the turning at curve is smooth and consistent over time without excessive
flanging of the adjacent truck.

3.3.6 Roof Shroud

Roof shroud, if provided, shall be aesthetically consistent with the carbody styling and
provide sufficient strength against the worst case combination of wind and operating speeds
specified herein. Roof-mounted equipment shall be shrouded so that, viewed from the side,
the vehicle will have unbroken lines at top and bottom. The shroud shall be made of high-
strength, low alloy (HSLA) steel, aluminum or fiberglass-reinforced plastic (FRP) with a
proper weather protective finish. Shroud shall be attached to roof structure by mechanical fasteners and shall be removable by ordinary tools. The roof shroud design shall be submitted to DART for review and approval (CDRL 3-2).

3.3.7 Skirts

Skirts shall be provided at the sides of the car to enclose trucks, tow bar, and any open spaces which may be accessible by pedestrians along the ROW. The skirts of the high-floor vehicle ends below the end sill shall be carried around the corners and down the sides of the vehicle to blend with the line of the bottom of the vehicle in the low floor area. The skirt design shall be submitted to DART for review and approval (CDRL 3-3).

The skirts shall be designed in such a way that removal of the shroud is not necessary for equipment access or maintenance activities. Skirts shall be made of HSLA Steel, Aluminum or FRP with proper weather protective finish and appear an integral part of the carbody. Skirts shall be attached with standard threaded fasteners. Skirts which cover equipment requiring periodic maintenance, including trucks, shall be provided with quick-release fasteners or similar devices to facilitate repeated removal. Skirts may be modified in the vicinity of trucks to accommodate turning.

For easy access to trucks for inspection and maintenance, the lower body shrouds (skirts) over the trucks shall be hinged, lift-assisted, and removable by sliding the moveable portion off of hinge pins. Quick-release securement of the truck-access panels in the closed position shall be provided. Shrouds (skirts) at the ends and corners of the vehicle shall be readily repairable following minor collisions.

If required, suitable openings in the shrouding may be provided to allow cooling air flow for equipment and to prevent heat build-up, provided the openings are in harmony with the overall vehicle aesthetic design.

3.4 Structural Design Requirements

The structural design shall be based on proven rail vehicle techniques and elements and shall accommodate all structural static, dynamic, and fatigue loads encountered in revenue service.

3.4.1 Vertical Design Load Strength Requirements

The completely equipped carbody shall be designed to carry the maximum loading of the vehicle weight AW4, less truck weight or running gear weight, distributed uniformly along the vehicle, with stresses not exceeding 65% of the guaranteed minimum material yield strength, and 65% buckling strength, and the allowable fatigue stress for joints and structural details which are fatigue critical. Allowable fatigue stresses shall be determined according to the requirements of AWS D 1.1, "Structural Welding Code—Steel", AWS D 1.2, "Structural Welding Code—Aluminum", AWS D 1.3, "Structural Welding Code—Sheet Steel", AWS D 1.9, "Structural Welding Code—Stainless Steel", and the AWS Handbook Requirements for dynamically loaded structures shall be applied.

For each joint design, the static stress at the AW2 load shall be less than the mean stress that determines the allowable fatigue limit.

The dynamic factor shall be as determined by the Contractor, but shall not be less than ±20%. The fatigue limit shall be established for 10 million cycles.
3.4.2 End Sill Compression Load

Under an end compression load of 90,000 lbf (400 kN), applied at the anticlimbers, the following conditions shall be met:

- There shall be no permanent deformation in any structural members, including sheathing. Replaceable energy absorbing elements may incur permanent deformation.
- At no point inboard of the coupler anchor shall the margin of safety be less than the lowest margin of safety outboard of the coupler anchor.
- That structural element with the lowest margin of safety inboard of the coupler anchor shall not be located in any part of the articulation or the yoke arms which attach the carbody sections to the articulation.
- The end sills at the front ends shall also be capable of transmitting the loads from the collision posts into the draft sill and side sills, without failure, when the posts are loaded to their ultimate strength.

3.4.3 Collision Posts

Collision posts shall be continuous through the end sill, extending from the bottom of the end sill to the structural shelf.

3.4.3.1 Anti-Telescoping Load Above Floor

The capacity of each collision post, when loaded in a horizontal plane 36 inches (915 mm) above the top of rail and within 15° either side of the longitudinal axis of the vehicle, shall be a minimum of 18,000 lbf (80 kN) with no yielding of any carbody structure. The posts and/or supporting structures in the end frame shall be designed such that when the post is overloaded, the initial failure shall begin as bending or buckling in the structure.

3.4.3.2 Anti-Telescoping Load at Floor

The minimum ultimate shear strength of each collision post shall be 56,000 lbf (250 kN) when the load is applied at a point even with the top of the underframe to which the post is attached.

3.4.4 Structural Shelf

A horizontal structural shelf shall be provided below the windshield and shall connect the tops of the collision posts to the corner posts. The shelf shall be capable of supporting a longitudinal load of 18,000 lbf (80 kN) applied anywhere along the span without permanent deformation of any part of the vehicle structure. The outer ends of the structural shelf shall be supported by the corner posts, which shall be attached to both the underframe and roof structures.

3.4.5 Corner Posts

Corner posts shall extend the full height from the underside of the end underframe to the roof rail.

3.4.5.1 Corner Posts, Horizontal Load

The capacity of each corner post, under an inward horizontal load in any direction from longitudinal to transverse, applied 36 inches (915 mm) above the top of rail, shall be 9,000
lbf (40 kN) with no yielding of any part of the vehicle structure. The connections of the posts to the supporting structure, and the supporting structure itself, shall be strong enough to develop the bending capacity of the posts. If the posts are designed to support more than 40 kN, then the supporting structure must be strong enough to support the increased bending capacity of the posts. The posts shall fail before the supporting structure.

3.4.5.2 Corner Posts, Shear Load

The ultimate shear strength of each corner post, in any direction from longitudinal to transverse, at the level of the top of the underframe or supporting structure shall be 17,500 lbf (78 kN).

3.4.6 Anticlimber Loads

The anticlimber shall withstand a vertical load of 1.1 times the static load required to raise the end of the vehicle, with the truck or running gear attached, combined with a longitudinal compressive load applied at the carbody centerline of 60% of the end strength, with no failures of the anticlimber, supporting carbody structure, or intervening connections.

3.4.7 Articulation Joint Anticlimber Loads

The articulation joint shall withstand the resulting forces of a vertical load of 1.1 times the static load required to raise the end of the vehicle combined with a longitudinal compressive load applied at the carbody centerline of 60% of the end strength, with no structural failures which may result in telescoping of the vehicle sections.

3.4.8 Floor Load

The following conditions shall be met for a fully equipped vehicle with a vehicle weight of AW4, evenly distributed:

- The floor panels shall not deflect more than 1/250 of the shortest span between supports, up to a maximum of 0.170 inches (4.3 mm).
- The floor beams shall not deflect more than 1/250 of the span between supports.

The maximum stress in the floor beams shall be less than 65% of the critical buckling stress, or 65% of the yield strength of the material, whichever is less.

3.4.9 Roof Load

All parts of the roof structure and walkways shall be capable of supporting concentrated loads of 300 lbf (1330 N) distributed over a 12 inch (305 mm) by 12 inch (305 mm) area, spaced 30 inches (760 mm) apart, as might be applied by maintenance personnel carrying tools and equipment walking on the roof.

3.4.10 Side Load

Any 8 ft (2.5 m) length of side sill and supporting structure shall be strong enough to resist a transverse inward load of 40,000 lbf (180 kN), evenly distributed over the 8 ft (2.5 m) length of side sill, without yielding or buckling. Any 8 ft (2.5 m) length of belt rail (at the lower side window edge) and supporting structure shall be strong enough to resist an inward transverse load of 10,000 lbf (44.5 kN), evenly distributed over the 8 ft (2.5 m) length of belt rail, without yielding or buckling.
3.4.11 Jacking Loads

For design purposes, the static AW0 vertical load on each jack point (symmetrical jacking) shall be increased by a factor of 2, and this load shall be combined with a horizontal load of 10% of the vertical load on each jack point applied in any horizontal direction. Under this loading condition, there shall be no permanent deformation of any carbody structure.

The carbody jacking pads, jacking sockets and supporting structure shall be capable of supporting, with a load factor of 1.5, an empty car (AW0 condition) with trucks under the load imposed by the diagonal jacking test of Section 16.3.8.4 without permanent deformation.

The stress analysis shall include an analysis of the jack pads, jack sockets, their connections to the carbody, and the immediate supporting car structure.

The same load factors as above shall apply for hoisting.

3.4.12 Equipment Loads

The load factor for the design of all underfloor, roof, and interior equipment, any portion of the equipment, equipment boxes, equipment hangers, standby supports, safety hangers, and the carbody supporting structure shall be 3 in the longitudinal direction, 2 in the vertical direction, and 2 in the lateral direction. The design load shall be the weight of the supported item multiplied by the appropriate load factor. These loadings shall be applied separately; each such loading may develop the ultimate load-carrying capacity of the member being investigated.

Equipment within an equipment box need not meet the above criteria provided it can be shown that the equipment will not penetrate the walls of the equipment box when exposed to these load levels. The equipment box shall conform to these load criteria with the rearranged equipment (i.e., equipment that is presumed to have broken loose) in addition to its normal arrangement.

Fastenings shall be designed so that in no case will the limit of the carrying capacity of a member be the strength of one fastener or the shearing of fasteners through the base material. All bolts used to support equipment shall be not less than 3/8 inch (10 mm) diameter.

3.4.13 Steps

If provided, steps shall be designed to support one person at 300 lbf (135 kg) per 12 inches (305 mm) of tread with a load factor of 2. The resulting stresses in any part of the steps assembly shall not exceed the yield strength of the material.

3.4.14 Truck and Running Gear Loads

Trucks (or running gear) shall be attached to the carbody such that they shall be raised with the vehicle unless intentionally detached. Stresses in the attachment structure shall not exceed 50% of yield with the truck or running gear hanging from the body.

The structural connection of the truck (or running gear) to the carbody shall be capable of resisting a minimum 30,000 lbf (133 kN) horizontal load applied in any direction through the actual or virtual pivot without exceeding the ultimate strength of the connection, and without exceeding the ultimate strength of the carbody and truck (or running gear) support structure. This requirement for strength in the horizontal plane shall apply both with and without the
weight of the carbody applied to the truck (or running gear), the latter being the case when the truck (or running gear) is hanging from the carbody when the horizontal load is applied.

3.4.15 Natural Frequency

The natural frequency of each vehicle section under a vehicle weight of AW4 and supported at the articulation yokes and at the bolsters shall not be less than 2.5 times the natural frequency of the secondary suspension.

3.5 Crashworthiness

3.5.1 General

The carbody shall be designed to maximize energy-absorbing capability within the specified strength parameters. In the event of a collision occurring on level, tangent track between two trains with mating anticlimbers locked together, deformation of the structure shall commence at the extreme ends and progress toward the coupler anchor, with all of the end structural members retaining their attachments to one another and to the roof and floor structures.

3.5.2 Alternate Energy Absorbing Design

As an alternate to the static, 90,000 lbf (400 kN) end strength requirement of Section 3.4.2, an energy absorbing design may be offered in accordance with the requirements of this Section.

The acceleration of the vehicles involved shall not exceed a maximum of 10g at any time after a 20-mph (32 km/h) collision of two vehicles on level, tangent track, and crush of carbody structure shall be limited to the zone outboard of the coupler anchor.

In order to assess the energy-absorbing properties of the structure, a crush energy analysis of the vehicle shall be performed. The analysis shall be based on the assumptions that:

- One vehicle impacts an identical vehicle on level, tangent track such that couplers and anticlimbers engage
- The impacting vehicle is traveling at 20 mph (32 km/h) with brakes applied in emergency
- The impacted vehicle is stationary with brakes applied in full service

The analysis shall show the following:

- Compression load developed by the longitudinal underframe members designed for crushing
- Buckling strength of the longitudinal members under the calculated compressive load
- The progressive buckling and bending of the carbody end structure
- The accumulation of energy during crushing, i.e., force versus distance
- The vehicle structure inboard of the coupler anchor does not fail while the end is crushing
• Underframe mounted equipment and underframe structural members other than those designed for energy absorption shall not provide any portion of, or interfere with, the crushing

• Acceleration of any vehicle does not exceed a maximum of 10g, and the maximum vehicle crush is limited to the portion of the structures outboard the coupler anchors, or 5 ft (1520 mm)

A crashworthiness analysis report shall be prepared and submitted for approval as described in Section 3.6.5. This report shall include the same reference information (drawing numbers, material properties, references for formulas, buckling coefficients, etc.) as required in the Stress Analysis Report described in Section 3.6.4. Compression tests in lieu of analysis may be performed on the various structural elements to show the energy absorbed by the element during crushing.

3.6 Stress Analysis

3.6.1 General

The Contractor shall submit a stress analysis of the carbody structure and all equipment supports for equipment weighing over 200 lbs (91 kg). The carbody structure includes all components discussed in this Section. The equipment support stress analysis report shall be submitted to DART not later than 60 calendar days prior to commencing manufacture of any carbody structural parts for DART’s review and approval (CDRL 3-4). Stress analyses for supports for items weighing less than 200 lbs (91 kg) may be requested for review at the discretion of DART.

A Stress Analysis and Tests Plan shall be submitted not later than 30 days after NTP (refer to Section 3.6.4.1) for DART’s review and approval (CDRL 3-5). The Stress Analysis Report (refer to Section 3.6.4.2) (CDRL 3-6) and the Finite Element Analysis Report (refer to Section 3.6.4.3) (CDRL 3-7) shall be submitted for DART’s review and approval not later than 60 days prior to commencing manufacture of any carbody structural parts.

The stress analysis shall be used to design the car structure to meet the requirements of this Specification and to obtain the lightest-weight car consistent with requirements. Structural tests shall be performed in accordance with Section 16.3.8 to confirm the accuracy of the analysis. The report shall be sufficiently complete and the analysis sufficiently accurate for DART to use the report to design repairs during the life of the vehicles.

The stress analysis shall show the calculated stresses, allowable stresses, and margins of safety for all elements for all specified loading conditions. The stress analysis shall include calculations of stresses in joints, joint elements, and other important elements.

The approved stress analysis shall be a prerequisite for approval of the structural test procedures and structural drawings required by this Specification, and shall be used as an aid in determining strain gage locations for use during the tests.

During the design and manufacture of the cars, the input to the stress analysis shall be updated to reflect the as-built configuration of the structure.

The initial stress analysis will require temporary assumptions as to configuration and weights; also manufacturing and other considerations may require design changes. As these changes are made, the stress analysis shall be revised and submitted for review. The final submitted and approved stress analysis shall be for the car in the as-built configuration.
Critical connections that cannot be adequately analyzed shall be prototyped and tested to demonstrate compliance with the requirements of the design and the Specification.

The elastic stability of plates, webs and flanges shall be calculated for members subject to compression and shear.

If stainless steel is used, the variation in the stainless steel compression modulus with stress shall be considered in calculating compressive stability of stainless steel members.

If FRP side skin and its connections exhibit non-linear properties, non-linear analyses shall be conducted to demonstrate the performance of these components. In computing the shear strength of a beam, only that portion of the beam that is in line with the force vector shall be considered as resisting the force. If the force is skew to the beam's web, the force vector shall be divided into components, one in line with the web and the other in line with the flange; the shear resistance shall then be computed separately for each component.

For any portion of the proposed design that is based on a service-proven vehicle, the Contractor may provide data from previous tests, historical data from operations, or stress analyses as required to satisfy the corresponding portion of these requirements.

3.6.2 Definitions

Permanent Deformation
A member shall be considered as having developed permanent deformation if one of the following conditions is met:
- The minimum yield strength as published by ASTM for the specified material and grade is exceeded
- For materials or grades not covered by an ASTM specification, the minimum yield strength as guaranteed by the manufacturer is exceeded
- The material has buckled or deformed and will not return to its original shape or position after the load is released

For materials without a specific yield point, the 0.2 percent offset method shall be used to determine yield strength.

Ultimate Load Carrying Capacity
The ultimate load carrying capacity of a member is the maximum load that the member can support before it separates at its ultimate strength or completely fails as a column.

Margin of Safety
Margin of safety (MS) is defined as follows:

\[
\text{MS} = \frac{\text{Allowable Stress}}{-1} - \frac{\text{Calculated Stress}}{-1}
\]

The calculated stress shall include the applicable load factors. MS shall be a minimum value, but a positive number.

Load Factor
Load factor is defined as a number by which the actual or specified load is multiplied in computing the calculated stress. The load factor shall include all applicable safety factors.
3.6.3 Buckling Analysis

The buckling strength of structural framing members shall be calculated. Any member in any of the analyses with a calculated compressive stress equal to, or greater than, 35% of material yield strength shall be included.

3.6.4 Elastic Stress Analysis Submittals

3.6.4.1 Carbody Stress Analysis and Tests Plan

A Carbody Stress Analysis and Tests Plan shall be submitted. Whenever the Plan for the analysis and testing of the carbody is revised, it shall be updated and resubmitted, but not more often than monthly. Each revision shall be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report as a result of the change.

The Carbody Stress Analysis and Tests Plan shall include an outline of the procedure the car builder will use to analyze and test the design of the carbody. It shall also include the following:

- Listing of load conditions to be used during analysis and test, with load magnitudes, supports and points of application
- Description of the analysis to be used for each load condition
- Structural sketch of the carbody, showing sheathing thickness and all framing member locations and shapes, and the indicating materials and thicknesses of each. Methods of joining shall be defined
- Diagrams of load applications and supports
- Procedure for analyzing the static and fatigue capability of FRP side skin and its connections, if used
- Table of material properties
- Description of the major assumptions
- Description of how analysis results will be correlated with test results, as required in Section 3.6.4.4

The Carbody Stress Analysis and Tests Plan must be approved prior to approval of the Stress Analysis Report required by Section 3.6.4.2. The Carbody Stress Analysis and Tests Plan shall be a volume of the Stress Analysis Report.

The Carbody Stress Analysis and Tests Plan shall follow the general requirements of the report in Section 3.6.4.2.

3.6.4.2 Stress Analysis Report

A Stress Analysis Report shall be prepared and submitted to DART for review and approval; refer to Section 3.6.4.1. The report shall demonstrate that the structure satisfies the requirements of the Contractor’s design and this Specification. The report shall be organized and in sufficient detail so that DART reviewer can readily follow the theory and its application to this car.

The Contractor shall certify that the analysis and calculations have been reviewed and checked before the report is submitted to City.
If a cited reference is not readily available to DART, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages that show the cited formula or data, the pages that show the development and interpretation of the formula or data must be included.

All references shall be in the English (USA) language. If an English (USA) reference cannot be found, an English (USA) translation shall be provided. Both the original and the translation shall be included in the report.

In addition to the body of the analysis, the stress analysis report shall include, at a minimum all of the following:

- A Table of Contents.
- The algebraic statement of all formulas and equations before the related calculations are performed. With the statement all terms shall be defined, and the values and units to be applied to these terms stated.
- Units shall be given with all quantities.
- References for all formulas, calculation procedures, buckling coefficients, material strengths, fatigue strengths, and other physical and mechanical properties must be cited where these items appear in the stress analysis.
- Each page of manual analysis shall be numbered, dated, and initialed by the analyst and the checker, and marked for revision level. In addition, in the event of a revision, the revision letter shall be included with revision date and initials of the analyst and checker. Each page of computer-generated analysis shall as a minimum be numbered, initialed by the checker, dated, and marked for revision level.
- The approved structural sketch (see Section 3.6.4.1).
- Diagrams displaying, for each load case, loads applied externally to the carbody and points of support.
- An analysis showing compliance with each design load and condition, as required by Section 3.4.
- Detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing, with a summary of the results.
- A table showing locations where the MS is less than 0.20 along with the design or operating conditions (loads) which cause the stresses.
- Particular reference in the stress analysis shall be made to, but not limited to the following:
  
  Side sill  
  Body sills (if used)  
  End sill  
  Anticlimber  
  Draft sills  
  Tow bar supports  
  Side frame rails  
  Side frame posts  
  Transverse and longitudinal sections at doorways
Body bolster
Floor and floor beams
Collision posts
Corner posts
Structural shelf
Articulation end frame
Roof structure
Equipment supports
Connections between structural elements
Any FRP skin and bonded connections used

- A tabulation or diagram of calculated deflections of the carbody under full vertical loading and under combined vertical and compression loads specified in Section 3.4.1, 3.4.2, and 3.4.3.

- Analysis of all critical and highly loaded connections, as required in Section 3.4.1, showing the joint is stronger than the weakest member being joined.

- Analysis of the strength of the connection of the trucks to the carbody, including calculated vertical and horizontal connection capacities.

- Analyses of the carbody structure under the torsional loading resulting from diagonal jacking described in Section 3.4.11, and under torsional loadings resulting from anticipated normal operations.

- A tabulation of the Contractor's selection of allowable fatigue stresses, with sources, and assumed applied fatigue stress ranges for structural members and connections that are critical in fatigue, and for FRP skin and its connections if used.

- A table showing the engineering properties of each grade and temper of each material used in the car structure. This table shall include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension, and compression and shear elastic moduli. In each case, minimum guaranteed values from the specifications for the corresponding grade and heat treatment of the material shall be used. Materials, grades and tempers not used in the carbody construction shall not be included in the tables.

- A table showing geometric properties, such as area and section moduli.

- Table(s) showing the minimum static and fatigue strengths of single and multiple spot welds. Values shall be given for each material, temper, weld size, and thickness combination used in the carbody. The source of the data shall be provided.

- If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall show the test procedure, raw data as well as reduced data, and summary.

- Each revision shall be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report as a result of the change.
3.6.4.3 Finite Element Analysis (FEA)

As part of the stress analysis, a linear-static finite element analysis (FEA) of the complete carbody shall be performed; refer to Section 3.4.1. The FEA shall be a recognized computer program such as NASTRAN, ANSYS, Algor, or approved equal. The purpose of the carbody FEA along with other analysis types shall be to show that the carbody design meets the requirements of this Section.

If FRP skin is used and the material and/or the connection between the material and the supporting structure exhibit non-linear properties then a non-linear static analysis shall be performed. This may be instead of the linear static FEA, or a local analysis in addition to a global static analysis.

The Contractor shall submit for DART’s review and receive approval of the finite element model prior to performing the analysis (CDRL 3-8). The finite element model report shall be submitted not later than 90 days after NTP. The element mesh, all assumptions, and a complete printed copy of the input file which includes input data, such as loads, boundary conditions, area properties and material properties, shall be included as part of the preliminary submittal and again as part of the complete analysis. A key to all symbols and colors shall be included. Boundary reaction forces of the shell at AW0 shall be included. Each revision shall be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report as a result of the change.

Each load condition submittal thereafter shall include diagrams of areas of mesh refinement, all assumptions, all input data, reaction forces, and a table to show static equilibrium.

Wherever required to be submitted, the input and output shall have each page numbered, and columns of data shall be clearly labeled on each page using terms, symbols, abbreviations, and units defined in the analysis report.

At the discretion of DART, finite element models and results shall be reviewed during live interactive sessions three weeks after each submittal. At these sessions, DART shall have full access to the finite element model input, output and use of the software on the computer used for the analysis.

Color plots shall be prepared showing the following:

- Deflections in all three axes separately plotted and imposed over the deflected shape
- von Mises, or other approved failure criteria depending on the material
- Maximum and minimum principal stresses
- Direction of maximum and minimum principal stresses
- Meshing accuracy index

All plots shall show the maximum and minimum values and all values that are greater than 80% of the specified maximum value. Each drawing shall include a triad showing the direction of the global axes. Plots at high magnification shall be keyed to a plot showing the structure to an extent sufficient to orient the high-magnification plots. There shall be a sufficient number of plots for each load case to see the stresses in all areas of the carbody with special attention given to those components listed below:

- Side sill
- Body sills (if used)
End sill
Anticlimber
Draft sills
Tow bar supports
Side frame rails
Side frame posts
Transverse and longitudinal sections at doorways
Body bolster
Floor and floor beams
Collision posts
Corner posts
Structural shelf
Articulation end frame
Roof structure
Equipment supports
Connections between structural elements

All areas with an MS less than 2.0 shall be shown in detail.

The FEA input and output data shall also be submitted on electronic media as approved by DART. Submittal of the input file is required with the model, and at any time the file is changed, but not more often than monthly. (CDRL 3-9)

Each revision shall be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report as a result of the change. Criteria for final approval of the stress analysis shall include the Contractor's submittal of the fully configured input data files as required by this Section.

Upon completion of the final design, the finite element model and analysis report shall be updated to represent the final configuration of the structure.

3.6.4.4 Validation of Linear Elastic Analysis

For each test required by Section 16, the carbody structural test results shall be compared with the corresponding stress analysis results. This information shall be tabulated and submitted with the carbody structural test reports for each test. Refer to Section 16.3.8.1.

The tables shall compare strains measured (stresses calculated) from the test strain gauge readings with analytical strains (stresses) from the FEA. The test procedure shall include a list of gauges to be used for the comparison, which shall not be less than half of the total number of strain gauges used during the test. The test procedure tables shall include the gauge number, element number, location and predicted strain (stress). The test procedure shall also include plots of the finite element mesh with all gauge locations indicated and dimensioned. The tables shall include the test strain (stress) value, the analytical strain (stress) value, the percent difference between the two values, and a space for annotation.

Approval of the carbody test report shall depend, in part, on the adequacy of the analyses of excessive variance between analytical and test stress values.
3.6.5 Crashworthiness Analysis Report

3.6.5.1 General

A crashworthiness analysis report shall be prepared and submitted for review and approval not later than 60 calendar days prior to commencing manufacture of structural parts. (CDRL 3-10) The report shall show that all structural members and the carbody satisfy the crashworthiness requirements of the Specification. The report shall demonstrate that the crushing of the carbody is stable.

The report shall include animations of the time-dependant, large-deflection analysis compatible with one of the current commonly available video formats, such as DVD or Quicktime®. The animation shall contain sufficient detail, view directions, and magnifications to review the behavior and stability of energy absorption elements, frangible elements, non-crushable structure inboard of the crush zones, and the carbody as a whole.

The report shall be organized and in sufficient detail so that DART can readily follow the theory and its application to this car.

The report shall include a description of the model in sufficient detail to show that the model is appropriate for this application. This shall include, as a minimum, descriptions of the elements and restraints, and the conditions of the simulation. It shall also include the output of the simulation to show that relevant Specification requirements have been met, including force-displacement plots.

For non-crushable structure inboard the crush zones, locations where the MS is less than 0.20 shall be shown in a table with a discussion of the results. There shall be no permanent deformation in this area of the structure.

References for all formulas, calculation procedures, buckling coefficients, material strengths, and other physical and mechanical properties must be cited where these items appear in the report. If a cited reference is not readily available to DART, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages that show the cited formula or data, the pages that show the development and interpretation of the formula or data must be included. All references shall be in the English (USA) language. If an English (USA) reference cannot be found, an English (USA) translation shall be provided. Both the original and the translation shall be included in the report.

All test reports required to verify the results of the analysis shall be included in CDRL 3-10. Such reports shall include the test procedure, raw data as well as reduced data, and a summary. DART shall determine the adequacy of the submitted test reports.

At the discretion of DART, all models and results shall be reviewed during live interactive sessions three weeks after each submittal. At these sessions, DART shall have full access to the model input, output and use of the software on a computer. Access shall be provided to view the crushing simulation on the computer.

3.7 CDRL

The following design submittals are required:

- 3-1 Jacking Pad Locations (Section 3.3.2)
- 3-2 Details of roof shroud construction, materials, and attachment methods (Section 3.3.6)
3-3 Details of skirt construction, materials, and attachment methods (Section 3.3.7)

3-4 Equipment support stress analysis report (Section 3.6.1) including
   - Detailed drawings of equipment supports
   - Outline drawings and weights of equipment
   - Material lists for all components and fasteners

3-5 Stress Analysis and Tests Plan (Section 3.6.1)

3-6 Stress Analysis Report (Section 3.6.1) including
   - Drawings included in CDRL 18-13
   - Materials and weights of all components

3-7 Finite Element Analysis Report (Section 3.6.1)

3-8 Finite Element Model (Section 3.6.4.3)

3-9 Finite Element Analysis output data on electronic media (Section 3.6.4.3)

3-10 Crashworthiness Analysis Report (Section 3.6.5.1)

END OF SECTION
SECTION 4
COUPLER

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SECTION 4

COUPLER

4.1 General
Coupling devices shall be provided to allow one vehicle to tow or push another vehicle under emergency conditions. Streetcars will not be coupled for normal service.

4.1.1 Configuration
The coupler shall be a manually-operated, storable, unit with resilient self-centering draft gear. The coupler assembly shall be mounted to the car structure under the cab floor via bolted connection. The Contractor shall submit a Coupler Design Report (CDRL 4-1) for DART’s review and approval.

4.1.2 Geometry
The coupler system shall be capable of operating over track profiles specified in Section 2, including a combination of worst-case horizontal and vertical curves, superelevation, track wear, and track misalignment without damage or stress outside the system design limits. Additionally, the coupler system shall accommodate variations between adjacent cars resulting from uneven loading, wheel wear, maximum suspension travel, and suspension failure without damage or stress outside the system design limits.

4.1.3 Strength
The coupler assembly strength shall be sufficient to meet the towing requirements and operational requirements specified in Sections 2 and 3.
Coupling at speeds up to 0.6 mph (1 km/h) shall be possible without damage to any coupler assembly components.
The coupler draft gear and anchor shall be capable of withstanding buff or draft loads of 90,000 lbf (400 kN) with no permanent deformation.

4.2 Draft Gear and Anchorage
The draft gear shall provide rubber cushioning for the coupler in both buff and draft, and provide resilient mounting in the vertical direction to maintain nominal coupler height above top of rail. A means of vertical height adjustment of the coupler head to compensate for vehicle and coupler variations and wear shall be provided.
The draft gear shall provide for automatic centering of the coupler. The centering device shall also allow the coupler to be manually swung to either side to facilitate maintenance and coupling on non-tangent track.

4.3 Lateral Stop
Mechanical stops shall be provided to positively limit lateral coupler swing and prevent damage to the carbody structure and other equipment in the event the vehicle is operated with the coupler un-stowed. The stop strength shall be sufficient to withstand the impact loading of the coupler, without damage, when it is accelerated from one stop to another, at
the maximum lateral acceleration possible on the specified ROW. The stop shall be
designed to fail before the structure to which it is attached.

4.4 Coupler Head
The coupler head shall provide the connecting mechanism between two couplers, and
include the devices necessary to safely lock the coupler heads together when coupled.
The shape of the head shall allow for vertical and lateral misalignment between coupler
heads when the couplers are brought together during a coupling operation.
When the coupler heads mate during coupling, the coupling mechanism shall be engaged
by inserting pins into the holes of the mating head and securing the pins in place.

One coupler “adapter” shall be provided with each car that will allow the Streetcar to be
mechanically coupled to the DART SLRV. The coupler used on the DART SLRV is the
Wabtec “Titelock” design. When in use this coupler adapter shall meet all operational,
functional and strength requirements for the coupler, as described in this section. Provisions
shall be provided to securely store the coupler adapter in an easily accessible location under
one end of the Streetcar when not in use.

4.5 Storage
When not in use, the coupler shall fold or retract under the vehicle behind a removable or
hinged cover.
The storage mechanism shall permit an operator to manually deploy and stow the coupler
with minimal physical effort. A device or devices, integral to the assembly, shall be provided
to lock the coupler into its operating position, and to release the coupler for storage.
In the stowed position, the coupler assembly shall be retained rigidly such that movement
due to car motion is prevented

4.6 Electrical Connections
The coupler assembly shall include a connector, wiring, and related hardware to provide a
temporary electrical connection for communication between vehicles, as described in
Section 13. Connection between cars shall be made by a separate cable with connectors, of
sufficient length to span the distance between the coupler connectors.
The connectors shall be a water-tight, multi-pin connector. A water-tight cap shall be
provided to protect the connector when not in use. The cap shall be retained by chain,
lanyard, or similar device when not applied. A connecting cable shall be stored in each
vehicle and accessible to the operator.

4.7 CDRL
Design submittal requirements are as follows:

4-1 Coupler Design Report (Section 4.1.1) including
   Dimensioned general arrangement drawings of all coupler components
   Geometric and clearance drawings
   Strength analysis and/or manufacturer’s test data
   Operating description for deploying, coupling, uncoupling, and storing
Dimensioned coupler cover drawings including weight and mounting
Details of communications connections, cables and storage of cables

END OF SECTION
# SECTION 5
## OPERATOR’S CAB

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SECTION 5
OPERATOR’S CAB

5.1 Operator’s Controls

Controls and indicators necessary for vehicle operation shall be placed in the cab at each end of the vehicle. The operator’s controls shall be arranged in three distinct areas, the master controller group, the operator’s console, and the lower control panel. Each control and indicator, shall have a durable and permanent label, and shall resist penetration by spilled liquids.

Controls, status indicators, and the control console materials and design shall be arranged to avoid glare on the windshield interior or to induce any other adverse visual distraction.

Within 180 days after NTP the Contractor shall submit an Operator’s Cab Design Package (CDRL 5-1), for DART’s review and approval.

Within 180 days after NTP the Contractor shall submit a Cab Control Design Package (CDRL 5-2), for DART’s review and approval.

5.1.1 Master Controller Group

The master controller group shall consist of a Key Switch, Reverser Switch, and Master Controller.

5.1.1.1 Key Switch

A Key Switch shall be provided to select the cab status. The Key Switch shall be mechanically interlocked with the Master Controller and Reverser Switch. Positions are:

ON Position
- Cab console controls shall be functional
- The cab console in the other end of the vehicle shall be disabled
- An emergency brake application shall result if the opposite cab key switch is also in the ON position
- The operation of the reverser switch shall be unlocked
- The key shall not be removable in this position

OFF Position
- All cab controls shall be non-functional, except the auxiliaries switch, pantograph switch, and Emergency Brake pushbutton
- The key shall be removable in this switch position

Additional Key Switch and Cab Interlock controls are detailed within this Section.

5.1.1.2 Reverser Switch

A three position (FORWARD, OFF, REVERSE) Reverser Switch shall be provided.
The Key Switch and the Reverser Switch shall be mechanically interlocked so that the Reverser Switch cannot be moved from the OFF position unless the associated Key Switch is in the ON position, and the Key Switch cannot be moved from the ON position unless the Reverser Switch is in the OFF position.

The vehicle control circuitry shall be such that vehicle operation shall not be possible unless the Reverser Switch in the controlling cab is placed in either the FORWARD or REVERSE position.

The Reverser Switch shall be interlocked such that the Master Controller handle must be in the Full Service Brake (FSB) position in order to move the Reverser Switch out of either the FORWARD or REVERSE position.

5.1.1.3 Master Controller

A Master Controller (MC) shall be provided to allow manual selection of braking and motoring efforts. The Master Controller shall be arranged to move linearly fore and aft, with motoring in the forward direction and braking towards the operator.

There shall be distinct tactile positions in the handle travel, indicated by stops or detents, as indicated below:

- Maximum Brake (MB) Stop (rearmost position)
- Full Service Brake (FSB) Major Detent
- Minimum Brake Detent
- Coast Detent
- Minimum Power Detent
- Maximum Power Stop (forward most position)

Maximum Brake (MB) is defined as Full Service Brake (FSB) plus the application of track brakes.

Between Maximum Power and Full Service Braking, braking and power efforts shall be linearly proportional to handle position.

The Master Controller shall stow in the FSB position when the cab is inactive. The MC shall be mechanically interlocked such that it can be moved from the FSB position only when the master controller Key Switch is in the ON position, and the Reverser Switch is in either the FORWARD or REVERSE position.

The handle shall be shaped, located, and oriented so as to minimize strain and fatigue on the operator.

5.1.1.4 Deadman

The Master Controller handle shall incorporate a deadman protection circuit. Release of the handle shall cause the deadman circuit to initiate a FSB application after a two second time delay. The circuit and timing function shall be a safe function as defined in Section 2.9.

After initiation by the deadman circuit, the brake application shall be retrievable by the Operator.

The deadman function shall be disabled when the controller handle is in the FSB or MB positions.
5.1.2 Operator's Console

The console switch panel shall be mounted immediately to the right of the master controller group and directly in front of the operator. Console controls shall be heavy-duty push button, rocker, or rotary switches. Indicating lamps, where provided, shall be LED and shall illuminate only in the active cab of the vehicle. All switches shall have a minimum protection level of IP65.

5.1.2.1 Operator's Console Control Switches

At a minimum, the following controls, and type of switch, shall be included on each console. See other parts of this Section for additional console controls.

<table>
<thead>
<tr>
<th>Control</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Door Close</td>
<td>MPB (Illuminated Green)</td>
</tr>
<tr>
<td>Left Door Open</td>
<td>MPB (Illuminated Red)</td>
</tr>
<tr>
<td>Left Door Release</td>
<td>MPB (Illuminated Yellow)</td>
</tr>
<tr>
<td>Wiper, Off/Intermittent/Low/High</td>
<td>4R</td>
</tr>
<tr>
<td>Wiper Delay Adjust</td>
<td>Rotary Potentiometer</td>
</tr>
<tr>
<td>Washer, Off/On</td>
<td>MPB</td>
</tr>
<tr>
<td>Pantograph Up</td>
<td>MPB</td>
</tr>
<tr>
<td>Pantograph Down</td>
<td>MPB</td>
</tr>
<tr>
<td>Headlight, Low/High</td>
<td>2R</td>
</tr>
<tr>
<td>Windshield Heating</td>
<td>2R</td>
</tr>
<tr>
<td>Track Brake, Off/On</td>
<td>MPB</td>
</tr>
<tr>
<td>Cab Heater Fan, Low Speed/High Speed</td>
<td>2R</td>
</tr>
<tr>
<td>Cab Heat, Off/Variable Temperature Control</td>
<td>2R/Rotary Potentiometer</td>
</tr>
<tr>
<td>Cab Light, Off/On</td>
<td>2R</td>
</tr>
<tr>
<td>Interior Lighting</td>
<td>MPB</td>
</tr>
<tr>
<td>Turn, Left/Off/Right</td>
<td>3R</td>
</tr>
<tr>
<td>Hazard, On/Off</td>
<td>LPB</td>
</tr>
<tr>
<td>Horn, Low/Off/High</td>
<td>3MRKC</td>
</tr>
<tr>
<td>Bell, Off/On</td>
<td>MPB</td>
</tr>
<tr>
<td>ESS, Off/On</td>
<td>MPB (Illuminated Green)</td>
</tr>
<tr>
<td>Auxiliary Headlights, Off/On</td>
<td>LPB</td>
</tr>
<tr>
<td>Silent Alarm, Off/On</td>
<td>LPB</td>
</tr>
<tr>
<td>Car Wash, Off/On</td>
<td>LPB</td>
</tr>
<tr>
<td>Emergency Brake</td>
<td>See Section 5.3.3</td>
</tr>
<tr>
<td>Right Door Close</td>
<td>MPB (Illuminated Green)</td>
</tr>
<tr>
<td>Right Door Open</td>
<td>MPB (Illuminated Red)</td>
</tr>
</tbody>
</table>
Right Door Release  MPB (Illuminated Yellow)
Console lights and indicators dimmer  Rotary Potentiometer
Console lights Push To Test  MPB

Type codes mean the following:

<table>
<thead>
<tr>
<th>Type Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPB</td>
<td>Latching pushbutton (push on, push off)</td>
</tr>
<tr>
<td>3LR</td>
<td>3 Position Latching rocker</td>
</tr>
<tr>
<td>MPB</td>
<td>Momentary pushbutton</td>
</tr>
<tr>
<td>3MRKC</td>
<td>3 position momentary rocker, return to center</td>
</tr>
<tr>
<td>2R</td>
<td>2 position rotary</td>
</tr>
<tr>
<td>3R</td>
<td>3 position rotary</td>
</tr>
<tr>
<td>4R</td>
<td>4 position rotary</td>
</tr>
<tr>
<td>Rotary Potentiometer</td>
<td>Continuously adjustable control</td>
</tr>
</tbody>
</table>

The Left and Right Door Open, Release and Close switches shall be back illuminated by light emitting diodes to provide the indications for the functions described in Section 6.5.2. Console and windshield design shall prevent glare from all illuminated console switches.

Controls for passenger doors shall be positioned for safe actuation, with the right side door controls on the right side of the console, and the left side door controls on the left side of the console.

The cab console shall also provide for installation of switches to acknowledge an ATP overspeed condition and initiate a self-test of the ATP system. Refer to Section 14.2.2.

5.1.2.2 Operator’s Annunciation and Indication Panel

The console display panel shall be located on the console and adjacent to/or included with the speedometer. A minimum of 12 LED indicators shall be provided. The indicators selected shall be coordinated with the operator’s fault display. The indicators shall provide sufficient information to the operator to allow safe operation of a streetcar in service with a non-functioning Train Operator Display and the status of the TSS system as described in Section 14.3.5. The TSS annunciators shall not be combined with the Train Operator’s Display.

An analog speedometer shall be provided. The speedometer shall display speed processed by the propulsion systems. The mounting of the speedometer shall allow for installation of the ATP Aspect Display unit as described in Section 14.2.2 without changing the dimensions of the console cutout.

An ESS capacity meter shall be provided as described in Section 9.5. The displayed value shall be compensated for the actual temperature of the storage media. Alternatives using the TOD as the display meter will be considered by DART.

5.1.2.3 Train Operator Display

The Train Operator Display (TOD) shall be located to the left side of the console display panel. The minimum dimensions for the TOD screen shall be 8 in wide x 4 in high (200 mm x 100 mm). The screen shall have an automatic as well as a manual brightness control feature.
The Operating Screen shall present information useful to the Train Operator when the streetcar is in motion or during a normal station stop. The Trouble Screen shall present pertinent troubleshooting information to the Operator concerning conditions that affect the immediate operation of the train. The Maintenance Screens shall provide detailed information to supervisors and maintainers to permit troubleshooting to the LLRU level. For detailed information on how the TOD shall function as part of the Monitoring and Diagnostic System refer to Section 9.8.

Items with urgency shall flash to catch the Operator's attention. Flashing of such items shall be canceled by the Operator's activation of a Fault Acknowledge control. Interface with the TOD shall be by control buttons located directly below or by pressing the appropriate area on the screen if a touch-screen system is provided. Controls shall be provided for, as a minimum:

- Fault Acknowledge
- Screen Selection
- Navigate through screens (menus)
- Select specific items
- Screen Brightness

### 5.1.2.4 Communications Control Panels

The audio and radio system control heads shall be located immediately to the right of the console switch panel. Arrangement shall permit safe operation of the streetcar with the operator's left hand on the master controller.

A separate passenger information control panel shall be mounted to the right of the audio and radio system control heads. The panel shall be used to control the automatic destination signs and announcements. The passenger information control may be incorporated into the Train Operator Display with DART’s approval.

### 5.1.2.5 Rear View Screens

The flat rear view video screens described in Section 13.8 shall be mounted on the left and right sides of the console. They shall be arranged to be viewed easily by either a seated or standing operator.

### 5.1.3 Lower Control Panel

A lower control panel shall be mounted under the console on the right side of the operator. At a minimum, the following controls, and type of switch, shall be included on each console.

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliaries Switch, Off/On</td>
<td>3MRC</td>
</tr>
<tr>
<td>Audible Alert Bypass</td>
<td>MPB, sealed</td>
</tr>
<tr>
<td>No Motion Bypass</td>
<td>MPB, sealed</td>
</tr>
<tr>
<td>Door Interlock Bypass</td>
<td>MPB, sealed</td>
</tr>
<tr>
<td>Speed Restriction Bypass</td>
<td>MPB, sealed</td>
</tr>
<tr>
<td>Spin/Slide Bypass</td>
<td>MPB, sealed</td>
</tr>
</tbody>
</table>
ATP Bypass See Section 14.2.2
TSS Trip Counter See Section 14.3.5
TSS Key-by Counter See Section 14.3.5
TSS Key-By Switch MPB, sealed
TSS Reset Switch MPB, sealed

Type codes mean the following:

MPB = Momentary pushbutton
3MRC = Three-position momentary rotary, return to center

5.2 *Miscellaneous Cab Equipment*

5.2.1 *Warning Devices*

Warning devices are required for operation on city streets intermixed with pedestrians and other vehicular traffic. The warning devices shall be considered safety-related equipment with no single point failure disabling both warning devices in a cab. Power for each device shall be provided by a separate circuit breaker.

The automobile warning device shall be a horn with two volume setting, low and high. Activation shall be by a momentary switch on the cab console and shall activate the horn on the appropriate end of the vehicle for the direction of movement. The high horn volume setting shall have an audible output of at least 95 dBA at 100 ft (30 m) in front of the vehicle. The low horn volume setting shall be adjustable by DART and is intended for use in residential areas.

A traditional sounding trolley bell shall be provided for pedestrian warnings. The bell shall have a minimal sound pressure level of at least 75 dBA, measured at a distance of 75 ft (23 m) in front of the vehicle. Activation shall be by a momentary switch in the cab. The bell shall produce a repeating sound with a repetition rate of approximately two strikes per second in response to continuous switch activation.

Warning sounds, horn and bell, may be produced by amplified, digitally-sampled audio data, heavy duty weatherproof speakers on each end of the vehicle shall be the source for the warning sounds. The volume of the warnings shall be adjustable by the maintenance personnel.

The Contractor shall submit warning device sounds to DART (CDRL 5-4) for review and approval.

5.2.2 *Windshield Wiper and Washer*

An electrically-operated windshield wiper shall be provided for each cab windshield. At least 80% of the width and 60% of the height of the total windshield area shall be swept over one complete cycle. Windshield wiper controls shall provide for variable speed and for interval operation to suit a wide range of rainfall conditions. Windshield wipers shall automatically park at a secure and unobtrusive location when not active.

Windshield wipers shall be provided with fluid dispensing windshield washers to aid in maintaining clear operator vision. The washer nozzle shall be attached to each wiper blade, and move with the blade. The washer fluid reservoir shall be easily accessed for refilling from outside the streetcar.
5.2.3 Air Comfort System

Each cab shall be provided with heating and cooling controlled by the operator, either as an independent cab unit, or as fed from the passenger compartment. Cab windshield heating shall also be provided. Capacity and control parameters are described in Section 7.

5.2.4 Odometer

An odometer as described in Section 10 shall be provided in the A-end cab. The odometer shall be easily visible by the Operator without leaving the Operator’s seat. The odometer shall measure increasing distances regardless cab activation or direction of travel (i.e., if car is operating in reverse).

5.3 Control Configurations and Interlocks

Various vehicle control schemes shall be implemented as described below. Control of systems not described below shall be determined by the Contractor.

Unless otherwise indicated or approved, all control signals, interlocks, and other vehicle level controls shall operate from the low voltage power supply.

The Contractor shall submit a Control Configuration and Interlocks design package (include in CDRL 5-2), for DART’s review and approval.

5.3.1 Cab Interlock

Control lines and associated circuitry shall be used to interlock the cab controls such that no more than one cab can take control of a vehicle at the same time.

All interlocking shall be provided by relay logic. Interlocking that depends on mechanical locking of transfer switches with electrical solenoids is prohibited.

5.3.2 Direction Control

Direction signals shall be given by a pair of control lines, designated Forward and Reverse relative to the A end of the vehicle. The associated circuitry shall be arranged such that one control line must be energized while the other must be de-energized for correct operation. Energization or de-energization of both control lines at the same time shall inhibit propulsion.

Direction signals shall originate at the controlling cab’s Reverser Switch.

5.3.3 Emergency Brake

Operator control of emergency braking shall be provided by an Emergency Brake Switch mounted on the operator’s console in each cab. Automatic initiation of emergency braking shall also be provided as described in this specification.

The console Emergency Brake Switch shall be a heavy duty, industrial grade pushbutton gang switch with a large, red mushroom-shaped actuating head. The switch mechanism shall be arranged with two switches for the main emergency brake circuits, with a switch contact in each of the positive and negative portions of the circuits. The actuation mechanism shall be sufficiently robust such that striking the mushroom head will assure breaking the circuit even with welded contacts.
The emergency brake circuit shall be interlocked with the no-motion detection system such that, once emergency brake is commanded, the emergency brake circuit cannot be reset to the normal state until no-motion is indicated.

The active cab shall provide the only power and return circuits for control of all emergency brake equipment in the vehicle. These circuits shall be controlled in a double break manner such that both the positive and negative supply leads to the emergency brake relay are switched by the console Emergency Brake Switch, the cab control and interlock relays.

The emergency brake control circuits shall be treated as vital, with maximum isolation maintained from possible sources of false energization. All emergency brake circuits shall be arranged in a fail safe manner, requiring that control lines be energized to sustain a permissive condition.

5.3.4 Track Brake Control

Track brakes shall be controlled via a control line that is energized to apply the track brakes. All track brakes in a vehicle shall be applied when commanded either by a brake application or manually via the console track brake switch.

When commanded by maximum brake or emergency brake, track brakes shall be interlocked with the no-motion system such that track brake application is canceled below the no-motion detection point.

Manual operation of the track brakes via the console switch shall not be canceled below the no-motion detection point. Propulsion shall not be inhibited by a manual track brake application.

Any track brake application shall activate the brake lights at the rear of the vehicle.

5.3.5 Passenger Stop Request

The passenger door pushbuttons shall initiate a stop request when the vehicle is in motion. Activating the passenger stop request anywhere in the vehicle shall sound the local stop request chime only in the passenger area of the vehicle, and shall sound an audible alert for 0.5 seconds in the operator's cab. The stop request shall illuminate a light on the operator's console.

Once activated, the cab stop request light shall remain illuminated and the cab audible alert shall latch off, until the doors have been cycled.

5.3.6 HVAC Control

The HVAC system shall be activated automatically whenever a Key Switch in either cab is placed in the ON position or when the Auxiliaries ON switch is activated. The HVAC system shall automatically shut down when the vehicle auxiliaries are turned off in accordance with Section 5.3.8.

5.3.7 Auxiliary Power Control

The auxiliaries ON/OFF switch shall control all low voltage dc circuits except those associated with propulsion and braking controls, layover heat, and standby battery charging. Charging of the ESS storage devices shall require activation of the auxiliaries.

Activation of the key switch in the master controller group shall automatically turn the auxiliaries on. However, moving the key switch to the OFF position shall not turn the auxiliaries off. Moving the key switch to the off position shall initiate an adjustable timer for
delayed shutdown of the auxiliaries. The shutdown timer shall be adjustable from 2 to 20
minutes and shall include sufficient time for the HVAC units to pump down prior to
deactivating all auxiliaries.

Each cab shall have an Auxiliary On/Off switch, which shall turn the auxiliary loads On or Off
as commanded. The Auxiliary On/Off switch shall not be functional if a Key Switch is
activated in any Cab. When the auxiliaries are commanded off by this switch, shutdown will
not be time delayed.

5.3.8 Exterior Lighting Control

Exterior lighting control shall be as described in Section 8. Exterior lighting control includes
the silent alarm switch.

5.3.9 Door Control

Door control shall be as described in Section 6.

5.3.10 Parking Brake Control

The parking brake shall automatically be applied when both reversers in each cab of the
vehicle are in the OFF position.

5.3.11 Bypass Circuitry

The following sealed switches shall be provided. The seal shall be breakable without the
need for tools by the operator. A bypass active indicator shall illuminate if any bypass switch
except Audible Alert Bypass is activated.

Audible Alert Bypass: Acknowledges and cancels the audible alarms for emergency
door operating device activated, friction brake fault, dynamic brake fault, or ESS
level low. The use of this switch shall not affect illuminated indicators associated
with these alarms and its use shall not illuminate the Bypass Active light.

No-Motion Bypass: This switch shall bypass the local no-motion detection circuits
which prevent door operation.

Spin Slide Bypass: This switch shall disable the spin/slide protection on a streetcar
in the event of a failure preventing operation.

Door Interlock Bypass: This switch shall bypass the summary door interlock circuit
which prevents propulsion in the event of an open door.

The bypass switches shall be in the circuit only if the operator’s console is activated in the
same cab as the bypass switches. When the console key is turned to OFF, all units shall
automatically return to normal function and remain so when that cab’s console is re-
activated.

5.3.12 Sander Control

A footswitch shall be provided for manual operation of the sander system. The switch shall
be of the momentary, spring-loaded type, arranged such that sand is applied to the rails in
front of the leading wheels of a truck. Manual operation of the sanders via the switch shall
not be canceled below the no-motion detection point.

Automatic operation of the sanders via spin/slide detection or emergency brake application
shall be canceled below the no-motion detection point.
5.3.13 Car Wash Mode

The car wash mode pushbutton shall be an illuminated whenever car wash mode is energized. The car wash mode shall be capable of being enabled or disabled only when the reverser switch is in the FWD or REV position and the master controller is in the FSB position. The car wash mode shall not be activated or deactivated with the master controller in any other position. De-activation of the car wash mode shall return the master controller to the operation described in Section 5.1.1.3.

In car wash mode, the master controller shall control the vehicle in the following manner:

- The deadman feature shall be operational;
- The maximum attainable speed in propulsion mode, regardless of the acceleration rate commanded, shall be less than 3 mph (5 km/h). The desired speed in 1 mph (1.6 km/h), however, in any case the maximum allowable speed shall be less than 3 mph (5 km/h);
- The deceleration rates commanded by the master controller shall be the same as provided in Section 5.1.1.3; and
- The coast mode shall be operational.

5.4 Cab Arrangement

An Operator's cab shall be provided at each end of the vehicle. The cab area shall contain all appurtenances necessary for normal and abnormal streetcar operation. The cab layout shall maximize the use of available space.

The cab shall be free of sharp edges, protruding objects, safety hazards and floor obstructions as required by Military Standard MIL-STD-1472, latest revision. Areas in which paper and other debris can accumulate will not be permitted.

The Operator's cab shall be full width and shall be fully enclosed to prevent unauthorized access. The enclosure shall be designed so that the Operator's forward view is not obstructed while standing or sitting. A door in the cab partition shall be provided, as described in Section 5.4.2, to allow access to the cab for Operators.

The cab and operator's seat shall be designed for use by an Operator in the size range of the fifth female percentile to the ninety-fifth male percentile of the general population as defined by Military Standard MIL-STD-1472D.

5.4.1 Cab Partition

A full width, transverse partition shall form the rear wall of the cab enclosure. The partition shall be constructed of 0.5 in (13 mm), melamine faced plymetal, of balanced construction. The cab partition shall be securely fastened to the car roof structure, floor, and carbody side structure. The cab partition shall not be attached to ceiling panels or side lining panels. The Contractor may propose aluminum cab partitions in place of plymetal, subject to DART's review and approval.

5.4.2 Cab Door

The cab door shall swing into the passenger compartment when opened. The door shall be equipped with a full length, stainless steel, piano-type hinge.
The cab door shall contain a vertically sliding sash window in the upper portion of the door to allow the Operator to look rearward into the passenger compartment. The sash shall be provided with a spring latch in the up (closed) position. The latch shall be operable only from within the cab. The window shall be constructed of 0.250 in (6.4 mm) minimum thickness, laminated safety glass mounted in an aluminum frame. The glass shall be adequately tinted to prevent glare on the windshield while operating at night. The door window shall be fully supported by the cab door panel on all sides. The bottom edge of the window shall be in alignment with the bottom edge of the side windows. The Contractor may propose aluminum honeycomb material for door panel construction, subject to DART’s review and approval.

Window curtains shall be provided on the cab door window to permit the operator to block light from entering the cab from the passenger compartment. Vandal Shield, or approved equal, shall be provided on the surface of the cab door window facing the passenger compartment.

In the operating mode, the door shall be closed and locked, closing off the cab to passengers. The cab door shall be constructed of the same materials as the cab partition, and shall be cut from the cab partition panel to maintain a proper color and pattern match.

The door shall automatically latch and lock in the closed position. The door lock shall have the capability to be unlocked from the passenger side with a crew key (refer to Section 14). Each cab door shall be equipped with a rapid door lock release mechanism, operable only from within the cab, to enable the door to be opened without the use of a crew key, by pressing on the panic bar. Door locks shall be constructed from nickel-bronze or stainless steel.

The cab door shall be equipped with a sight-tight, louvered, grille in the lower portion for ventilation. The door shall be equipped with 0.030 in (0.76 mm) minimum thickness, stainless steel kick plates, 8 in (200 mm) high, along the bottom portion of the inside and outside face.

5.4.3 Cab Flooring

The subfloor of the cab and cab floor covering shall be the same as provided in the passenger section. The floor covering shall have a smooth surface as used under the passenger seating. Refer to Section 15 for details of construction and application.

5.4.4 Operator’s Seat

The operator area of each cab shall be equipped with an operator’s seat located on the vehicle’s longitudinal centerline. The seat and back cushion shall be upholstered with low smoke foam and covered with transportation grade fabric backed vinyl. Covering material shall breathe to minimize perspiration buildup and operator discomfort. The seat shall be adjustable vertically and in a forward and backward direction. The back support shall also be adjustable. The seat back shall provide adjustable lumbar support. The seat shall be equipped with flip-up armrests. The seat cushion shall be a minimum of 4 inches (100 mm) thick.

The seat shall swivel a minimum of ±30º from the forward facing position. Upon return to the forward facing direction, the seat shall automatically lock and prevent further turning. The lock shall be easily released by the operator while seated to permit swiveling. Seat adjustment controls shall be operable from a seated position.
The seat frame shall be of corrosion resistant tubular construction and shall be designed for hard vehicular usage. The seat and its attachment to the floor shall have adequate strength. Adequate foot space shall be provided to accommodate the operator's feet.

5.4.5 Sunscreens

Adjustable sunscreens shall be provided as need to aid the operator in all external light conditions, including simultaneous front and side sunlight. Each screen and its: material, mounting, and adjustment, shall be service-proven in a similar transit application; considering factors, window size/arrangement, operator position, color, and light blockage ratio. The sunscreen material shall not neutralize the color of traffic control signals.

5.4.6 Convenience Outlets

Two (2) duplex convenience outlets, rated for 120 Vac, 15 A service, shall be provided, one in each cab, at locations approved by DART. Each ground fault circuit interruption (GFCI) protected outlet shall be fed from a dedicated circuit breaker.

5.4.7 Fire Extinguisher

A 10 lb (4.5 kg) capacity fire extinguisher with a minimum rating of 4-A:30-B:C, marine type, shall be located in each operator's cab. The fire extinguisher shall be listed by Underwriters Laboratory and shall be provided with a marine type mounting bracket. The fire extinguisher shall be clearly marked and accessible to the operator.

5.4.8 Coat Hook

A folding, flush, nickel-bronze coat hook of approved design shall be provided in each cab on the cab rear partition. A strap shall be provided to restrain hanging items.

5.4.9 Operator's Storage Locker

An easily accessible storage locker shall be provided in the cab for the storage of the Operator's personal items while operating the train. The storage locker shall have a door, which is attached by a stainless steel piano hinge. The door shall be secured with a lock, operable with the crew key. The locker shall be constructed of the same materials used in the construction of the adjacent cab linings.

5.4.10 Waste Receptacle

A detachable, stainless steel waste receptacle, of approximately 2 gallons (8 liters) capacity, shall be provided in the cab within reach of the operator when seated. The waste receptacle shall be designed to be leak-proof, and shall be secured to its mounting surface to prevent rattling when the vehicle is operating in service. The waste receptacle shall be designed to accommodate commercially available trash receptacle liners.

5.4.11 Cup Holder

A flip-down cup holder to retain a 12 oz (355 ml) beverage cup or container shall be provided within reach of the operator, but not over the console.

5.4.12 Auxiliary Seat
A tip-up auxiliary seat shall be provided in each cab for the purposes of driver training and other activities where it may be advantageous to have a supervisor or trainer in the cab for relatively brief periods of time.

5.5 CDRL

The following submittals are required:

5-1 Operator’s cab design package (Section 5.1)
   • General arrangement drawings of the cab, including:
     • Drawings included in CDRL 18-11
     • Drawings showing cab console attachment and maintenance access
     • Drawings showing seated operator’s range of visibility out the windshield, and viewing range of rear view cameras
     • Electrical and storage lockers
     • Drawings of all control, indicator, wiring terminal and breaker panels, with all components identified
     • Parts list for all cab components

5-2 Cab control design package (Section 5.1)
   • Functional description of all cab controls, including interfaces to MDS
   • Control schematics
   • Functional description of the TOD, including:
     • Sample screen displays, monitor details (resolution, colors, etc).
     • Listing of available displayed data for each system

5-3 Warning devices sounds (electronic audio files) (Section 5.2.1)

END OF SECTION
# SECTION 6
## PASSENGER DOORS

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SECTION 6
PASSENGER DOORS

6.1 General

Each streetcar shall have a minimum of two door openings, one per side, for the boarding of passengers. All doors shall be of the sliding plug type. The doors shall be flush with the carbody exterior skin when closed. Doors shall not protrude more than 3 inches (75 mm) from the vehicle side during any portion of the open or close cycle.

The doors shall be provided to meet all ADA requirements, 49 CFR 38 Subpart D. The Contractor shall communicate and cooperate with the Dallas Streetcar wayside construction Contractors on platform interface issues to assure the design accommodates both the ADA requirements and the vehicle dynamic envelope. Within 90 days after NTP the Contractor shall submit, for DART's review and approval, a door platform interface design package. (CDRL 6-1)

All door equipment for a single leaf or double leaf configuration shall be interchangeable from one location to any other similar location and from car to car. To this extent, all mounting holes for all hardware shall be jig-drilled to ensure interchangeability.

All doors shall be vibration and rattle free, while the vehicle is underway, and while doors are operating when the vehicle is stationary. The door system, in conjunction with the vehicle’s aerodynamics, shall prevent whistling and other objectionable noises at all vehicle speeds.

The door system shall be designed in accordance with the safety requirements of Section 2.9. No single point failure of the door system shall cause:

- Any door to unlock and/or open when an open request has not been commanded
- A door open command to be transmitted or responded to when the train is in motion
- A door closed indication to be transmitted when any door is unlocked or open
- A traction interlock OK status when any door is unlocked or opened
- A door closed indication to be transmitted when an unlock or opening command is stored anywhere in the system

6.2 Doors

Within 180 days of NTP the Contractor shall a door system design package for DART's review and approval, (CDRL 6-2)

6.2.1 Door Panels

6.2.1.1 General Requirements

All side doors shall be of high-strength low alloy (HSLA) steel or aluminum construction, and joined into an integral unit by adhesive bonding or resistance welding. All edges and joints shall be completely sealed to prevent the infiltration of moisture. Interior cavities, where it is
possible for condensation to form, shall be provided with drain holes at the bottom. Door frames shall be free of dimples and warping, and shall be reinforced at the mounting points of all hardware.

Each door panel shall contain a laminated safety glass window, of the same materials and color as the side windows. The door window shall be as high and as wide as possible to allow maximum visibility of station platforms by passengers and to make door positions more clearly identifiable to waiting passengers. The window height shall be sufficient to permit direct viewing of the door closing movement warning signal by a passenger on the platform, when the doors are closed.

The window retention arrangement shall be watertight.

6.2.1.2 Strength Requirements

The door panel skin, structure, and mounting hardware shall sustain a concentrated load of 200 lbf (890 N) applied perpendicularly to the plane of the door at any location on the panel, with the door panel installed on the car; the load-bearing surface shall be 4 inches by 4 inches (100 mm by 100 mm) for this requirement. The allowable maximum deflection under these conditions with the door simply supported at the top and bottom shall be limited to 3/8 inches (10 mm) maximum with no permanent deformation after the force is removed.

6.2.1.3 Weather Sealing Requirements

The door panels and doorways shall be weather-stripped to be watertight when the car is being washed under pressure and for all service speeds with the worst case possible combination of climatic conditions as described in Section 2.3.5.

Sealing shall be provided by a vertical seal at the carbody edges, the top edge of the door, the forward edge of the door where the panels meet in the closed position, and at the bottom edge. All seals shall be applied in a manner which enables them to be easily replaced with the door panels in place.

6.2.2 Door Operator

Door movement shall be via electrical operator and shall have sufficient power to reliably open and close the doors at the specified performance levels with the most unfavorable ambient wind and vehicle pressurization conditions. The left and right door panels in a given doorway shall move simultaneously. One operator shall be provided per doorway.

The operator shall be located in the transom area above the doorway. All operator equipment shall be concealed, except as necessary for the sliding mechanism, such that it is not directly visible when the door is opening and closing, or when the door is in the fully closed position. Access to the door operator shall be by opening a cover or removing an access panel, without the need to move or disconnect other equipment. Sufficient clearance and access space shall be provided to maintain all components on the operator assemblies, and to remove the assemblies as complete units.

All door tracks shall be mounted within the carbody or within the door panel. Separate sliding door lock assemblies, if required by the door design, shall be within the carbody.

The operator shall be powered from the low voltage dc power system and shall be capable of operating over the specified voltage range without affecting the reliability, specified performance, or service life of the operator. The operator shall be capable of withstanding stall current indefinitely, or, alternately, shall be capable of detecting this condition and
removing power if it persists for a preset time, without adverse affect on the reliability and service life of the equipment.

6.2.3 Door Locks

The doors shall be positively retained in the closed position via mechanical means. The lock function may be a separate mechanical lock or an over-center function of the operating linkage if the linkage is directly connected to the door panels. If the operator employs a drive belt, the lock mechanism shall not rely on the belt. The lock shall automatically engage when both door panels reach the closed position, and shall not require electrical power to remain locked.

6.2.4 Door Control Panel

An independent door control panel shall be provided in the transom header area of each doorway. The system shall control all aspects of door motion, including opening speed, closing speed, closing forces, detection of stalls, accelerations and decelerations, and door close time delays. Access to the transom header shall be by crew key.

The controller shall read and respond to commands, monitor door status, and provide system diagnostics as described in Section 6.2.5 below.

The control panel shall include provisions for adjusting and controlling door opening and closing speeds, door closing forces, door timing, and similar features via laptop computer and software provided by the door supplier.

6.2.5 Diagnostics and Adjustments

The status of the door system shall be available via a diagnostics system integral to the door controller and via the streetcar’s MDS system described in Section 9.8.

The diagnostics system shall include a data/fault logger to monitor all critical internal functions, external inputs, and the mechanical door system, including door open, closed, and lock status. Actual door performance, such as door speeds on opening and closing, shall also be monitored. System faults and associated system parameters shall be time and date stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

Each door controller shall be serially linked with the other door controllers in the streetcar such that the diagnostic output of any door controller in that vehicle may be monitored at a single location with a laptop computer and appropriate software from the door system supplier. The location of the common diagnostics port shall be subject to DART’s review and approval. (Include in CDRL 6-4) If necessary, one door controller may be designated as the master for this purpose. The master controller shall be identical in configuration and software with the other controllers. Failure of the diagnostic link shall have no effect on door operation. Link failures shall be announced at the diagnostics port. Diagnostics from each door controller shall also be available either via separate connector at the controller, or by disconnecting the serial link connector.

The door controller shall also permit adjustments of all operating variables, such as door speeds and timing, via Portable Test Units. These adjustments shall be available both locally and via the common diagnostics port. The software system shall provide a visual prompt to notify the user that a variable has been changed and shall require a confirmation action by the user to initiate the change. There shall be a separate adjustment location for
system wear. All operating variables shall be stored in non-volatile memory in the door controller.

It shall be impossible to affect the door parameters at speeds above No-Motion speed.

The mounting of all sensors and switches shall be such that no readjustment shall be necessary when any given sensor or switch is replaced.

The diagnostics and adjustment capabilities of the door system shall be reviewed and approved by DART. (Include in CDRL 6-4)

6.3 Door Control Requirements

Within 180 days of NTP the Contractor shall submit a door controller system design package. (CDRL 6-4) The submittal shall include both hardware and software control functions and their interdependencies and comply with the documentation requirements of Section 17.27.3.

Door motion shall be smooth and free of shock and impact. Cushioning shall be provided at the end of travel of the door in both the opening and closing directions. In the event of a loss of local control power, the doors shall remain in the last commanded position during absence of control power and when power is restored.

6.3.1 Door Operation

Doors may be opened by the operator, or by passengers on the inside or outside of the vehicle. The door nearest the lead cab on each side shall also be controlled by exterior crew switches.

When an active cab has been established, door operation shall only be possible when the vehicle has achieved no-motion, and the Master Controller is in the FSB position. When the streetcar's auxiliaries are energized, but an active cab has not been established, all doors shall be operable from either cab console.

All door operations shall be enabled by the operator via a Release command issued from the operator's console. The Release command shall be interlocked with the no-motion circuitry both in the cab and at each doorway.

Issuing a Release command for the doors on a given side of the vehicle shall cause the local door control panels to enable and illuminate the inside and outside passenger door pushbuttons on that side of the vehicle, indicating to passengers that door control is available. Pressing any passenger door pushbutton shall cause the enabled door to open. The doors shall remain open until the operator issues a Close command from the console.

The operator may open all doors on a vehicle side by issuing an Open command from the console. An Open command from the console shall automatically cause a Release command to be issued. The Open command shall be interlocked with the no-motion circuitry both in the cab, and at each doorway, independently of the Release command.

The Open and Release commands must both be present at each doorway before any given door can open.

If opened by an Open command by the operator, all open doors shall remain open until the operator issues a Close command from the console, at which time all Release and Open commands for the selected side shall be canceled and all doors on the selected side of the car shall close.
6.3.2 Performance
The delay time from receipt of a door command signal by the door controls to the first motion of a door panel shall not exceed 0.15 seconds.

The operating time of any door, from time of first motion to the point of completion, including cushioning, shall be 3.0 seconds to open and 4.0 seconds to close, ±0.5 seconds. The maximum door closing speed shall be 1.3 ft/s (400 mm/s). Operating times shall be adjustable by DART via laptop computer between 2 and 5 seconds on both open and close in 0.5 second increments.

6.4 Door Obstruction Detection
The door system shall detect obstructions by sensing operator motor current and/or speed/time information, and by a sensitive edge. A sensitive edge shall be incorporated within the leading edge of each door panel seal which shall activate a pressure wave or tape switch. The routing of air control lines to a pressure wave switch shall require a protective sheath to prevent damage and carriers to ensure smooth motion with the door panels.

6.4.1 Operational Requirements
Upon detection of an obstruction, the door panels in the affected doorway shall immediately decelerate, open and remain open for a preset period controlled by an adjustable time delay circuit. This timing circuit shall be adjustable from zero to 10 seconds. The door panels shall then again attempt to close. If the obstruction is no longer detected, the doors shall close and lock.

If the obstruction is still detected, the door panels shall continue to recycle for a pre-set number of times. If the recycle count is exceeded, the doors shall remain in the open position until reset by the operator. The recycle count shall adjustable from 3 to 10 times by DART.

If an open command is issued at any time, it shall override and reset the obstruction detection circuitry.

6.4.2 Sensitivity Requirements
Each obstruction detection system, sensitive edge and additional approved method, shall detect any force opposing door motion in excess of 30 lbf (130 N).

In addition, the sensitivity of the obstruction detection system for each panel separately shall be as follows:

- It shall detect a flat bar, 3/8 inches (10 mm) wide and 3 inches (75 mm) high, held rigidly between and perpendicular to the door panel, as a hand might be held to stop the doors. This sensitivity shall be required everywhere along the length of the panel except the uppermost 3 inches (75 mm) of the nosing seal.

- It shall detect a cylindrical object, 3/4 inch (20 mm) in diameter, held rigidly between and perpendicular to the door panels at all locations along the length of the door nosing seal, except the uppermost 3 inches (75 mm) and lowermost 1 inch (25 mm) of the seal.
6.5 Control Switches and Pushbuttons

6.5.1 General Requirements

The doors shall be controlled from the crew switches, the cab door control pushbuttons, and the passenger pushbuttons. Switches and pushbuttons used for these controls shall be of heavy-duty, industrial type, suitable for frequent use in DART’s rail transit environment. All switches shall be rated per IP65. Samples of all switches, pushbuttons, and tape switches shall be submitted to DART for review and approval. (CDRL 6-5)

6.5.2 Cab Console Switches

Each cab shall include momentary pushbutton switches for control of doors by the operator. The switches shall be arranged logically and physically separated left and right to reduce the possibility of inadvertent door operation.

The switches for each side shall be: Open, Release, and Close.

6.5.3 Crew Switches

One door at each end of the vehicle on opposite sides shall be provided with weatherproof electrical rotary switches operated by the crew key. Switches shall be located inside and outside the vehicle, a total of two per doorway. The outside switches shall be located beyond the open position of the door panels.

The crew switch and related circuits shall have applied power only when both cabs in the vehicle are keyed Off. The switch and the adjacent door operator shall be arranged so that they can function independently of the cab console controls and status of the vehicle’s auxiliaries.

The crew switch shall have three positions, with spring-return to center: Open, Neutral, and Close. When the crew switch is rotated to the Open position, the adjacent door shall open.

When the switch is rotated to the Closed position, the door shall close. The control logic shall be configured to allow closing of any door that has been opened from the crew switch from an active cab console.

6.5.4 Passenger Pushbuttons and Tape Switches

Each doorway shall be provided with illuminated pushbuttons on the inside and outside of the vehicle to permit passengers to open the doors. The passenger door pushbuttons shall be colored yellow. The pushbutton illumination shall be Green when active, and dark or Red when inactive.

The sizes, locations, colors, graphics, and other features of the pushbuttons shall be approved by DART (CDRL 6-6). Approval shall require the prior approval of samples (see CDRL 6-5).

The interior door pushbuttons shall also provide the passenger stop request function. See Section 5.3.5.

6.6 Manual Door Release Mechanism

Interior and exterior door release mechanisms shall be provided to permit doors to be opened locally without the use of electrical power. Operation of the release mechanism shall also initiate an irretrievable Full Service Brake stop. A reset device shall be provided to restore the doors to their normal operating condition after use of a manual release.
mechanism. The reset device shall be contained within the door control panel or transom area above the doors. Access to this area shall be by the crew key.

6.6.1 Interior Manual Door Release (Passenger Emergency Switch)

A lever or pull knob to operate the combination manual door release mechanism and passenger emergency switch (release device) shall be provided on the interior of the car at each doorway in a location accessible to all passengers. This release device is to be used under emergency conditions only, and suitable measures shall be taken to assure that its location and enclosure discourage everyday use. Suitable graphics shall be provided to explain operation in an emergency and warn against unlawful use. The graphics shall advise that the emergency door opening device is also an emergency stop activating device.

Activation of this release device shall allow both panels in a doorway to be unlocked and manually pushed open regardless of whether electrical power is available or not. This mechanism shall override all other door controls and devices. When the manual release mechanism is activated, the following shall automatically occur:

- The motion of the release knob or lever shall cause the release mechanism to interrupt the door status interlock causing propulsion power to be removed and a Full Service Brake application to be applied. Circuitry shall be provided to annunciate "PASSENGER EMERGENCY" on the console indicator panel in each cab and sound a cab audible alert. See Section 13.5.2.

- The motion of the release knob or lever shall then cause the mechanism to unlock the adjacent door panels and open them approximately 1 inch (25 mm) to allow the door panels to be manually pushed fully open. Electrical power to the door operator shall be removed from the door operator.

Operation of the release mechanism shall not electrically bypass the no-motion interlock.

6.6.2 Exterior Manual Door Release

Manual door release devices shall be provided for crew, maintenance and emergency personnel use for entry to the car when no power is available. Two releases shall be provided, each diagonally opposite the other at the side end doors. The manual release mechanism shall be located behind a DART-approved cover and shall not require a crew key to operate.

6.7 Interlock Requirements

6.7.1 No Motion Interlock

All door controls shall be electrically interlocked, in a failsafe and redundant manner, with the no-motion circuitry described in Section 2.6.10, so that the doors can be powered, opened or released, only when the vehicle has reached no-motion.

Power to the door opening operating motors, shall be switched with non-welding critical circuit relays controlled by the no-motion logic. When motion is detected, both the positive and negative feeds for these circuits shall be disconnected from the low voltage power. All diagnostic and fault monitoring, logging, shall remain active when the train is in motion.

Independent of these interlocks, the door control logic shall monitor the no-motion trainline and ignore any open or deploy commands without a no-motion signal present, and shall issue a fault indication if this condition occurs.
6.7.2 Door Status (Open) Interlock

An electric loop circuit shall be provided to monitor the position of each door panel for each side of the vehicle. Separate position sensing switches shall be provided to positively detect that each door panel is closed and locked. The switches sensing the closed state shall be separate to switches provided to detect if each panel is properly locked.

For each side of the vehicle, the switches shall be placed in series and activate a Summary Door Status, when all door panels are properly closed and locked. If any one of the closed or locked switches is not made up, the Summary Door Status relay shall not be energized, the cab Door Open light for that side of the vehicle shall be illuminated, propulsion power removed, and Full Service Brake shall be applied.

If an attempt is made to apply power with any door panel not closed and locked, the master controller shall have to be placed in the Full Service Brake position after the Summary Door Status relays are energized before the brakes can be released and power applied.

No single point failure in the loop circuit shall cause a false door closed and locked signal. Where failures in the loop circuit are not self-annunciating, they shall not lead to a false doors closed and locked signal, from the door interlock circuit, or in association with other single point failures.

6.8 Bypass Devices

Bypass devices shall be provided to circumvent specific door system faults so that the vehicle can continue in revenue service, or be removed from revenue service and returned to the maintenance facility, or moved to clear the line.

6.8.1 Door Interlock Bypass

A sealed door interlock bypass feature shall be provided in each cab. This function shall be active only when the associated operator's console is powered. It shall permit movement of the vehicle under emergency conditions in the event that all doors are not sensed as being closed or retracted and locked, and the source of the difficulty cannot be readily determined.

The door interlock bypass feature shall bypass the door status interlock so that the brakes can be released and power applied. It shall not provide a false doors closed indication.

6.8.2 Door Cutout

A door cutout device shall be provided at each door operator and shall be arranged to perform the following functions in the event that a defective door must be cut out:

- Disconnect door motor and door controller
- Bypass door-closed and door-locked interlocks for that door
- Assure that the door remains closed by mechanical restraint; however, operation of the manual door release devices shall disable or release this mechanical restraint to allow the door to be opened
- Deactivate the local passenger pushbutton lights and annunciate a cutout in the operator's cab
- Illuminate the door out-of-service indicator for the affected doorway.

The cutout device shall be located in the transom area above the doorway.
6.9 Annunciators
The Contractor shall submit a Door Warning Indication (CDRL 6-7) for review and approval by DART.

6.9.1 Door Open Indications
Two Door Open indicator status lights shall be provided on the cab console indicator panel, one for each side of the car. The indicators shall be illuminated when any door on the associated side of the vehicle is sensed as being unlocked, open, or both.

6.9.2 Door Close Warning
An audible warning shall be provided 2 seconds prior to doors closing. Either the door control or communications system shall generate the audio and control signals. The warning shall be audible inside and outside the train, at each doorway. The warning tone, buzzer, or message shall be reviewed and approved by DART. (CDRL 6-7)

An Amber door closing visual warning shall flash, with the audible warning, on both sides of each doorway. The visual indicators shall be located on the side of the door frame, visible inside and outside the vehicle regardless of door position. If the visual door warning cannot be seen from outside the vehicle with the doors closed, a duplicate weatherproof device shall be provided on the outside of each doorway. The indicator shall be reviewed and approved by DART. (include in CDRL 6-7)

6.9.3 Door Out-of-Service Indicator
An illuminated Door Out-of-Service indicator shall be provided on the interior and exterior at each doorway. The indicator shall be illuminated any time a door is removed from service by activation of the door cutout switch.

The door out-of-service indicator shall be an LED back-lighted sign, showing “Use Other Door” legend only when lighted, and shall be located adjacent to the passenger door switches. The exterior door out-of-service sign shall be readable in direct sunlight. Alternative indicators may be proposed for DART approval.

6.10 CDRL
The following design submittals are required:

6-1 Door Platform Interface Design Package (Section 6.1)
Drawings showing the horizontal gap and position of the open doors for nominal, maximum tolerances toward platform, and maximum tolerances away from platform

Drawings showing the vertical height, including wheel wear and all tolerances, of the door threshold at load weights of AW0, 1/2 of AW2, and AW3.

Clearance details for the dynamic envelope of the vehicle with the worst case tolerances toward the platform while in motion.

6-2 Door System Design Package (Section 6.2)
Details of the door panels including sections, weather sealing, and sensitive edge installation
Details of the door operator assembly drawings including both mechanical and electrical
Details of locks, manual release, and securement of a cut-out door panel
Parts and materials used in the doors and door operator
Required adjustments during installation and maintenance

6-3 DELETED

6-4 Door Controller System Design Package (Section 6.4)
System functional description
Hardware design description
Software design description

6-5 Door system switch and pushbutton samples (Section 6.6.4)

6-6 Passenger pushbutton and tape switch location and graphics (Section 6.6.4)
Door Warning Audible and Visual Indications (Section 6.10.2)

END OF SECTION
# SECTION 7

## HEATING, VENTILATING AND AIR CONDITIONING

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SECTION 7
HEATING, VENTILATING AND AIR CONDITIONING

7.1 General
The streetcar shall be provided with an air comfort system to automatically maintain the temperature and relative humidity conditions defined in this Section. It shall be of robust, heavy duty construction and proven in rail transit applications. All system components shall be service proven and supported by adequate design and test data adequate to demonstrate compliance with the Section. (CDRL 7-1)

The power source for the air comfort systems shall be three phase ac obtained from the auxiliary power supply described in Section 9.3. All components in the air comfort system shall be service proven in combinations and systems of comparable characteristics.

Within 180 days of NTP the Contractor shall prepare an HVAC system design report for DART’s review and approval that includes all of the design submittals required by Section 19.6.4 (Reference CDRL 19-15). The design report shall include the interface to the Monitoring and Diagnostic system described in Section 9.8. When data is requested in this Section for design review it shall be included in this report unless otherwise specified. (CDRL 7-2)

7.2 Ventilation
The air comfort system shall deliver fresh air to the vehicle in the amount of not less than 7.4 ft³/min (3.5 liters/sec) per passenger at AW2 load. Fresh air intakes shall be at roof level.

Ventilation of each carbody section of the vehicle shall be accomplished by the blower fans of the evaporator unit supplied as part of the air conditioning system. Air distribution shall be by ducts and diffusers. A positive static pressure of not less than 0.1 inch of water (25 Pa) and not greater than 0.4 inch of water (100 Pa) shall be maintained within a closed stopped or moving vehicle.

Full ventilation shall be continuously available in the event of refrigeration failure or load shedding from the ESS (Section 9.5).

7.2.1 Air Distributions Ducts and Diffusers
An air distribution duct arrangement with ceiling mounted diffusers shall be provided. The ducts shall distribute conditioned air to all sections of the passenger compartment through diffusers arranged in a minimum of two continuous rows, one on each side of the car interior. The diffusers shall be adjustable and permit adjustment of the air flow balance to eliminate drafts and temperature differences throughout the interior of the vehicle.

The main air distribution ducts shall be located in the car ceiling and shall be suitably insulated to minimize noise, heat transfer through the roof by direct conduction, and the formation of condensation. No ducting shall be visible to passengers. The ducting and insulation shall be non-flammable.

7.2.2 Air Filters
Air filters shall be provided for the return and fresh air, or mixed and fresh air, to remove airborne dirt, lint, and other fibrous material. If replaceable cardboard frame filters are used, they shall be of a readily available commercial size. Filter frames shall accommodate both
disposable cardboard frame filters and metal frame washable or replaceable filters. Filter arrangement shall be designed for easy maintenance access. Filter manufacturer’s recommended face velocity shall not be exceeded. (CDRL 7-3)

7.3 Heating Requirements

The vehicles shall be electrically heated by a thermostatically controlled system using overhead heat and floor heat. The system shall have sufficient capacity to maintain interior temperature between 65°F (18°C) and 72°F (22°C) with an ambient temperature 22°F (-6°C). Vehicle temperatures during heating shall be maintained without reliance on passenger heat contribution and solar loading as heat sources. The temperature of any heating equipment surface exposed to passengers shall be limited to 125°F (52°C).

7.3.1 Overhead Heat

Overhead heat capacity shall be sufficient to bring outside fresh air to car interior temperature without sensible cool air drafts. The heating elements shall be incorporated into each packaged air conditioning unit. The overhead heat and controls shall modulate the heat to match the fresh air temperature for all heating conditions. The overhead heating elements shall also be used to provide reheat for dehumidification and cooling offset at conditions lower than design cooling conditions.

The control circuitry must have means to both regulate the required heat to the interior space and to prevent damage from excessive heat build up in the element plenum, such as may occur with loss of air flow. As a minimum, the following protections shall be employed:

- An approved air flow switch shall be installed in the evaporator-heater discharge dust to prevent damage from excessive heat build-up in the element plenum, such as may occur with loss of air flow. A blower current sensor may also be used for this purpose.
- An automatic high limit temperature sensor shall be installed adjacent to each overhead heater unit to detect the presence of excessive temperature due to loss of air flow and/or failure of the air flow switch.
- A back-up protection device in the form of a fusible link, or shunt trip circuit opening the circuit breaker, shall be provided in the line to the overhead heat coils to remove power in the event of excessive current draw or failure of other protection devices. If fusible link is used, means to suppress the arc at rupture shall be provided as approved.

The ac power supply shall be used for overhead heat. The loads shall be balanced between the three phases of the ac source.

7.3.2 Floor Heat

Floor heating shall be provided with sufficient capacity to compensate for all carbody heat loss through conduction and radiation without consideration of any internal car heat sources. The controls shall modulate the floor heat to avoid temperature fluctuations in the passenger area. (CDRL 7-4)

Floor heat shall be provided by baseboard convection units.

Floor heat shall be provided by the three phase ac supply with phase to neutral voltage limited to less than 300 volts and balanced between the three phases. High voltage, e.g. 750 Vdc primary voltage, shall not be permitted in the passenger compartment.
7.3.3  Cab Heat and Side Window Defroster

The operator's cab shall be provided with one or two forced-air cab heaters for heating the cab and defrosting the side windows. They shall have a capacity adequate to maintain a temperature of not less than 70°F (21°C) in the full-width cab compartment with 22°F (-6°C) exterior ambient temperature, the overhead air diffuser shut-off, and the side windows closed, but in no case shall their total capacity be less than 2 kW per cab. The heaters shall be distributed in the cab, shall be designed such that heat can be directed at the side windows, and shall also supply heat at the operator's feet.

The heater elements and blower motors shall operate from the ac power supply.

The heater housings shall be constructed of approved heat-resistant, nonflammable material and shall fully enclose the heater elements. Surface temperatures of the enclosures exposed to operating personnel shall not exceed 125°F (52°C).

An approved automatic high limit thermostat shall be provided in the heater housing which shall remove power in the event excessive temperature is developed. The heater assembly and case shall be permanently grounded.

An adjustable heat capacity and heater fan speed control shall be provided in the operator's cab for control of the cab heaters. The controls shall be active only in an active cab. In non-active cabs, the layover conditions shall be maintained, regardless of the cab heater switch position.

Heated/cooled ventilation air shall also be supplied to the cab under the control of the vehicle comfort control system.

7.3.4  Windshield Defrosting and Defogging

The car shall be equipped with electrical defrosting circuits embedded in the cab windshield. In the event of electrical system failure, the operator’s cab heating system shall also provide for windshield defrosting and defogging. The system shall have sufficient capacity to defog the windshield and cab side windows with a 22°F (-6°C) ambient temperature and a 68°F (20°C) interior dew point, such that sufficient moisture has condensed to just begin to run down the glass, in a period not to exceed 20 minutes. (CDRL 7-5)

7.3.5  Layover Heat Control

The streetcars shall be equipped with a thermostatically controlled layover heating system. The layover heat shall maintain average car temperature at 40°F ±5°F (7.2°C ±2.8°C) using the floor heaters only. The layover heat shall be energized at 35°F (1.7°C) and de-energized at 45°F (7.2°C).

Location of the layover thermostat, if a separate thermostat is used, shall be subject to DART’s review and approval. (CDRL 7-6)

7.4  Air Conditioning

Air conditioning shall be provided by unitized roof-top cooling units utilizing a vapor compression direct expansion refrigeration cycle proven in transit service. The units shall not require the opening of any refrigerant piping for installation or removal of the unit from the vehicle roof.

The units shall use hydrofluorocarbon (HFC) R-134a refrigerant or other approved, environmentally-friendly refrigerant conforming to USDOT 40 CFR 82 (Protection of
Stratospheric Zone). The unit design shall comply with current environmental regulations governing the refrigerant use, handling, and recovery.

7.4.1 Design Criteria

The vehicle shall be cooled and dehumidified by equipment of adequate capacity to provide the required interior temperatures under the following summer design conditions:

Design Ambient Temperatures: 100°F (38°C) DB
75°F (24°C) WB

Passenger Load: 450 Btu/hr per Passenger at 55% Sensible Heat Ratio.

Solar Load: Follow ASHRAE Recommendations

Heating Load: Total wattage of interior lights and vehicle equipment

During vehicle cooling, the interior temperature shall be maintained within the range of 72°F (22°C) to 76°F (24.5°C) and the relative humidity shall be below 60% with the design and less than design load conditions. (CDRL 7-2) For ambient temperatures above 100°F (38°C), the interior temperature may rise above the specified range, but shall maintain at least 24°F (13.3°C) below the ambient temperature. Car temperatures during cooling shall be maintained with an AW2 passenger load and maximum solar load based on worst case sun position and vehicle orientation.

The system shall be able to operate at full capacity at the ambient temperature up to 115°F DB (46°C DB), and at reduced capacity, if necessary, up to 125°F DB (52°C DB).

7.4.2 General Design and Construction

The HVAC units shall have stainless steel or corrosion-resistant aluminum frames and drip pans. Non-structural enclosures may be stainless steel, aluminum, or fiberglass. Any fiberglass used in weather exposed conditions shall have appropriate UV inhibitors for a thirty year life against break down in ambient sunlight.

Enclosures shall be designed with hinged covers that allow open access to all serviceable parts. Covers shall be capable of holding the load of a 300 lb (136 kg) maintainer carrying a 25 lb (12 kg) tool box without permanent deformation.

Refrigerant liquid lines shall have a serviceable or replaceable filter-drier and a sight glass with moisture indicator.

The refrigeration system shall be protected against explosion by a pressure relief device as recommended by UL Standard 1995, Section 33 and ANSI/ASHRAE Standard 15. In addition, the system should meet the applicable requirements of UL 207: Refrigerant Containing Components and Accessories.

Refrigerant compressors shall be scroll type, powered by the three phase alternating current, and shall be fully hermetic, service proven in rail transit service.

To reduce the possibility of refrigerant migration during off cycles, a check valve on the compressor discharge line and an automatic pump down circuit is required. Other approved and service proven in rail transit equipment methods to control the liquid refrigerant slugging of the compressor will be considered in lieu of a pump-down.
A compressor crankcase heater shall be employed if it is required by the compressor manufacturer for the described operating conditions.

Equipment shall have a means of capacity control, including multi-circuited (two circuits minimum) evaporators, a thermo-expansion valve for each evaporator circuit, and compressor(s) capacity control. Equipment using capillary tubes instead of expansion valves shall not be accepted.

Cooling coils shall be of corrosion resistant material suitable for transit vehicle service conditions. Copper tubes and fins with a minimum thickness of 0.008 inches (0.2 mm) and a minimum spacing of 10 fins per inch (25 mm) are required to facilitate coils cleaning. Fins shall be capable of withstanding 1.75 bar (175 kPa) water or air pressure from a cleaning wand.

7.5 Controls

Car interior temperatures shall be uniform. During steady-state operation the interior temperatures shall not vary more than 5.5°F (3°C) between points in the same horizontal plane of the vehicle and between any point 4 inches (100 mm) above the floor to 67 inches (1700 mm) above the floor in a vertical plane. Air comfort controls shall automatically activate appropriate operation modes to achieve the specified temperature and humidity inside the vehicle depending on ambient and vehicle interior conditions. The controls and systems shall be designed for energy-efficient and reliable operation, and easy maintenance.

Air comfort controls shall be activated automatically when an operators’ console is activated. De-activation shall include a time delay to accommodate changing ends or an in-service layover.

The controls shall provide status and fault indication displays, located for convenient observation by maintenance personnel. Operator warning indications shall also be made to the operator if immediate service is needed.

7.5.1 Control Logic

The HVAC system control logic units shall be microprocessor-based with associated peripherals and I/O, as required, to meet all of the specified functions and performance criteria. The control units shall provide self-diagnostic routines, fault monitoring of internal and external devices, and user programmable operating characteristics. Control programs shall be stored in field-programmable, non-volatile memory. The HVAC controls shall comply with the design requirements of Sections 2, 9 and 16 and documentation requirements of Section 17.27.3. The Contractor shall submit the HVAC controller design report with 180 days after NTP. (CDRL 7-7)

Independent control logic units and logic power supplies shall be provided for each unitized HVAC unit such that the streetcar’s HVAC controls can function if any one HVAC unit has failed. The control logic units shall monitor and control air conditioning, overhead heating, and floor heating to maintain specified temperature and air flow in the interior of the vehicle. Cab heaters and windshield heaters shall not be controlled by the control logic. Layover heat may be controlled by the HVAC control logic with the review and approval of DART.

Electronic control equipment shall be segregated from the power equipment. Control circuitry and control voltage sources shall be isolated from power circuitry and high voltage sources using opto-couplers or transformers.
The control unit shall provide continuous monitoring of critical parameters, including temperatures, refrigerant pressures, and air flow. The control unit and all related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions such that equipment damage is prevented or minimized.

7.5.2 Monitoring and Diagnostics

The status of the HVAC system shall be available via a diagnostic system integral to each HVAC control logic unit and via the streetcar’s MDS system described in Section 9.8.

The diagnostics system shall include a data/fault logger to monitor all critical internal functions, external inputs, and the operation of all external HVAC components controlled by the control logic such as floor heat. System faults and associated system parameters shall be time stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

Portable Test Units (PTU) for the HVAC system shall be provided as specified in Section 18.2.1. The PTUs will be used by maintenance personnel to isolate refrigeration circuit problems and temperature control problems, load new software (password protected), and monitor the status of the system as it functions. The PTU connectors shall be accessible from the return air plenum via plug connectors mounted on the HVAC control unit and at a convenient location within the passenger compartment for system monitoring with the return air grilles closed and the vehicle in motion. The PTUs shall be able to override the automatic heating and cooling control system such that any possible operational mode can be selected regardless of the actual ambient conditions at the time of the test, unless doing so will result in equipment damage, in which case the PTU shall display a message that the requested mode cannot be implemented and stating the reason. The PTU shall also provide the ability to individually control each powered device in the system; however, doing so shall not allow safety functions to be overridden. The PTU shall indicate and verify the function status of all HVAC control devices.

The diagnostics and adjustment capabilities of the HVAC system shall be reviewed and approved by DART. (Include in CDRL 7-7)

7.6 Air Conditioning System Test and Charging

Each self contained air conditioning unit shall be charged and tested at the factory, prior to shipping to the car builder. In-factory testing shall include functional testing of control systems and unit output.

System pressure testing, evacuation and charging shall be performed to the manufacturer’s procedures and approved by DART. (CDRL 7-8)

7.7 CDRL

The following submittals are required:

7-1 Vehicle HVAC unit arrangement showing the number, location, and heating/cooling capacity of each unit on the vehicle (Section 7.1)

7-2 HVAC unit system design report including: (Sections 7.1)

Air cooling and heating loads analysis;
o Fan curves – fan differential pressure versus SCFM showing the RPM and BHP. Evaporator blower type, dimensions, model number shall be provided.

o Evaporator coil design criteria – entering and leaving wet and dry bulb conditions at the design saturated temperature. The evaporator coil face velocity. Wet and dry coil pressure drops at the design air flow rate. The dividing of the coil for modulated cooling, and the number of rows and fins spacing shall be presented.

o Compressor manufacturer’s capacity curves and make/model number of the compressor.

o Condenser coil design – air-to-refrigerant temperature differential and degrees of subcooling and pressure drop at the design conditions shall be specified.

o Motors – current draw, horsepower, and RPM versus percent load shall be provided for the evaporator blower, condenser and compressor motors, and make/model number of the evaporator blower and condenser motors.

o Pressures/Temperatures – design suction and discharge temperatures and pressures, and the high pressure and low pressure cutout and modulation pressure settings.

Refrigerant flow diagram including all elements, controls, and connections, showing piping sizes.

Electrical schematics and wiring diagrams showing resistance values of each resistor, contactor and solenoid coil, and wire sizes. Schematics and parts lists for all printed circuit boards shall be included.

Vibration mounts design selection.

Balancing criteria for fan wheels and fan/motor assemblies.

Heaters – design data, rating, and electrical data.

7-3 Manufacturer’s data for air filter: including brand, type, size and quantity. (Section 7.2.2)

7-4 Design data, rating, and electrical control data for floor heaters. Include arrangement drawings showing number and locations in carbody interior. (Section 7.3.2)

7-5 Design data, rating, and electrical control data for auxiliary cab heating and air defrosting system. (Section 7.3.3)

7-6 Layover heat control and thermostat locations (Section 7.3.4)

7-7 HVAC controller design report (Section 7.5.1)

System functional description

Hardware design description

Software design description
HVAC unit manufacturer’s leak test, evacuation, charging and testing procedures (Section 7.6)

END OF SECTION
SECTION 8
LIGHTING

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SECTION 8
LIGHTING

8.1 General Description

Requirements for normal interior lighting, emergency interior lighting, and vehicle exterior lighting are provided as a basis for design. The vehicle lighting systems shall be designed to withstand the vibration and shock loads, seasonal design conditions, applicable voltage ranges, and environmental conditions typical in Dallas as described in Section 2.3.5.

All lighting fixtures shall be designed to provide ease of installation, cleaning, lens, lamp and ballast change-out, adjustment, and housing removal. Lamp access shall be by gasketed enclosure covers secured by captive, stainless steel fasteners. Where possible, covers shall be retained by hinges. Hinges on the vehicle exterior shall be made from stainless steel.

Fixtures installed on the vehicle exterior and in the interior within 24 inches (610 mm) of a doorway shall be watertight except for interior ceiling lights.

Power wiring to the lamp fixtures shall be insulated from carbody ground. Lighting systems shall not use the fixture housings or sockets as a ground return. All fixtures and their exposed metallic surfaces shall be grounded to the vehicle structure.

The Contractor shall submit a Lighting System Design Package (CDRL 8-1), for DART’s review and approval within 180 days after NTP.

8.2 Interior Lighting

8.2.1 Overhead Lights

The average intensity of the illumination within the car, at an elevation of 33 to 66 inches (840 to 1670 mm) above the floor, shall be at least 30 lumens per square foot (320 lux), at the nominal rated voltage.

The average light intensity at the floor in the passenger aisles and articulation section shall not be less than 20 lumens per square foot (215 lux).

The average light intensity at the car entrances and exits within 20 inches (500 mm) of the doors shall not be less than 20 lumens per square foot (215 lux) at the floor.

8.2.1.1 Passenger Compartment Lighting Fixtures

The passenger section shall be illuminated by two continuous rows of LED lighting fixtures mounted in the ceiling above the seats. Overhead lighting shall be of a harmonious, attractive design that presents a clean, neat surface with a minimum of visible fasteners and a maximum of surface continuity. Overhead fixtures shall be finished to match the interior color scheme.

The light fixtures shall be dust and moisture proof and may be combined with the air diffusers. All portions of the fixtures (except lens) shall be anodized aluminum. All visible portions shall have a brush finish. The lens material shall effectively hide the individual LEDs and provide for an even distribution of light along the fixture. Each fixture shall be provided with a driver module.
The white balance of the LEDs shall be adjusted to mimic the warm white color of fluorescent tube lighting. Lamps shall have an average rated life in excess of 60,000 hours. The lights shall start reliably down to 0°F (-18°C) interior carbody temperature.

Each fixture shall include a lens contained in a door with an integral, concealed hinge. The lens shall be manufactured from transparent polycarbonate, with a smooth exposed surface and patterned back surface designed to achieve specified illumination levels and even distribution of light. The lens mounting shall preclude the lens from being pushed into the fixture housing by passengers and shall prevent the lens from vibrating under all operating conditions. The lens door shall be secured in the closed position with tamper-proof fasteners. The fasteners shall be stainless steel, captive, and of the quarter-turn type. Lens material shall meet the flammability and smoke emission guidelines of Section 17.14.

An interior lighting design report on the passenger compartment lighting system shall be provided for DART’s review and approval. The report shall include a complete description and manufacturer of the LED lighting strips, driver modules, and vehicle level control package. Prior experience and references for the subcontractor shall also be included. (include in CDRL 8-1)

8.2.1.2 LED Fixture Driver Modules

The LED fixtures shall be powered from the low voltage dc power system and operate over the voltage range specified in Section 2.4.2. Safety grounding of the driver and fixture shall be isolated from the power return. Reversing polarity on the driver module shall not result in damage to the module.

The driver modules shall have an over-temperature protection feature which automatically resets when the temperature drops to acceptable levels. The modules shall not be damaged by the intermittent or continuous application of reverse polarity direct current power up to 34 Vdc.

Each driver module shall be able to individually adjust the intensity of the LEDs with a pulse width modulated output.

The driver module shall be mounted on the outside of the light fixture housing and shall be accessible from the inside of the fixture through a hinged plate. The hinged plate shall be retained by captive mounting screws. The driver modules shall be configured mechanically and electrically so that they are easy to replace.

8.2.1.3 Interior Lighting Control

The main interior lighting shall be turned on whenever the car auxiliaries are turned on by the Master Controller Key Switch or the Auxiliaries Switch. (Refer to Section 5.3.7). The interior lighting system shall be separated into three separate circuits, with alternating sets of lights powered by the separate circuits. The emergency lights shall occupy one circuit while the remaining interior lights shall be divided into two other circuits. Each circuit shall be fed through a separate circuit breaker. The lighting circuits shall remain on when primary power is momentarily lost, such as when the car is going through a non-bridging isolator. If power is lost for an extended period only the emergency lights shall remain on.

The lighting control shall be provided with the capability to individually adjust the intensity of each fixture to minimize glare. Additionally, a photo sensor shall be used to adjust the overall lighting level relative to ambient light for passenger comfort.
8.2.2 Doorway Floor Lights

LED cluster lights shall be provided at each doorway for threshold and platform illumination. The fixtures shall be located so that they will provide not less than 5 lumens per square foot (54 lux) of illumination measured on the surface of the platform 3 ft (900 mm) away from the vehicle side in the horizontal direction.

The light shall be illuminated when the passenger door starts to open and shall be extinguished when the door is closed and locked.

The doorway floor lights are not required if the passenger overhead lights provide the specified illumination levels.

8.2.3 Stairway Floor Lights

LED cluster lights shall be provided at each stairway, if provided in the interior, for step illumination. The fixtures shall be located so that they will provide not less than 5 lumens per square foot (54 lux) of illumination measured on the surface of the steps.

The lights shall be illuminated when the interior lights are on and shall be powered by the emergency light circuit.

8.2.4 Operator's Cab Light

Each cab shall be provided with an LED light fixture, powered from the low voltage power supply (LVPS), suitably placed in the ceiling to illuminate the operator's console. The light beam shall be controlled to avoid glare on the windshield. The average illumination intensity measured on the operator's controls shall be at least 30 lumens per square foot (320 lux).

The cab light shall be controlled from a switch on the operator's console that shall function only when the local operator's console is powered. At all other times, the light shall be extinguished.

8.2.5 Console Light

Each cab console shall be illuminated with small LED clusters to enable the operator to see the console labels, pushbuttons and switches under varying lighting conditions. The console light shall be mounted at the top edge of the console and shielded from the operator's eyes. When illuminated, the console light shall not cause glare on the windshield.

The console light shall be energized automatically when the operator's console is powered. A dimmer control shall be provided for variable adjustment of the brightness. At all other times, the light shall be extinguished.

8.2.6 Door Close Warning Light

Amber LED cluster lights shall be provided on each side of each doorway to indicate the door will be closing in accordance with Section 6.9.2.

8.3 Exterior Lighting

Exterior lighting assemblies shall be set in waterproof enclosures. All bezels and trim shall be made of either aluminum or stainless steel, have captive stainless steel fasteners, and be consistent with good mechanical mounting principles. All exterior lights shall be LED cluster except for headlights and shall be powered from the LVPS with each LED lamp fixture having its own internal current regulator.
Headlights, taillights, stoplights, turn signals, and clearance and marker lights shall conform to Federal Regulation 49 CFR 571.108 for vehicles of 80 inches (2030 mm) or more overall width.

8.3.1 Headlights

Two headlights, meeting the requirements of SAE J2560, shall be provided on each end of the vehicle. The lights shall be powered from the LVPS with voltage dropping resistors for each filament or a regulated power supply to obtain proper lamp voltage.

The headlights to be illuminated shall be determined by the forward and reverse directional trainlines so that headlights function on the leading end of the streetcar only, regardless of which cab is powered.

A high beam indicator light shall be provided on the console and it shall be illuminated any time the console is powered and the adjacent headlights are switched to energize the high beams.

The headlights shall be easily adjustable to permit proper aiming of the beams.

8.3.2 Auxiliary Headlights

Auxiliary headlights shall be provided to permit operation of the streetcars on DART trackage. The auxiliary headlights shall be activated from the console mounted pushbutton described in Section 5.1.2.1.

Two 150 watt auxiliary headlights shall be provided in the upper corners of the vehicle near the marker lights in addition to the headlights. The auxiliary headlights shall be a 32 Vdc, PAR 46 type lamps with a light output of 100,000 candelas, minimum. They shall be aimed to enable an Operator to have the visibility required to view a 5-foot (1,524 mm) person standing erect at no less than 800 feet (243.8 m) in front of the train.

Auxiliary headlights shall be controlled from an illuminated pushbutton on the Operator’s console. The pushbutton shall be active only in the active cab and shall illuminate in the direction of operation as determined by the reverser switch. The pushbutton shall be illuminated when the auxiliary headlights are powered.

Auxiliary headlights shall be protected by a dedicated circuit breaker.

8.3.3 Silent Alarm Lights

Each end of the vehicle shall be provided with a blue light, visible for 360° in the horizontal direction, mounted above the left hand corner of the roof to indicate activation of either cab’s silent alarm switch within that vehicle. Each light, when illuminated, shall be plainly visible from distance of not less than 500 feet (152.4 m). The lights shall be powered directly from the standby battery and be available at all times regardless of whether the auxiliaries being energized. The silent alarm light shall be activated from the console mounted pushbutton described in Section 5.1.2.1.

8.3.4 Tail Lights and Stop Lights

Two red LED cluster taillights meeting the requirements of SAE J2040 shall be provided at each end of each vehicle. They shall be illuminated as follows:

- At both ends of a vehicle whenever the auxiliaries are ON and no direction is selected.
At the trailing end of a vehicle whenever a direction has been selected, by placing one reverser switch in FORWARD or REVERSE, as determined by the forward and reverse directional control lines, which shall also cause the taillights on the leading end of the streetcar to extinguish.

The taillights shall not be illuminated at any other time. When illuminated, the taillights shall be plainly visible from a distance of not less than 500 ft (152 m).

Two red LED cluster stoplights meeting the requirements of SAE J2261 shall also be provided per end. The stoplights shall be illuminated on the trailing end of a vehicle, as determined by the forward and reverse directional control lines, when the vehicle is powered with the reverser switch in FORWARD or REVERSE, and either the dynamic, friction, track, or parking brakes are applied.

8.3.5 Marker Lights

One amber and one red LED cluster marker light meeting the requirements of SAE J2042 shall be provided near each end corner of the vehicle, for a total of 8 per vehicle. When illuminated, each marker light shall be plainly visible from a distance of not less than 500 ft (152 m). They shall be illuminated as follows:

- At both ends of a vehicle whenever the auxiliaries are ON and no direction is selected.
- Amber on the front end and red on the rear of the streetcar whenever a direction has been selected, by placing one reverser switch in FORWARD or REVERSE, as determined by the forward and reverse directional control lines.

At all other times the marker lights shall be extinguished.

8.3.6 Turning Direction Lights

Flashing LED cluster turn signals shall be provided on the front, sides, and rear of a vehicle. The front and rear turn signals shall meet the requirements of SAE J2261, and the side turn signals shall meet the requirements of SAE J2039. When illuminated, each turn signal light shall be plainly visible from a distance of not less than 500 ft (152 m).

The turn signals shall be controlled from a three-position switch located on the operators' console. The center position shall be the neutral and it shall function as OFF. The other positions shall be LEFT and RIGHT, respectively.

8.4 Emergency Lighting

The following lights shall be powered from the low voltage system and shall remain on or available after the loss of high voltage power to the converter:

- All overhead lights in the doorways
- All of the doorway floor lights
- All of the stairway lights
- Operating cab console and lights
- Headlights
- All of the tail lights, stop lights, and turning lights
- All exterior marker and indicator lights
8.5 CDRL

The following design submittals are required:

8-1 Lighting system design package (Section 8.1)
   Details of all light fixtures, assemblies and lamps
   Analysis including illuminating characteristics, beam spread, and intensity for all lamps showing compliance with this Section and cited SAE standards
   Parts list for all lamps and assemblies including manufacturer's part number

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SECTION 9
AUXILIARY ELECTRICAL EQUIPMENT

9.1 General

This section specifies general electrical equipment not specifically related to propulsion, HVAC, or other electrical systems. Included are the overhead power collection system, power distribution, grounding, ac and dc supplies, energy storage system (ESS), monitoring and diagnostics, and similar equipment and systems.

9.1.1 General Configuration and Isolation

The term "auxiliary" used in this section refers to the vehicle-sourced electrical power distribution system and supplies. The term "primary" used in this section refers to high voltage dc circuits.

All electric equipment, wiring, connections, and other devices shall be selected to function properly and safely under the worst case combination of ambient conditions, equipment operating tolerances, and voltage drop on wiring and connections.

The vehicle electrical circuits shall be physically and functionally segregated according to voltage. As a minimum, line voltage, ac, low voltage dc, signal, and communication circuits shall be segregated from each other. Where circuits of different voltages must function together, component location and physical barriers shall prevent interaction.

No wiring with a potential of greater than 300 volts referenced to carbody structure shall be permitted within the passenger area, except as specified elsewhere or as specifically authorized by the City. If authorized, such wiring shall be run in grounded steel conduit.

9.1.2 Safety Grounding

All equipment on the vehicle, including resiliently mounted equipment, enclosures, the truck frame, and truck-mounted equipment, shall be safety grounded to the vehicle structure. The vehicle structure shall be safety grounded to the axles. Specific requirements appear later in this Section.

Within 180 days after NTP the Contractor shall submit a complete grounding scheme including safety grounding and power circuit returns for the City's review and approval. (CDRL 9-1)

9.1.3 Circuit Protection

All low voltage dc circuits and ac circuits shall be individually protected by circuit breakers except where otherwise specified. Circuit breaker terminals shall not be used as junction points. All circuit breakers shall be sized to protect both the equipment and the minimum wire size used for power distribution within the protected circuit. Fuses are not permitted in low voltage dc and ac applications except where specified or approved. Ac and low voltage dc circuit breakers shall be mounted in panels in the operator's cab.

High voltage dc circuits shall be protected at the pantograph interface level by high speed dc rated circuit breakers or fuses, as required elsewhere in this Specification. Primary distribution circuits in the vehicle shall be individually protected by high voltage dc rated fuses mounted in insulated self-extracting fuse holders.
Local circuit protection shall be coordinated with main source protection such that faults or overloads downstream of the local protection shall trip the local protection, and not trip the main source protection. Local protection trip settings shall be lower than the main source power or current limit settings.

All equipment operated from the Overhead Contact System (OCS) shall be rated for continuous operation at the maximum OCS voltage, as described in Section 2.4.1 and 2.4.4.

9.1.4 Return Circuits

The vehicle structure shall not be used as a normal circuit return path for any electrical equipment.

The primary return circuits shall be grounded to the axles per the requirements of this Section.

The low voltage dc return circuits shall not be grounded to the vehicle structure at any location, except at a single point common to the battery and low voltage power supply (LVPS). This ground connection may be direct, resistive or resistive/capacitive, depending on system design.

The ac neutral shall be single point grounded.

Each system or circuit fed from a circuit breaker or fuse shall have its own return wiring. Each circuit return wire shall be connected, via its own separate terminal, to a return bus located in the same electric locker that contains the circuit breaker that supplies the circuit.

9.2 Primary Power System

9.2.1 Pantograph

Vehicle primary power shall be collected from the OCS by a roof-mounted upward pressure sliding pantograph. The operating range of the pantograph shall comply with Section 2.5.4. The width of the collector, including horns, shall not exceed 6.5 ft (1980 mm). The Contractor shall submit a Pantograph Design Report (CDRL 9-2) within 120 days after NTP for the City's review and approval.

The pantograph shall be a service-proven, single-arm design, with a spring supported double carbon contact assembly capable of stable bi-directional operation at all specified vehicle speeds and external system characteristics.

The contact assembly shall contain replaceable curved carbon inserts of one-piece design. The carbon surfaces in contact with the OCS shall have a lateral radius of 20 to 33 ft (6 to 10 m), or other approved value. The contact assembly, and the carbon inserts, shall be individually replaceable with common hand tools.

Contact force on the contact wire shall be selected for optimum tracking and minimum wear, but shall be no greater than 25 lbf (110 N) at the maximum adjustment range. Contact force shall be adjustable 5 lbf (25 N) from nominal and shall not vary by more than 5 lbf (25 N) over the combined full ranges of operating height, vehicle speed, and direction.

A mechanism shall be provided to automatically restrain the pantograph in the fully lowered position. The mechanism shall function at all times regardless of failures in power, control, or other system elements. The mechanism shall be released automatically when the pantograph is commanded to be raised.

The pantograph shall be spring raised when the restraining mechanisms are released. The raising speed shall be damped or otherwise controlled to prevent carbon strip damage upon
striking the contact wire. This speed control shall be active at all times except during normal wire tracking.

The pantograph raising and lowering circuit shall not be operable from either cab when the master controller is in any propulsion mode. It shall only be operable while the train is at rest or moving in a coast or brake mode. Lowering of the pantograph shall not affect a requested brake rate and shall result in a coast mode if the vehicle is in a coast or power mode. Electric raising and lowering mechanisms shall operate throughout the voltage range specified for all low voltage equipment.

The pantograph control shall be interlocked with the ESS system to prevent initiation of ESS operation without confirmation the pantograph is latched in the down position and to prevent the pantograph from being released when operating from the ESS. Pantograph position shall be available to the Operator via the vehicle’s MDS system described in Section 9.8.

Provision shall be made for manually lowering and raising the pantograph in the event of a loss of power or control. These manual mechanisms shall be operable from, and located within, the vehicle, but shall be secured in such a manner as to be accessible only to the operator.

The Contractor shall prepare a design report on the pantograph, including data to support the ratings of the components, data sheets on each component, parts lists, electrical drawings and assembly drawings for the City’s review and approval. The Contractor shall include the pantograph dynamic envelope as a dedicated section in the design report, and shall show that the pantograph does not lose contact with the wire under normal and abnormal operating conditions identified in this Specification. (CDRL 9-2)

9.2.2 Primary Circuit Protection

Adequately rated overvoltage protection, ground fault protection, current sensing, fault clearing devices, and any other circuit protection deemed necessary by the Contractor or this Specification shall be provided to protect auxiliary and propulsion system components from fault or overcurrent damage.

Auxiliary circuits are defined as all line voltage operated systems other than the propulsion circuits. Auxiliary circuit protection may be provided via a high speed fuse with a voltage rating of not less than 1000 Vdc.

Propulsion and ESS primary power circuit protection shall be provided by an electrically resettable High Speed Circuit Breaker(s) (HSCB). Resetting of the HSCB shall be possible from inside the vehicle.

The Contractor shall prepare a design report on the primary power circuit protection for the City’s review and approval. The report shall include all primary voltage fuses and HSCB(s) and associated components, with data to support the ratings of the components, data sheets on each component, parts lists, electrical and assembly schematics and drawings, and the integration of the ESS. (CDRL 9-3)

A dry-type lightning arrester shall be mounted on the roof, on or adjacent to the pantograph base. The arrester shall be rated by the manufacturer for outdoor dc operation. The arrester shall be rated to prevent any voltage transients and surges from damaging or degrading carborne equipment, including the arrester itself. The arrester rating selection design analysis shall be reviewed and approved by the City. (CDRL 9-4)
9.2.3 Shop Power Connection

A knife switch shall be provided to enable shop personnel to connect primary power to the vehicle without energizing the overhead contact wire, pantograph, or pantograph frame. The switch shall provide positive visual indication of switch position discernible from at least 10 ft (3.3 m) with direct line of sight.

Alternatives using a rotary switch with enclosed contacts may be proposed for the City's review and approval. Alternatives must provide a positive indication other than handle position of contact opening for isolation of the pantograph and other high voltage connections that may be exposed to maintenance personnel.

The knife switch shall allow for energization of the auxiliary power devices operating from the primary power supply without enabling the propulsion system.

Primary power shall be supplied from a 750 Vdc receptacle in the knife switch box fed by a plug-in cable from the maintenance shop. The power connector on the vehicle shall use a male power prong that mates with an insulator enclosed, recessed, female connector on the shop cable. Two auxiliary contacts shall be provided on the shop cable and vehicle receptacle which break prior to the breaking of the main power contacts. The Contract shall provide a minimum of four shop cable connectors within 180 days of NTP for use in the completion of the Operations and Maintenance Facility.

The switch shall be mounted in a non-metallic enclosure easily reached from the side of the vehicle at roof level. The box cover shall close only with the blade in the normal position. The box or cover shall be gasketed and the cover shall be sufficiently robust to withstand rough handling without damage.

No metallic surfaces at ground potential shall exist within the box. The installed enclosure shall be watertight when subjected to a water test equal in severity to that for the carbody.

The Contractor shall prepare a design report on the knife switch or alternative arrangements, with data to support the ratings of the components, data sheets on each component, parts lists, electrical and assembly schematics and drawings. (CDRL 9-5)

9.2.4 Ground Brushes

Ground brushes and contact elements shall be provided for primary current return to the running rails by using the wheels and appropriate visible shunts around the wheel resilient elements. The arrangement shall prevent any current return through the journal bearings, gear units, or motor bearings.

Ground brushes shall be provided for safety grounding the carbody and truck equipment. Safety ground brushes shall be separate from those used to carry primary current.

Ground brushes shall be provided for each wheel or for each through (not stub) axle in a conventional truck. The ground brushes shall be rated to carry 2.0 times the circuit rms current, and 1.5 times the circuit peak current.

Ground brush life shall be no less than 310,000 miles (500,000 km) of streetcar operation.

The Contractor shall submit a design report including a description of the ground brushes, drawings for the hardware and a circuit diagram showing ground brush arrangements and ground connections. (CDRL 9-6)
9.2.5 Line Filters

Line filters may be individual elements of various systems that are fed by the primary power, or may be combined provided that system isolation switches or contactors are supplied to permit independent operation of each supplied system. Although these filters may be elements of individual systems, they are described here to eliminate duplicate specifications.

Line filters shall filter the voltage applied to the power components of the auxiliary electric, ESS, and propulsion systems and shall suppress high frequency voltage transients caused by insulated gate bipolar transistor (IGBT) switching operations. The resonant frequency of each filter shall be less than 60 Hz, and shall be inductive above 55 Hz. Capacitors shall have a rated life of at least 15 years.

Calculations supporting capacitor life expectancy shall be submitted for the City’s review and approval and shall include, as a minimum: manufacturer's data and application information, ripple currents, and ambient and operating temperatures. (CDRL 9-7)

Electrolytic capacitors shall be fused and shall have blown fuse indicators readily visible without necessitating the removal of components. Capacitors with rated lives less than twenty years shall be readily replaceable without soldering or disassembly of other components.

A bleeder resistor shall be permanently connected across the terminals of each capacitor in the capacitor bank. The resistance value shall be selected to reduce the voltage at the terminals of the capacitor bank to 50 V or less within 3 min after primary voltage is removed from the bank. A permanent sign shall be positioned adjacent to the capacitors to warn maintenance personnel of the presence of high voltage and the procedure to be used to discharge the capacitor bank before commencing work (for instance, lower the pantograph, wait 5 min, manually bleed, then short circuit the capacitor before commencing work). The sign shall be visible when the door to the enclosure which houses the capacitor bank assembly is open.

9.3 Ac Power Supply

Auxiliary electrical power conversion shall be accomplished by one or two independent dc-to-ac inverters, powered from the overhead catenary system and supplying power to the ac auxiliary loads. Each inverter shall supply the loads for either the complete car or in its respective car half (see Section 9.3.2, below). The output of the inverter(s) shall be electrically isolated from the primary power system. Refer to Section 2.4.3 for output voltage and frequency requirements.

The inverter(s) shall start automatically and provide full performance when the steady-state input voltage is as specified in Section 2.4.1. The inverters may shut down when the steady-state input voltage is not within the range specified in Section 2.4.1.

An isolation transformer shall be provided to supply 120 Vac single phase loads.

The inverters shall be sized for the worst case continuous operation of all loads, and the maximum peak individual load with all other steady-state loads applied.

The auxiliary inverter shall provide the output voltages as specified in Section 2.4.3, with the 3-phase output in compliance with the following requirements:

- Output frequency tolerance: +/- 2%
- Distortion under nominal load: < 10%
- Maximum dv/dt of the output voltage: < 10V/μsec
- Maximum allowable phase voltage unbalance: < 1%

The controls for the inverters shall prevent damage both to auxiliary equipment, and the inverter itself, resulting from:

- High and low frequency
- Over and under voltage
- Out of tolerance voltage-to-frequency ratio
- Frequent repetitive starts (manufacturer defined limits)
- Rapid variations and transients in line voltage or loads
- All primary power interruptions
- Ground faults
- Excessive harmonic distortion
- Phase loss

The control logic shall permit the equipment to automatically restart for shutdowns caused by self-correcting failure conditions. Major faults shall latch the equipment off until reset by maintenance personnel.

The Contractor shall prepare a design report within 180 days after NTP on the auxiliary power supply and associated loads to justify the selected configuration and to confirm compliance with the requirements of this Specification for the City’s review and approval. It shall include load analysis, description of how the equipment operates under extreme conditions and faults, ratings sheets, software descriptions, electrical schematics drawings, and assembly drawings. (CDRL 9.3-8)

9.3.1 Monitoring and Diagnostics

The status of the ac power supply shall be available via the diagnostic system integral to the ac power supply and via the streetcar’s MDS system described in Section 9.8.

The diagnostics system shall include a data/fault logger to monitor all critical internal functions and external inputs. Actual performance, such as voltage, frequency, and current imbalance, shall also be monitored. System faults and associated system parameters shall be time stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

9.3.2 Failure Management

Loss of a single ac inverter shall not result in loss of propulsion, braking, or other functions critical for vehicle operation.

For the case of a car equipped with two inverters, in the event of an inoperable ac inverter, provision shall be included to transfer ac power for the essential loads to the second inverter. As a minimum all safety and vehicle operation related functions must be kept operational, so that a vehicle with a failed ac inverter can be operated over the whole alignment on its own power from the remaining ac inverter to the circuits in the other body section for propulsion, ventilation, and other ac loads as may be required by the propulsion system.
Critical friction brake loads, where permitted to be powered by ac, shall also be transferred.

The ratings of each ac inverter shall include these redundancy transfer loads in addition to the loads of its respective body section.

For the case of a car equipped with one inverter the critical loads, including propulsion blowers and pumps shall be operated from the cars low voltage dc system. Critical blowers and pumps shall be provided with brushless dc motors.

The Contractor shall submit a fault management design report to the City’s for review. (Include in CDRL 9-8)

### 9.4 Low Voltage Dc Power System

A source of low dc power shall be provided for specified vehicle loads, and for Standby Battery charging. Refer to Section 2.4.2 for specific voltage range and design requirements.

The LVPS shall include circuitry to detect LVPS and Standby Battery charging failures. The circuit shall provide fault indications to the operator’s cab.

#### 9.4.1 Low Voltage Power Supply

The low voltage power supply (LVPS) shall be a regulated dc power supply powered either from the ac inverter or from a dc source which may be either the catenary supply or an intermediate voltage pre-regulating power supply. Designs which include the LVPS as part of the auxiliary inverter will be acceptable. If combined, operation or failure of the LVPS shall not affect operation of the ac inverter. The LVPS shall provide complete electrical isolation of the output from the primary power system.

The LVPS shall have sufficient capacity to charge the Standby Battery, if provided, while simultaneously providing constant voltage to all vehicle control circuits. The battery charging portion shall also include a temperature-compensated current limiting feature that ensures the battery manufacturer’s recommended charging current level is not exceeded.

The LVPS shall automatically start when primary power is applied. Battery power shall not be required as a prerequisite to starting, or for closing circuit breakers or contactors needed to permit LVPS operation.

The status of the low voltage power supply shall be available via the diagnostic system integral to the ac power supply and via the streetcar’s MDS system described in Section 9.8.

The diagnostics system shall include a data/fault logger to monitor all critical internal functions and external inputs. Actual performance, such as voltage, current, and battery charging, shall also be monitored. System faults and associated system parameters shall be time stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

The Contractor shall submit a LVPS and Standby Battery charger report within 180 days after NTP for the City’s review and approval. It shall include load analysis, description of how the equipment operates under extreme conditions and faults, ratings sheets, software descriptions, electrical schematics drawings, and assembly drawings. (CDRL 9-9)

#### 9.4.2 Standby Battery

The Standby Battery shall be a service proven railway or transit quality NiCad battery with a reserve electrolyte capacity appropriate for transit vehicle service. The battery compartment and case material shall provide for easy visual checking of the electrolyte level. The battery
compartment shall be external to any passenger space. The battery compartment arrangement shall accommodate batteries from at least two independent suppliers.

Alternatives to a standby battery using the ESS and capable of supplying the emergency power requirements of Section 9.4.4 while maintaining full propulsion performance with a non-functional LVPS may be proposed to the City for review and approval.

The battery shall be installed in a ventilated compartment and outside the passenger compartment. If mounted underfloor, the battery assembly shall be mounted in a stainless steel, ball-bearing supported roll-out tray with extension depth of the tray sufficient depth to permit the battery to be fully extended such that all cells may be inspected and filled. If mounted on the roof, the battery assembly shall be mounted in a stainless steel tray with lifting points and shall permit verification of electrolyte level while installed within the enclosure.

A circuit breaker shall be provided for battery and battery circuit protection. The circuit breaker shall be a two pole, explosion proof breaker mounted in the battery box or of non-explosion proof design located in an electric locker within 10 ft (3 m) of the battery box. Parallel breakers are not permitted. The circuit breaker shall be rated to withstand the short circuit capacity of the battery and shall be connected into the B+ and B leads from the battery terminals.

The battery shall be equipped with a fire alarm system for heat and smoke detection and be arranged to trip the battery circuit breaker upon detection of an excessive heat or smoke, as required by NFPA 130-2010 Chapter 8.6.9. The temperature setting shall be as recommended by the battery manufacturer.

An accessible battery cut-out switch shall be provided if the battery circuit breaker is not accessible from the side of the vehicle or at a convenient interior location, as required by NFPA 130-2010 Chapter 8.6.9.

The Contractor shall submit a battery design report (CDRL 9-10) within 180 days after NTP for the City’s review and approval. It shall include the battery description and specification, heat and smoke detection, means of cut-out, recommended charging processes, emergency load calculations and assumptions, and mounting location. In the event the design report proposes an alternative which eliminates the standby battery, the report shall be submitted within 120 days after NTP.

9.4.3 Emergency Power

Emergency power shall be provided by the battery. The battery shall be sized to provide at least the following loads, with associated duty cycles.

- Emergency Lighting (continuous)
- Door Control (cycle doors open for 20 seconds every 5 min)
- Braking Power and Control (continuous)
- Operator's Console Indicators and Interlocks (continuous)
- Horn and Bell (on for 10 seconds every 2 min)
- Track Brakes (on for 20 seconds at end of each 20 min period)
- Pantograph Control (raise and lower twice)
- Headlights, tail and stop lights (continuous)
- Windshield Wiper (continuous)
- Passenger Information System

The standby battery capacity shall be able to supply all the loads below for a period of 45 minutes and maintain emergency lighting for a total of 90 minutes without discharge to below 1.0 V per cell.

9.5 Energy Storage System

The Contractor shall provide an on-board energy storage system (ESS) for the Dallas Streetcar. The ESS shall meet all criteria and requirements of this Specification, including Section 17.

9.5.1 General

The installed capacity of the ESS system shall be twice the capacity required to operate along the catenary-free section of the alignment at an AW3 passenger load and worst case ambient temperature conditions. Operation shall include all auxiliary and HVAC loads and shall be identical to operation of the auxiliaries with an overhead contact power supply. The preferred system shall allow for isolation of one-half of the capacity in the event of a fault and continued revenue operation.

Additionally the ESS shall be capable of providing for off-wire streetcar operation in the yard and shop areas.

The ESS shall use batteries based on Nickel Metal Hydride (NiMH) or Lithium (Li) technologies and/or double layer capacitors. Technologies which require the addition of an energy storage media such as hydrogen or alcohol are not permitted. Lithium Cobalt Oxide and Lithium Sulfur Dioxide batteries are prohibited.

The Contractor shall prepare a design report within 180 days after NTP for the City’s review and approval on the ESS, including the management system, and associated loads to justify the selected configuration and to confirm compliance with the requirements of this Specification for the City’s review and approval. It shall include load analysis, description of how the equipment operates under extreme conditions and faults, ratings sheets, software descriptions, electrical schematics drawings, and assembly drawings. Recommended procedures for fire/life safety response to catastrophic system failures, e.g. fire, shall be included. (CDRL 9-11)

9.5.2 Functional Requirements

The ESS system shall be provided with ground fault protection in addition to the primary circuit protection described in Section 9.2.2.

If batteries are provided, a battery management system shall also be provided. The battery management system shall:

- Regulate the charging and discharging of the storage devices to prolong the useful service life;
- Regulate the charging current from the overhead distribution system to acceptable levels to prevent damage to the pantograph carbons or overhead wire when charging at a stationary location, e.g. “Stop 1”;
- Monitor the charge status of the ESS and provide for a “green” or “yellow” indication as described in Section 9.5.3 below; (Automatic load shedding of
cooling and heating loads is permitted with the “yellow” indication, though ventilation shall be required):

- Provide control for the ESS climate control system, if provided;
- Provide health monitor and isolation of faults on a per cell basis; and
- Provide for monitoring and mitigation of safety risks resulting from over-temperature, over-pressurization, and fire.

The battery management system may be provided as a separate control system or may be integrated into the propulsion or auxiliary power control units. If provided as a stand-alone system, a fault management system shall be required to automatically detect failures, provide annunciation for the operator, and interface to the monitoring and diagnostic system.

An exterior cut-out switch for the ESS shall be provided on the side of the vehicle and shall be accessible by fire/life safety personnel. The switch shall isolate the ESS storage devices and meet the requirements of NFPA 130-2010 Chapter 8.6.9.

9.5.3 Operation

The Operator shall control the initiation and termination of the ESS drive mode.

Each cab console shall be provided with an ESS On/Off switch and a gauge that annunciates the ESS charge status in each cab as required in Section 5.1.2. The gauge shall indicate actual charge status corrected for the operating temperature of the storage devices and be provided with green and yellow indicating bands or highlights on the Train Operator’s Display (TOD). The gauge will read green if sufficient energy is stored to complete the maximum requirements for operation off the wire. The City shall be provided with the means to alter the setpoints for the indicators based on revenue service experience.

To initiate operation on the ESS the Operator must stop the vehicle, e.g. at a station platform, lower the pantograph, and press the ESS On switch. The initiation of ESS operation shall be interlocked with the pantograph down position to prevent operation with the pantograph extended. When the ESS mode is active, neither the pantograph nor pantograph frame shall be energized.

To terminate operation on the ESS the Operator must stop the vehicle, press the ESS “Off” switch, and then raise the pantograph. The pantograph up command shall be interlocked with the ESS system to prevent raising the pantograph with the ESS active.

Wireless operation shall commence at the passenger station designated as “Stop 1” and terminate at the station designated as “Stop 2”. The system will operate from an overhead distribution system between “Stop 2” and the end of the line at “Stop 4”. (See Figure 2-3)

The design report, CDRL 9-11, shall address the feasibility of recharging the ESS on the main line without an OCS and the necessary equipment.

9.5.4 Installation Requirements

The ESS shall be isolated from the passenger compartment and Operator’s cab. Where partitions are used, the partitions shall be fire and explosion proof. Air used to control the climate in the ESS compartments shall not be mixed with the air provided for passenger or Operator climate control.

The ESS may be installed under the vehicle floor, in the sidewalls outside of the passenger compartment or on the roof of the streetcar. Installations under the vehicle floor or in the vehicle sidewalls shall be shock-mounted inside separate enclosures. The enclosures shall
meet the side load requirements specified in Section 3.4.10 without damage to the storage devices or hardware used to retain the storage devices. Two layers of electrical insulation shall be provided between the storage devices and the carbody structure.

For installations under floor or in the vehicle sides, provisions shall be made for inspection on the vehicle and removing/replacing the devices with a portable lift from the floor of the maintenance facility. For roof installations, provisions shall be made for inspection from the top of the enclosure and removing/replacing the devices with an overhead crane.

See Section 17 for additional requirements.

9.5.5 Monitoring and Diagnostics

The status of the ESS system shall be available via a diagnostics system integral to the ESS controller and via the streetcar’s MDS system described in Section 9.8. The ESS controller may be a separate battery management system or incorporated into the auxiliary power or propulsion control units as appropriate.

The diagnostics system shall include a data/fault logger to monitor all critical internal functions, component health, and external inputs. System faults and associated system parameters shall be time stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

The diagnostics and adjustment capabilities of the ESS system shall be reviewed and approved by the City. (Include in CDRL 9-11)

9.6 Auxiliary Electrical Distribution

Auxiliary circuits are defined as all non-traction, power generation, and distribution circuits. Distribution circuit protection shall be branched in a logical organization to facilitate fault isolation and shall minimize any operational impacts on other systems.

All circuits shall be protected by circuit breakers. Fuses may be used only where specified in this document and where applicable circuit breakers are not commercially available.

All circuit breakers and fuses shall have permanent labels installed adjacent to the device.

All low voltage dc control breakers shall be grouped logically on a breaker panel in each cab. Ac loads that are in the cab shall have their respective breakers in the cab. Other ac distribution breakers shall be located within the vehicle such that they may be readily inspected by the operator, but not accessible to passengers.

The main battery circuit breaker(s) shall be located under the vehicle, adjacent to the Standby Battery and readily accessible from the side of the vehicle.

All primary power system voltage circuit breakers and fuses shall be mounted on the vehicle roof. High voltage fuses shall be mounted in totally enclosed fuse holders with no exposed high voltage connections. The fuse shall be extracted from the circuit when the fuse holder is opened and the exposed fuse shall be safely isolated from any circuit connection.

Except for the knife switch described in this section, there shall be no primary voltage switches capable of manual operation. All high voltage dc circuits shall be manually interrupted by either activating the respective circuit breaker or activating a low voltage switch which subsequently controls a high voltage contactor.
9.7 Control Signal Architecture

Vehicle control signals may be either hard-wired with discrete components or transmitted using digital data communications. It is the City's strong preference to utilize service proven methods. The Contractor may make use of digital data communications within their system where service proven.

9.7.1 Prescribed Discrete Control Signals

Conventional battery level trainlines shall be used for all safety-critical signals. These are described as Type I circuits in IEEE Standard 1475. At a minimum these shall include:

- Emergency brake
- Door control commands
- Doors closed signal
- Propulsion mode
- Coast mode
- Brake mode
- Track brake
- Friction brake release signals
- Forward
- Reverse
- Sand control trainlines

9.7.2 Digital Control Signal Requirements

The requirements in this section apply to the usage of digital control signals on the streetcar. Contractors with vehicles meeting the service proven requirements of Section 2.9 may submit actual performance data for approval in lieu of the required analysis and documentation detailed in this section.

The following minimum requirements shall be reviewed and approved by the City as CDRL 9-12 within 180 days after NTP.

- The network protocols and transmission methodology shall be subject to the City's review and approval.
- Networks shall conform to IEEE Standard 1473. The Contractor shall present the selection factors for combinations of categories I, II, III, and IV. The City shall select the combination to be used for these streetcars considering the Contractor recommendations. The proposed use of category III circuits in safety critical applications shall require software validation and verification methodologies to be simultaneously submitted.
- Each vehicle shall include a Vehicle Network Controller (VNC). The VNC shall manage the local vehicle network(s). Data that does not need to pass between the various networks shall be restricted from so doing. The VNC may be considered as a functional entity and may be physically implemented within a more comprehensive equipment package.
• The network system shall utilize an open design that is either non-proprietary or available from multiple sources. Complete interface descriptions and details shall be provided for the City review and approval. Network components and transceivers shall be available from multiple sources.

• The network protocol shall provide services at all seven layers of the ISO/OSI communication model. All layers other than the application layer shall be transparent to the various vehicle system Suppliers.

• Communication related to real time control, such as propulsion control, shall be prioritized to the extent that anomalies in system stability and operation are prevented. The Contractor shall present calculations of the variations in transmission time, as related to the real-time control requirements, for review and approval by the City. The submittal shall include a statement of acceptability by the propulsion and the brake Supplier.

• Prior to approval of the network design, the Contractor shall submit detailed calculations of peak and average data traffic levels and calculations of network delays, for the City's review and approval. The network delay calculations shall include the expected average delays and the distribution of the delay times. The Contractor shall also submit peak and average traffic levels for the transmission media, as recommended by the protocol Supplier. The calculated peak and average traffic levels shall not exceed 60% of the recommended peak and average traffic levels. During vehicle commissioning the Contractor shall measure peak and average traffic levels. The actual peak and average traffic levels shall not exceed 70% of the recommended peak and average traffic levels.

• Protocols shall include error detection. All nodes on the network shall collect summary statistics regarding current and historical error rates and make that information available through the Monitoring and Diagnostic System.

• Network wires shall be physically isolated from sources of Electromagnetic Interference (EMI). Where redundant networks are employed, they shall not be run in the same conduit, wireway, or other such routing path.

• In the consideration of fault tolerance, the network design shall include an evaluation of the network topology and whether the network is operated as Peer-to-Peer or Client-Server.

• The Contractor shall describe the process whereby problems with the networks will be detected, reported, and repaired.

• The Contractor shall provide the Computer Aided Software Engineering (CASE), ladder-logic and flow chart tools for the general car controls, monitoring, and diagnostics, including interfaces to sub-systems. These tools shall allow the City to read and modify the control charts and to compile revised control software that can be downloaded to the equipment. The Contractor shall provide training in the use of the tools as part of the training courses discussed in Section 18.

9.8 Monitoring and Diagnostic System

9.8.1 General

The Monitoring and Diagnostics System (MDS) consists of hardware, software and the City’s maintenance philosophy. The maintenance philosophy on which the hardware and
software depend shall be defined at the system level during the earliest Program Review meetings. A wide variety of accurate operating (status) information and current and historical fault data shall be available from all subsystems whether or not they utilize microprocessor controls. The intelligent subsystems will each have their own requirements for internal self-testing, diagnostics and fault logging. The City’s interest is in data that assists in operating and maintaining the fleet. The purpose of the MDS is to minimize the time required to troubleshoot and repair the cars. The system shall make it possible for the Operator or other field personnel to immediately determine the cause of an existing or impending serious problem and take corrective or preventive action. The system shall also make it possible for maintenance personnel to troubleshoot any problems to the Lowest Level Replacement Unit (LLRU). The Contractor shall submit a design report on the MDS system to the City for review and approval within 180 days after NTP. (CDRL 9-13)

9.8.2 On-Board Equipment

Each vehicle shall be provided with an on-board MDS. The system shall collect, analyze, and report information to the crew and maintenance personnel regarding the vehicle subsystems.

The MDS shall consist of data collection and transfer modules, which facilitate interface with the subsystems of each car. It shall report information by way of the Train Operator Display (TOD) located in the cab console of each cab. Each individual vehicle subsystem shall perform its own diagnostics and shall log data appropriate to every fault. A subset of this fault information, along with selected operating status information, shall automatically be provided to the MDS. The function of the MDS is to gather, process, and record information from the monitored systems, and report its findings through the TOD. The MDS shall use the control sensors to the greatest extent possible, and independent sensors only where essential.

The MDS may be an independent subsystem or may be combined with the data networks described in Section 9.7.2. Each individual subsystem’s complete diagnostics and fault log data shall be available via network described in Section 9.7.2 or via a common interface port located in each cab.

9.8.3 Interface with Train Operator Display (TOD)

The Operating Screen, the Trouble Screen and the Maintenance Screens on the TOD shall obtain the information to be displayed from the MDS. Each screen may employ one or more levels of subsidiary screens which present more extensive information. No subsidiary screen shall be employed unless the complexity and scope of the information to be presented precludes its presentation directly on a higher level screen. Subsidiary screens shall be arranged hierarchically, with a consistent interface to facilitate moving up and down the hierarchy. Where the same information is provided on several different screens, it shall be presented the same way (text, graphics, color) and in the same location, but not necessarily the same size. The interface for screen selection shall be consistent among all of the screens described in this Section and Section 5. All screens shall display the time and date in the 24-hour system and MM-DD-YY format.

9.8.3.1 Operating Screen

The purpose of the Operating Screen is to provide pertinent information to the Operator during normal operation of the train. Information provided on the Operating Screen shall be a subset of information collected from the train and vehicle subsystems and analog sensors.
The Operating Screen shall present, as a minimum, the following train information and functions:

- Indicator of new information (unacknowledged) on the Trouble Screen
- Passenger Emergency Intercom: activation: location
- Pantograph voltage
- Pantograph/ ESS current
- ESS capacity level
- Door status with a graphical indication of location
- Any active bypass

Operating screen content shall be subject to the City’s review and approval.

9.8.3.2 Trouble Screen

The purpose of the Trouble Screen is to provide pertinent information to the Operator or field personnel concerning conditions that affect the immediate operation of the train.

Information provided on the Trouble Screen shall be a subset of information being collected from the vehicle subsystems and analog sensors. Providing the trouble information to the TOD shall have priority over other activities of the Monitoring and Diagnostics System.

The Trouble Screen shall present, as a minimum, the following train information and functions:

- Manual door release activation: location
- Door/Bridgeplate Not Closed and locked: location – leaf
- Door Open/Bridgeplate Extended Enroute: location
- Door Cut Out: location
- Friction Brake fault
- Emergency Brake
- Propulsion fault
- Auxiliary Power fault
- Battery Management System fault
- Network fault
- HVAC fault: location
- Acknowledgement: reset indicator on operating screen

If corrective action must be taken immediately, the suggested action shall be listed.

Trouble screen content shall be subject to the City’s review and approval.

9.8.3.3 Maintenance Screens

There shall be a selection of Maintenance Screens, arranged to provide access to all MDS functions and capabilities. In addition, it shall be possible for a maintainer to request additional data from the fault log in any system connected to the MDS for presentation on
the TOD or a laptop connected to an interface port located in the cab. Maintenance screen content shall be subject to the City’s review and approval. Access to the functions shall be protected by password.

Status screens shall display real time status information from system, subsystem, and intelligent sensors (not part of a subsystem) at the vehicle level. Status shall include "active" faults.

Fault logging screens shall display the major failures of the car's subsystems. The fault data shall include the time, vehicle number, the system and all information contained in the individual subsystem’s fault log. Format of the individual subsystem fault logs shall be consistent regardless of the source of the fault data. Provision shall be made to identify the most important fault modes in each vehicle system, including time keyed in and out. Provision shall be made to allow the user to scroll through the content of individual subsystem fault logs resident in the subsystems. All fault logs shall be available to the maintenance personnel for review on the screen or to be downloaded to the Portable Test Unit (PTU) or storage device. A message "Fault Log Full" shall indicate when newer faults began to overwrite older faults in any fault log. Provision shall be made to conserve fault log memory by incrementing a counter for repetitive faults rather than making a new entry. Alternatives to this scheme will be considered.

One of the Maintenance Screens shall allow a maintainer to select customized subsets of historical or status data, such as a time frame of interest or specific data from different subsystems for display on the same screen.

One of the Maintenance Screens shall allow the maintainer to initiate self-tests of all subsystems and view the results without changing screens. Testing shall be disabled unless the cab reverser is in the Off position.

It shall be possible to set up data gathering parameters in advance for a specific test run or revenue service run. Such parameters include selecting signals, setting triggers, and sampling rates to be captured. The data capture shall be accomplished without additional equipment on board during the test or revenue service runs and sufficient storage shall be provided to investigate any foreseeable problems.

Downloading the fault information to a laptop PC or to a flash memory device shall not automatically clear the log. A separate action shall be taken from the PTU to clear the log and reset faults.

9.8.4 Monitoring and Diagnostics System Interfaces with Other Systems

The MDS shall be designed and suitably buffered such that a failure of the system does not adversely affect the systems it is monitoring, and failures of monitored systems and sensors do not adversely affect the MDS.

Wherever possible, the MDS shall be capable of distinguishing between a complete failure of a specific system and a failure to communicate with it.

The MDS shall communicate with other parts of itself and with other systems and sensors connected to the system. The coding structure(s) shall be defined during the first MDS design review meeting. Automatically transmitted fault information shall not be transmitted as text messages, but responses to special searches initiated by a maintainer may be transmitted as text messages.

The system shall be capable of providing a specific subset of trouble data to off-board data collector modules if such modules are added at a future date. This capability shall consist of
an output data port suitable for connection to a radio link or transponder to be added at a future date, along with the necessary software for data port control and access. The transmission (broadcast) technique shall not interfere with or be interfered with by any other system on the train or wayside. A sample implementation of one off-board collection system, selected by the Contractor, shall be included in the MDS systems report (include in CDRL 9-13).

The following interfaces with other systems (also called subsystems) are required:

- **Time Stamp Coordination:** The MDS clock shall provide the official time stamp for information from all subsystems.
- **Exception Reporting:** Conditions outside of specified parameters shall be reported to the MDS.
- **Failure Indications:** All major system failures during operation or during the self-tests shall be reported to the MDS.
- **Diagnosis Documentation:** All parameters associated with failure indications and exception reporting shall be clearly documented. This includes the identification of the parameters, the relationship(s) among parameters, filtering, time delays, levels, and counting and reset requirements.
- **Historical Data Storage:** All subsystem reports shall be stored in a non-volatile memory for diagnostic use. Records shall include time stamp, condition and associated data. At a minimum, data shall be recorded for the period from 2 seconds before the fault event to 2 seconds after the event at a sampling rate that is appropriate for the application. Identical log formats shall be used for all vehicle systems. This data shall be accessible at the system, using the PTU (Section 18.2.1) and through the TOD with network based control systems. The Contractor shall determine the amount of memory required for the Historical Data Storage based on a 30 day preventative maintenance schedule.
- **Test on Demand:** Each system shall respond to MDS commands for controlled self-test and shall report the results to the MDS. The MDS shall also be capable of initiating self-tests of the individual subsystems and displaying the results. Tests will not be allowed unless the active cab reverser is in the off position.
- **Real Time Data:** Each system shall provide specific pre-determined operating (status) data to the MDS at sampling rates appropriate to the rate of change and priority of the sampled signal, and also respond to MDS requests for updated data. Sampling rates shall be menu selected. Custom rates shall be adjustable by PTU. Transmission time delays shall be defined and identifiable.

### 9.8.5 Additional Subsystem Diagnostics (Data/Fault Loggers)

The diagnostics for each subsystem (data/fault loggers) shall meet the following requirements for microprocessor controlled subsystems, and shall apply to non-microprocessor controlled subsystems to the extent appropriate. The information is expected to correlate directly with and be more extensive than that reported to the MDS:

- **Failure Indications:** As described in Section 9.8.4
- **Diagnosis Documentation:** As described in Section 9.8.4
- **Historical Data Storage:** As described in Section 9.8.4
The Contractor shall prepare a report for each subsystem listing the parameters that will be recorded, events to be recorded, self-tests, sampling rate, and other related items for review and approval by the City. (CDRL 9-14)

An LED display on each system shall allow visual verification of the health of the system without the use of either the MDS or a PTU.

9.9 CDRL

The following design submittals are required:

9-1 Vehicle grounding scheme (Section 9.1.2)
9-2 Pantograph design report (Section 9.2.1)
   Detailed drawings of the pantograph, collector head, and carbon inserts
   Details of the pantograph frame and mounting on the vehicle roof, including insulators
   Electrical schematics and interface to vehicle circuits, including ESS
   Pantograph dynamic envelope
   Parts list, including component ratings and manufacturer’s parts number
9-3 Primary Power Protection Design Report (Section 9.2.2)
9-4 Surge Arrestor Description (Section 9.2.2)
9-5 Knife Switch Design Report (Section 9.2.3)
9-6 Ground brushes description and drawings (Section 9.2.4)
9-7 Line filter description and drawings (Section 9.2.5)
9-8 Auxiliary power supply design report (Section 9.3)
   Analysis of ac loads, phase current imbalance, and equipment ratings
   Mounting and cooling air requirements
   Fault detection, trip levels, and system response
   Failure management strategy
   Assembly drawings and circuit schematics
   System functional description
   Hardware design description
   Software design description
9-9 Low voltage power supply design report (Section 9.4.1)
   Analysis of dc loads and equipment ratings, including emergency power requirements
   Details of battery charging characteristics
   Dead battery start provisions
   Mounting and cooling air requirements
   Fault detection, trip levels, and system response
Assembly drawings and circuit schematics
System functional description
Hardware design description
Software design description

9-10 Battery design report (Section 9.4.2)

9-11 Energy storage system design report (Section 9.4.3.1)
Analysis of ESS loads including peak and rms current requirements and
ratings of storage devices at ambient temperatures of -25°F (-32°C), 77°F
(25°C) and 104°F (42°C)
Details of storage device charge management
Installation details and climate control requirements
Isolation of faults and ESS cut-out procedures
Assembly drawings and circuit schematics
System functional description
Hardware design description
Software design description

9-12 Control signal architecture design report, if provided (Section 9.7.2)

9-13 Monitoring and diagnostic design report (Section 9.8.1)

9-14 Subsystem monitoring and diagnostic details (Section 9.8.5)

END OF SECTION
SECTION 10
PROPULSION SYSTEM AND CONTROL

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SECTION 10
PROPULSION SYSTEM AND CONTROL

10.1 General
The propulsion system shall include power modulation devices, traction motors, drive gear units, control logic, control logic, wheel spin-slide correction, circuit protection devices, and all accessories necessary to meet the specified requirements of propulsion and dynamic braking.

Each streetcar shall be provided with two functionally independent but coordinated regenerative propulsion systems. The functionally independent propulsion systems may share common electrical filtering components and resettable electrical fault primary interruption devices. Dynamic braking and dynamic brake initiation shall be completely independent for each system. Each propulsion system shall be able to operate independent of the other propulsion system to provide a “limp-home” capability with a single vehicle. No failure other than the pantograph, high speed circuit breaker, or common filtering components shall interfere with the capability of operating on one propulsion system.

The core of the propulsion system shall be dual ac inverter drives. The equipment shall be of a proven design as described in Section 2.12. For equipment which does not meet the requirements of Section 2.12 the Contractor shall provide, the location and duration of the equipment's revenue service operation showing that it has been operated for at least one year in revenue service on a rail vehicle, the names and addresses of references at the operating authority, a detailed description of the development process showing how preceding service proven equipment designs have been modified, and a detailed description of any additional modifications which will need to be made to comply with this Specification.

Within 180 days after NTP the Contractor shall prepare a propulsion system design report for DART’s review and approval that includes all of the design submittals required by Sections 17.27 and 19.5.3 (Reference CDRL 19-16). When data is requested in this Section for design review it shall be included in this report unless otherwise specified. (CDRL 10-1)

10.2 System Requirements

10.2.1 Propulsion System Configuration
Power modulation in both propulsion and dynamic braking shall be accomplished by microprocessor-controlled, IGBT (insulated-gate, bipolar-transistor) inverters.

For conventional bi-motor trucks, the motors shall be electrically connected in parallel or single axle drives (one inverter/motor per axle). For unconventional trucks or running gear, motors and drive gears shall be arranged to minimize un-sprung weight and tractive effort losses, reduce curve negotiation noise, optimize adhesion utilization, and reduce mechanical stress from the motor output, through the gear drive, to the wheel/rail interface.

10.2.2 Drive Configuration
Drive configuration shall be one motor per axle or stub axle or one split motor per longitudinal wheel pair. The traction motor shall drive its associated axle(s) through a gearing arrangement. In the case of one motor driving a longitudinal wheel pair, the
individual wheels shall not be mechanically locked through the motor/gearing arrangement and shall permit slip between the individual wheels. The arrangement shall minimize unsprung weight on the driven axles and provide resilience to absorb the shocks resulting from running through special trackwork. All motors, gear units and couplings shall be interchangeable between motor trucks.

10.3 Equipment Thermal Capacities

The Contractor shall submit the simulations and component thermal ratings for both normal and abnormal duty cycles for DART’s review and approval. (CDRL10-2) The report shall address the thermal rating and projected temperature of all propulsion system components including cooling air motors, IGBTs, and braking resistors.

Rheostatic braking resistors shall be sized for the specified duty cycles, as though there were no regenerative braking, and the resistors must dissipate all braking energy.

Propulsion motor temperature rise shall be classified according to IEEE Standard 11 or IEC 60349. Propulsion motor temperature rise for the normal duty cycle shall be limited to the allowable temperature rise for one class less than the actual insulation class provided.

10.3.1 Normal Duty

The continuous thermal rating of all propulsion system components shall exceed the rating that is necessary to operate with the normal duty cycle specified in Section 2.6.14, over the allowable range of primary voltage. All propulsion system components shall function as specified without damage under these conditions.

10.3.2 Abnormal Duty

The abnormal duty cycle shall be based on consideration of the following three cases: towing requirements, operation with one truck cut-out, or the normal duty cycle, all as defined in Section 2.6.14, whichever is worse. If the normal duty cycle provides the worse case, all equipment shall be thermally rated as specified in Section 10.3.1, above.

If the towing requirements or operation with one truck cut-out present the worse case, then the traction motor abnormal duty rating may be based on the temperature rises allowed for its actual insulation class.

10.3.3 Equipment Temperature Control

Equipment may be air or liquid cooled. Equipment cooling shall be provided on a per-truck or per-motor basis so that continued operation is possible in the event of cooling system failure.

Forced air cooling shall not use ambient air in any area of exposed voltage stress above 50 volts.

Liquid cooling systems shall be sealed and shall not require the addition of supplemental cooling fluid at intervals of less than one year.

10.4 Switching Line Transients

Switching line transients normally generated by the propulsion system shall be suppressed such that the instantaneous voltage does not exceed 110% of no-load line voltage, with an absolute limit of 925 Vdc.
All vehicle-borne equipment shall withstand all vehicle and wayside generated transients without damage or reduction in life. Refer to Section 2.4.4.

10.5 Electromagnetic Interference

Electromagnetic interference (EMI) limits as specified in Section 2.8 shall not be exceeded as a result of propulsion system operation. In addition, the propulsion system shall be designed to operate in an environment of high ambient electrical noise. Such electrical noise could be self-generated, generated by other vehicle systems, and generated off-vehicle.

10.6 Performance Characteristics

The propulsion system shall provide train acceleration and deceleration rates as specified in Section 2.6. The Contractor shall provide tractive effort vs. speed curves for motoring and braking at the minimum, nominal, and maximum voltage conditions specified in Section 2.4.1 and 2.4.4. (CDRL 10-3)

10.6.1 Accuracy and Response Times

The propulsion system time response shall be sufficiently fast to:

- Provide the specified vehicle acceleration and deceleration rates, with accuracy, jerk rate, and mode change dead times as specified in Section 2.6.
- Provide the specified wheel spin and wheel slide correction performance.

The specified accuracies and response times shall be independent of ambient temperatures within the range specified in Section 2.3.5, variations of the low voltage supply within the limits specified in Section 2.4.2, and variations in the wayside power supply voltages as specified in Section 2.4.1 and 2.4.4.

10.6.2 Load Compensation

The propulsion control system shall adjust tractive effort to compensate for varying passenger loads on a per-one-half vehicle basis, with the system for a truck providing the tractive effort for load on that truck and one-half of the load on the adjacent center truck (if a center truck is provided). Compensation shall be provided by measurement of passenger loading on a per-truck basis in both propulsion and braking. Sensors and associated circuits shall be continuously or periodically checked to verify that they are functioning properly. Refer to Section 2.6.11.

In the event the load compensation signal is not within the allowable range, the system shall default to AW0 and notify the Operator through the MDS system.

Load compensation may use signals processed by the propulsion control or signals that have been processed by the friction brake system, however, in either case the same signal shall be used by both propulsion and friction brake systems.

10.6.3 Friction Brake Control

Control of disc brakes may be provided by the propulsion system electronic control unit or a separate friction brake electronics control unit. If the propulsion system logic includes the friction brake control logic, it shall function with the friction brake pressure control units to automatically apply braking effort when the required deceleration rates are not achieved by dynamic braking. This control signal shall meet the safety requirements of Section 2.
If the friction brakes are controlled by independent control logics, the propulsion system logic shall provide an accurate dynamic brake delivered signal per inverter to the brake control logic as specified in Section 12.5.2 and wheel spin/slide control shall be coordinated with the review and approval of DART. (Include in CDRL 10-1)

10.6.4 Emergency Brake Control

The propulsion control system shall respond to the emergency brake trainlines by inhibiting the drive mode and producing dynamic braking effort at vehicle weights above AW0 to supplement friction brake effort so that the vehicle achieves the braking performance specified in Section 2.6.6. Regenerative braking shall be disabled during emergency braking by opening the line switch.

10.6.5 Dynamic Brake Capability

Dynamic braking effort shall be produced by the propulsion system as specified in Section 2.6.4. The dynamic brake shall be combined regenerative and rheostatic and shall be continuously available from maximum vehicle speed down to a vehicle speed of 3 mph (5 km/h) or less. The dynamic brake control system shall continuously monitor line voltage on each inverter cycle, shall supply to the line the maximum amount of energy possible within the line voltage limits prescribed, and shall divert to the braking resistors only that generated energy in excess of the energy accepted by the line or energy storage system. Full dynamic braking shall be available independent of the presence of line voltage.

10.6.6 Direction Change

Direction change shall be provided by traction motor field rotation reversal. The inverter control shall respond to the direction control signals generated by the reverser switch in the cab. A change of direction shall be possible only when no-motion is detected and thetractive effort is zero. Correspondence between the control line command and motor rotation shall be monitored, with out-of-correspondence conditions to be annunciated as a propulsion system fault, with the propulsion mode inhibited on the vehicle with the fault.

10.6.7 Mode and Rate Selection

The propulsion system shall directly utilize the rate, direction, brake, and power mode selection signals generated by the master controller as specified in Section 5.1.1. The propulsion control equipment in each vehicle shall passively interpret the mode and rate selection commands without loading the control lines beyond their design limits.

The drive mode shall be inhibited, at a minimum, by the following:

- Emergency Brake Applications, as indicated by de-energized Emergency Brake Trainlines. Refer to Sections 2.6.6 and 5.3.3.
- Service Brake Applications, parking brake applications, low hydraulic fluid level, and low hydraulic accumulator supply volume and pressures (inhibited on a timed basis). Refer to Sections 12.5.3, 12.5.6 and 12.5.7.
- Doors Open or unlocked as indicated by the Door Status Interlock trainlines. Refer to Section 6.7.2.
- Direction Out of Correspondence, on a vehicle basis as described in Section 10.6.6.
10.6.8 Cut-Out Control

Provisions shall be included for each powered truck of a vehicle to be independently isolated from the propulsion control signals and the catenary supply. This isolation will be referred to as "propulsion cut-out". With one truck cutout on a single vehicle, it shall be possible to operate the vehicle in either direction with no damaging effects over the whole alignment.

If required, a speed limit may be automatically applied when any truck is cut-out. Refer to Section 10.6.10, below. All other systems shall remain operational and propulsion cut-out shall not affect the operation of the master controller in the cut-out cab. Braking effort may be increased on the remaining power trucks to minimize the thermal loads on the friction brake system. The lower speed limit shall be submitted to DART for review and approval. (Include in CDRL 10-1)

10.6.9 Wheel-Spin Slide Correction

A wheel spin-slide detection and correction circuit shall be provided as an integral part of the propulsion control system. The wheel spin-slide correction system shall meet the requirements of Section 2.6.7 and shall be coordinated with the friction brake slide control if separate friction brake controllers are provided.

10.6.10 Overspeed Protection

The propulsion control system shall include overspeed protection which limits vehicle speed to set values by means of tractive effort and brake control. Speed information shall be derived from a source which is corrected for wheel wear.

The overspeed protection logic shall remove propulsion, and command an FSB application when the vehicle speed exceeds the overspeed protection set point. Braking shall be maintained to a full stop or until the operator has moved the Master Controller to a braking position.

The overspeed protection set point for the system shall be 43 mph +1 mph (72 km/h +2 km/h) when all systems are normal. An additional overspeed protection set point may be utilized when any propulsion or brake equipment has been cut-out or when a propulsion or brake system failure has been detected.

10.6.11 Line Switch

A high speed line switch shall be provided for each inverter to make and interrupt power during normal or faulted conditions and to isolate the inverter from primary power when the inverter is cut-out. Operation of the line switch shall be coordinated with the HSCB described in Section 9.2.2 and during emergency brake as described in Section 10.6.4. Line switch capability shall be coordinated with input protective device capability. The line shall be a solid state device or electro-mechanical contactor and shall operate with bidirectional current flow.

Source and return power to the line switch shall be interlocked such that an emergency brake application opens the line switch, but leaves dynamic brake functional.

The line switch, its control, and associated equipment shall be arranged to limit instantaneous inrush currents under all operating conditions to a value that will not cause failure or deterioration of any component, including fuses, or not cause nuisance tripping of wayside substation breakers. Any means adopted to achieve this capability shall not
materially interfere with car performance under conditions of intermittent collector contact, as with an icy contact wire.

10.6.12 No-Motion Logic
The propulsion system may include the vital no-motion logic specified in Section 2.6.10.

10.6.13 Distance Signaling
A separate odometer signal with a pulse rate of one per 3 ft (0.914 m) shall be made available for use by other subsystems and future addition of subsystems by DART.

10.6.14 Circuit Protection and Visual Annunciation
Circuits powered from the overhead contact system shall be protected as required by Section 9.2.2.

Control circuits shall be protected by low voltage circuit breakers.

Dynamic brake failure detection circuits shall be provided for each truck. Whenever dynamic brake is commanded, the circuit shall verify that dynamic braking effort of the correct level is produced; if it is not produced, a local propulsion fault shall be indicated for that truck. The dynamic brake feedback signal to the friction brake system shall be clamped at zero under dynamic brake failure conditions. Dynamic brake failure detection design shall minimize nuisance fault annunciations due to transient events, including momentary loss of primary power when braking is initiated.

Visual annunciation of all propulsion system faults, including cut out, dynamic brake failure, general faults, ventilation failure, and overheating shall be annunciated in the cab via the MDS system described in Section 9.8.

10.7 System Components

10.7.1 Traction Motors
AC traction motors shall have the following basic design features:

Motor Type: Three phase, squirrel cage induction motor, with welded copper cage, and formed stator coils.

Ventilation: Forced-ventilated or self-ventilated.

Duty: Thermally rated in accordance with the duty cycles as defined in Sections 2.6.14 and 10.3.

Load Sharing: The motor characteristics shall allow achievement of all performance requirements with wheel diameter differences which vary between 0 and 1/4 inch (6.4 mm) between axles on the same truck.

Motor Standards: IEC 60349 or IEEE Standard 11, except as otherwise specified, and IEEE Standard 112 as applicable.

Insulation: Motor insulation shall be IEC Standard 85, Class 200 insulation system or better. The motor stator coils shall be vacuum pressure impregnated in the complete stator frame assembly.

Enclosure: Splash proof or totally enclosed.
Mounting: Each traction motor shall be resiliently mounted, either directly to the truck frame or to both the truck frame and gear unit. Unsprung mass of the motor-gear unit assembly shall be kept to a minimum. Safety straps, tabs or hangers shall be provided as required to prevent damage in the event of motor or gear unit mount failure.

Shaft Coupling: A splined, taper fit, flexible coupling or flexibly coupled Cardan shaft shall be provided between traction motor and gear unit shafts. The coupling design and motor-gear unit mounting arrangement shall minimize coupling dynamic angular displacement.

Design Speed: The motor design maximum speed shall correspond to a vehicle speed of at least 48 mph (80 km/h) with any permissible condition of wheel wear. Based on this maximum vehicle speed, the IEC 60349 definition of "maximum speed" shall be used.

Bearings: Grease lubricated, NFL, antifriction bearings shall be provided. Grease cavities shall be large enough to hold a five year supply of lubricant. Configurations which use gear lubricant for the traction motor bearing at the pinion end are acceptable. Bearings shall have an ANSI/AFBMA L10 rating life equivalent to 1,600,000 km of service, or greater.

Motor and Rotor Balance: Motors shall be dynamically balanced to meet the requirements of NEMA MG 1-12.06 or VDI 2060. In addition to the NEMA requirements for the amplitude of vibration, the IEEE Standard 11-13.2.2 requirements for the velocity of vibration shall be met. In addition to NEMA requirements for the assembled machine, rotors shall be dynamically balanced to within a maximum unbalance of 1.0 in-oz (0.72 mm-kg), even if a greater unbalance will satisfy the NEMA MG 1-12.06 requirements. Balancing shall be effected by using metal weights, welded in place, or by drilling the rotor core.

Noise: Motor shall be free of objectionable windage and mechanical noises at all vehicle speeds and under all load conditions.

Markings: Terminals, leads, and motor frames shall be clearly marked for positive identification.

Electrical Connections: Motor connections to vehicle wiring shall be subject to DART’s approval. Leads shall be secured to avoid insulation chafing and shall be routed to accommodate all truck motions without interference or excess strain. The current value used in determining the minimum size of motor leads shall not be less than 50% of the maximum load current seen under the most severe duty or as determined by the root-mean-square method and shall conform to NFPA 130 Section 8.6.3.6. All wires, connectors and related hardware shall be rated for the peak voltages and currents present.

Overtemperature Protection: If the winding temperature rises 27 ° F (15° C) above the designed operating temperature limit, the control unit shall reduce the motor duty cycle by imposing a speed restriction.

10.7.2 Gear Drive
Each motored axle or wheel shall be either a parallel or right angle drive, single reduction or double reduction drive designed and manufactured for bi-directional service.

Gear units shall be equipped with anti-friction bearings throughout. Bearing design and selection shall require inspection or adjustment no more frequently than once every 250,000 miles (400,000 km). Bearings shall have an ANSI/AFBMA L₁₀ rating life equivalent to 1,000,000 miles (1,600,000 km) or more of service. External bearing shaft seals shall be the labyrinth type, with supplemental sliding contact seals, if necessary to keep high velocity splashed water from entering the gear units.

Gears shall be designed and applied to require inspection and adjustment no more frequently than once in every 250,000 miles (400,000 km) and have a life of at least 1,000,000 miles (1,600,000 km).

The gear unit shall be oil lubricated and provided with sufficient baffles, dams, and passages to ensure an adequate flow of lubricant to all bearings and gears under all combinations of acceleration, speed, direction, load, and environment. The gear unit shall prevent infiltration of moisture into the lubricant from any and all sources and shall not require replenishment of oil at a rate in excess of one quart for every 100,000 miles (160,000 km).

The gear unit shall have openings with removable plugs located with easy access for filling and draining. Plugs shall be of a type or be located to prevent damage by obstacles on the track and the resultant loss of lubricant. Plugs shall be secured by lock wires, lock tabs, or other approved means to prevent loosening in service.

The filler plug opening shall be arranged to provide an indication of oil level and also prevent overfilling. Drain plugs shall have magnetic particle collectors.

Removable and accessible oil-tight and airtight inspection covers shall be provided on the gear housing for visual inspection of the gears.

### 10.7.3 Dynamic Brake Resistors

The dynamic brake resistors shall have sufficient capacity to provide full power dissipation during operation at full service braking over the specified profile and passenger loadings up to and including AW3, assuming no regeneration into the line. Maximum active element temperature under these conditions shall be limited to 1200°F (650°C). Other propulsion, energy storage system, and brake system power resistors shall have a power dissipation capability that is 50% greater than the maximum load that they can be exposed to under any specified operating condition.

Resistor grids shall be electrically isolated from their frames, and the frames electrically isolated from the vehicle body and heat shield with high temperature insulation. Provision shall be made for grid expansion to prevent warping. The resistor grids shall be convection ventilated and roof mounted. Screens shall be provided to protect resistors from overhead vandal damage.

All resistor elements, resistor frames, heat shields, screens, enclosures, and hardware shall be made of stainless steel. All resistor components shall be selected for both their thermal and mechanical properties and corrosion resistance.

### 10.7.4 Static Power Devices

Propulsion power semiconductor assemblies shall be functionally grouped, keyed, and mounted in modular form to facilitate maintenance and easy removal. Power semiconductors shall be applied and installed per the manufacturer's recommendations.
All propulsion system control components and the insulators associated with such components, other than braking resistors, shall be mounted in sealed cabinets to prevent dirt and moisture from affecting the components and from reducing the insulation rating of the equipment. If necessary to avoid ozone build-up, the enclosures where power contactors are mounted may be connected to the atmosphere via screened and filter-protected openings. Any filter elements used for this purpose shall be designed to preclude snow and water ingestion into the enclosure and shall have replacement interval in excess of two years.

Forced air may be used where required for heat sink temperature stabilization, but shall not be used to ventilate the inside of the equipment cabinets. Cooling air shall be routed through channels free of high voltage stress to avoid arc-over at dirt build-up zones. Inclusion of heat sinks at voltage potentials other than ground is prohibited.

10.7.5 Contactors

The use of contactors for propulsion control shall be minimized to the greatest possible extent.

All propulsion system contactors shall be capable of safely interrupting the maximum possible load current in the event of a control malfunction. Contactor rating and operation shall be coordinated with circuit protection elements. The arrangement of arc chutes, blowout coils and venting, along with the contactor tip size, shall allow safe continued operation upon reset after a malfunction.

The contactors shall be designed for a minimum of 1,000,000 mechanical operations with a minimum contact life equivalent to 500,000 miles (325,000 km) of normal operation.

Contacts connected in series shall not be operated in circuits where the voltages and currents exceed the single contact ratings. Contacts shall not be connected in parallel.

10.7.6 Propulsion Line Filter

The line filter(s) shall conform to the requirements of Section 9.2.5. Each input filter shall be provided with a charging circuit that shall limit charging current and input voltage overshoot to approved levels.

10.7.7 Control Logic

The propulsion system control logic units shall be microprocessor-based with associated peripherals and I/O, as required, to meet all of the specified functions and performance criteria. The control units shall provide self-diagnostic routines, fault monitoring of internal and external devices, and user programmable operating characteristics. Control programs shall be stored in field-programmable, non-volatile memory. The propulsion controls shall comply with the design requirements of Sections 2, 9 and 16.

Within 180 days of NTP the Contractor shall submit a propulsion controller system design package. (CDRL 10-4) The submittal shall include both hardware and software control functions and their interdependencies and comply with the documentation requirements of Section 17.27.3.

Independent control logic units and logic power supplies shall be provided for each truck such that one truck can function if the propulsion equipment for the other has failed.
Electronic control equipment shall be segregated from the power equipment. Control circuitry and control voltage sources shall be isolated from power circuitry and high voltage sources using opto-couplers or transformers.

The status of the propulsion system shall be available via a diagnostics system integral to the control unit and via the streetcar’s MDS system described in Section 9.8. The diagnostic capabilities of the control logic units shall be reviewed and approved by DART.

The control unit shall provide continuous monitoring of critical parameters, including motor currents, switching device currents, and component temperatures. The control unit and all related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions such that equipment damage is prevented or minimized. The detection and response times shall permit detection and corrective action before other protective devices, including the HSCB, react. System faults shall be time stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

Each control logic unit shall include chart recorder outputs with a minimum of eight analog outputs for monitoring and recording on a PTU. Each output shall have the capability to address all logic signals significant to analysis and diagnosis, including signals to and from contactors, and all external inputs and outputs. Scaling shall be integral with the design and require no supplementary effort by the user, and shall be logically decoded. The sampling rate shall be not less than 100 Hz for each channel. The accuracy and sensitivity of the chart recorder signals in relation to the actual source conditions shall be independently verified during the propulsion system qualification testing.

Refer to Sections 17.20 through 17.28 for general electrical and electronic design standards.

10.8 CDRL

The following design submittals are required:

10-1 Propulsion System Design Report (Section 10.1)
   Propulsion and drive system configuration
   High voltage and grounding schematics
   Primary power and traction motor cabling
   Outline drawings of major components
   Cooling air requirements, filtering, and blowers
   Manufacturer, part number, and ratings of power semiconductors
   Line reactor details
   Filter capacitor details
   Traction motor vacuum impregnation process
   Traction-gearbox coupling
   Interfaces with ESS and friction braking systems

10-2 Normal and Abnormal Duty Cycles Report (Section 10.3)
   Normal operation
   Towing operation
Propulsion cut-out operation

10-3 Propulsion system performance in motoring and braking for line voltages of 525V, 750V and 900V (Section 10.6)

10-4 Propulsion controller system design package (Section 10.7.7)

System Functional Description
Hardware Design Description
Software Design Description

END OF SECTION
SECTION 11
TRUCK ASSEMBLIES

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SECTION 11
TRUCK ASSEMBLIES

11.1 General

This Section specifies the design and functional requirements of the truck assemblies. The "trucks" are defined as all components from the rail to and including the first components rigidly fastened to the carbody. Gear boxes, motors, wiring, brake system components, and associated mounting brackets are physically part of the truck assemblies but are not included in this section, except that any mechanical interface requiring welding or drilling on the truck frame shall be considered part of the truck.

Each vehicle shall be equipped with a minimum of two motor trucks. The truck frames may be of either inboard or outboard bearing design.

The trucks shall be designed, and the truck frames manufactured, by a supplier(s) that has designed and manufactured the same trucks previously for the vehicle offered. Adaptations are limited to changes in dimensions, materials or procedures necessary to comply with this Specification. The trucks shall have operated in the same or more unfavorable climatic conditions over track meeting FRA Class 4 requirements, and at the same or higher maximum speed.

The trucks shall minimize resonant vibrations when in operation. Surface contact between truck components, except suspension stops, shall be made through service-proven, non-metallic materials to impede the transmission of vibration and noise.

The trucks shall be suitable for safe operation at speeds up to 50 mph (100 km/h) and shall provide the specified ride quality up to 42 mph (70 km/h) over the entire range wheel wear and vehicle loading.

11.2 Design Considerations

11.2.1 Service Life

The truck structure shall have a service life of 30 years minimum, without the need for structural repairs.

11.2.2 Wheel Base

Truck wheel base shall be from 70 to 75 inches (1,780 to 1,910 mm).

11.2.3 Interchangeability

Motor trucks shall be interchangeable among any vehicles furnished under this Contract, without modification. Non-powered trucks, if provided, shall be interchangeable among any vehicles furnished under this Contract, without modification.

11.2.4 Clearance Considerations

The complete truck assembly shall clear the carbody and carbody-mounted equipment by not less than 1/2 inches (12 mm). All truck parts, except wheels and track brakes, shall clear the plane of the top-of-rails by not less than 2 inches (50 mm). These clearance limits shall be met when full allowance is made for the most unfavorable combinations of:
- Wheel tread or flange wear
- Static and dynamic primary and secondary spring deflection
- Primary and secondary suspension failure
- Static and dynamic suspension stop deflection, including possible wear of the suspension stops to the condemning limit
- The full specified range and worst case combination of horizontal and vertical curves
- Any other possible movement of the trucks and associated parts including that caused by the maximum excursions of any truck-mounted parts

The Contractor shall submit drawings showing truck clearances under the above mentioned worst case conditions.

The design shall permit the removal of the motor trucks from under the vehicle in areas of minimum headroom. It shall not be necessary to raise the carbody more than the minimum distance required for the truck and traction motors to pass beneath the emergency tow bar in order to roll the trucks out from under the carbody.

### 11.3 Suspension System

#### 11.3.1 General Requirements

Truck suspension shall be comprised of a primary and secondary suspension system. The carbody shall be supported on the secondary suspension.

The maximum change in car floor height due to car loading changes from AW0 to AW4, with suspension failure, shall be limited by the safe operating requirements, clearance requirements, and prevention of interference between the doors and wayside loading platforms during door opening. In combination, under normal conditions, the suspension system shall keep the car floor and door threshold height above top-of-rail to the value and tolerance specified in Sections 2.3.4 and 2.5.3.

#### 11.3.2 Primary Suspension

Primary suspension shall be by means of elastomeric elements in compression. The vertical resonance frequency of the primary suspension system shall not exceed 12 Hz. The longitudinal spring rate shall be selected such that all the requirements of this Specification are met. The longitudinal spring rate shall permit the axles to align properly (absent squealing or hunting) in curves, but shall in no case exceed 90,000 lbf/in (1600 kg/mm).

#### 11.3.3 Secondary Suspension

The carbody shall be supported by a secondary suspension system consisting hydraulic springs, designed to resist those lateral forces expected in rail service. The springs shall be augmented by horizontal and vertical shock absorbers to optimize ride quality.

The secondary suspension springs shall be installed between the truck frame and the truck bolster for motor trucks, and between the truck frame and center body section for the non-motored truck.
11.3.4 Shock Absorbers
Vertical and lateral shock absorbers shall be of the hydraulic type and shall have a minimum service life of 10 years.

11.3.5 Suspension Stops
Lateral and vertical suspension stops shall be provided with replaceable elastomeric cushions. Stops shall develop sufficient force to limit motion to within clearance requirements. Vertical suspension stops may be incorporated into the vertical dampers.

11.3.6 Wear Adjustment
Provision shall be made in the truck design for vertical mechanical adjustment of the primary or secondary suspension to compensate for maximum wheel wear and wear or settlement of other truck parts. The adjustments shall be accomplished with standard maintenance shop equipment, and shall not impair the operation of the truck. Adjustment at any level shall not cause the vehicle to exceed the specified dynamic envelope. The adjustment range shall be 10% greater than the full range of tolerances plus wear.

11.3.7 Load Leveling
Hydraulic spring pressure shall be controlled by leveling valves or equivalent sensors on each truck connected around the secondary or secondary and primary suspensions as required to meet the specified performance. These valves shall control the height of the floor to compensate for changes in passenger load and distribution.

The suspension system shall maintain the top of the car floor and door thresholds at the heights specified in Section 11.3.1. Leveling valves or sensors shall have a response deadband commensurate with the floor leveling requirements, but shall not be susceptible to spring pressure oscillation.

Sudden loss of suspension hydraulic pressure on either side of a truck shall initiate a rapid venting of the opposite spring on the same truck.

11.3.7.1 Load Compensation
A method of indicating passenger load to propulsion and friction brake control shall be provided. The load compensation system design shall meet the accuracy and safety requirements described in Section 2. Each spring assembly shall have a suitable connection to pressure transducers for load compensation signals to the propulsion and friction brake systems. Transducers shall not be mounted to the truck frame or bolster.

11.3.7.2 Electronic and Hydraulic Control Units
If electronic and hydraulic control units are provided as part of the load leveling system, they shall comply with the requirements stated in Sections 12.6.3 and 12.6.4 for friction brake control components. The load leveling control may be combined with the friction brake controls, provided that separate control hardware is used for each function.

11.4 Truck Frame and Bolster

11.4.1 General Requirements
Truck frames and bolsters shall be of a service-proven design, fabricated by welding, castings, or a combination of the two.
There shall be no sliding surfaces involved in the method of retaining the journal bearings in their proper positions. The design of the truck shall allow compensation for the expected maximum level of creep or settlement of the primary and secondary suspension springs.

Where pockets or partially enclosed spaces exist, adequate drainage shall be provided so that no moisture collects anywhere within the truck frame and bolster.

Threaded fasteners, adjustment points, and structurally-critical locations shall be accessible for inspection and work using conventional means and tools.

11.4.2 Connection

A positive mechanical connection shall be provided between the carbody and trucks, such that the trucks will be raised with the carbody without disengaging any part of the suspension system. These connections shall be detachable by conventional hand tools to permit de-trucking. The strength of the connection shall provide a factor of safety of not less than two times the yield strength of the material when lifting a fully assembled truck.

The ultimate strength of the truck-to-carbody connection shall be sufficient to secure the entire truck to the carbody under conditions in which a horizontal load of 45,000 lbf (200 kN) is applied in any direction at any point on the truck, without separation of the truck and carbody. The ability of the truck-to-carbody connection to sustain this load shall be independent of the presence of any vertical load. The horizontal load may be transmitted from the truck to the carbody through structural members, positive stops, or other rigid, mechanical safety devices. The Contractor shall submit calculations for the strength of the truck-to-carbody connection for DART’s review and approval. (CDRL 11-1)

11.5 Journal Bearings

Journal bearings shall be grease lubricated, tapered or spherical roller bearings with an L_{10} life probability of not less than 1,000,000 miles (1,600,000 km) at AW3 vehicle weight with the shock and impact loads typical of rail vehicle service. Bearings shall be service-proven for streetcar use. The Contractor shall submit bearing life calculation for approval. (CDRL 11-2)

11.6 Wheels

The truck shall use a resilient wheel with a steel center (hub). The tire shall be replaceable by bolted connections, and shall not require the pressing off any axle components. The wheel assembly shall be SAB/Wabco V-type with noise dampeners, Bochum 84, or other approved design.

The wheel and tire assemblies shall be rated by the manufacturer for continuous operation at vehicle weights up to and including AW3.

The wheel assembly shall also serve as the electrical interface for grounding the vehicle to the running rails for the return of propulsion and auxiliary current, and to shunt the signal system track circuits from rail-to-rail. Conductive paths with the capacity to conduct all specified currents shall be provided by no less than 3 external shunts, per wheel, between hub and tire. External shunts shall be visible from the side of the vehicle.

11.7 Axles

The Contractor shall submit a load diagram and static and dynamic stress calculations for the axles which show, at a minimum, the maximum value of stresses to which the axles are expected to be subjected in service, and a prediction of the axle’s fatigue life using the
cumulative damage (or other approved) calculation method. The Contractor shall consider the effect of the bending loads induced by the presence of restraining rails in the axle bending fatigue stress calculations. (CDRL 11-3)

11.8 Wheel and Axle Assembly

The wheels, bearings, and ground brush ring shall be fitted to the axle by pressing or mounting. The fit tolerances and pressing forces shall be as recommended by the equipment manufacturers. The Contractor shall submit the press fitting procedure for all components pressed on the axle for approval. (CDRL 11-4)

Pressure graphs of all gear coupling, disc hub, grounding ring, journal bearing, and wheel-to-axle pressings shall be furnished to DART. (CDRL 11-5) The graphs obtained shall correspond with those shown as “acceptable” or better in Section 2 c), Wheel Press Practice of the AAR’s Wheel and Axle Manual. The graphs shall also be included in the car history book.

Each full-length tire-wheel-axle assembly shall provide a maximum shunting resistance of 0.01 ohm when measured from tire tread to tire tread. Maximum wheel tire tread-to-axle resistance for assembled stub-axle-wheel units shall be 0.005 ohm.

Wheel and axle assemblies shall be interchangeable between all powered trucks and all non-powered trucks, if provided.

11.9 Track Brake Support

The track brakes shall be supported from the journal bearing housings. The track-brake support arrangement shall maintain positive lateral alignment of the track brake with the running rail. Track brake forces shall be transmitted to the truck frame as near to the top-of-rail as practical to minimize the moment on the track brake unit.

11.10 Safety Bars

Safety bars shall be provided at the outboard ends of the trucks. They shall be mounted with a maximum clearance of 4 inches (100 mm) to top of the rail when all truck parts are new. Clearance shall not be less than 2 inches (50 mm) for the worst case combination of conditions specified in Section 11.2.4.

Safety bars shall be arranged and mounted for replacement with common hand tools.

11.11 Grounding Device

Each truck shall be provided with grounding devices meeting the requirements for electrical grounding specified in Section 9.2.4. Ground brush life shall be a minimum of 300,000 miles (500,000 km).

11.12 Flange Lubricators

One axle of each motor truck shall be equipped with wheel flange lubricators (diagonally opposed). The motor truck lubricators shall be installed so that each provides friction modifier material between the flange of the wheel and the rail. The center truck, if provided, shall incorporate wheel flange lubricators (two per truck) and shall be installed so that each provides friction modifier material between the flange of the wheel and the rail. The sticks and stainless steel applicators used for the motor and center trucks shall be identical, and shall use sticks approved by DART. (CDRL 11-7)
11.13 Design Data Requirements

11.13.1 Design Loads

In addition to those loads identified elsewhere in this Specification, the truck frame and all truck parts, including motor, gear unit, and friction and track brake equipment supports shall be capable of withstanding the maximum load variation imposed by the forces acting on the frame. The basis for determining maximum load variation shall include forces resulting from passenger load, track shocks and forces, motor torque, friction brakes, track brakes, and any possible combination of these forces when operating under all possible conditions on track meeting the minimum requirements of the FRA Class 4 "Track Safety Standards", per 49 CFR Part 213.

The static strength design condition for the truck frame and bolster shall be based on the trucks share of a design load weight equal to the AW4 weight minus the weight of the trucks. The vertical load on the truck shall not be less than the truck’s share of the design load, augmented by the weight transfer effects such as tractive effort reactions. The longitudinal load, applied at the center of gravity of the car, shall not be less than the maximum possible instantaneous braking effort (friction and dynamic plus track brake) with AW4 loading and 50% adhesion. The lateral load, applied at the center of gravity of the car, shall not be less than that developed at car overturning. Accessory loads, such as those from brake units, track brakes, and traction motors, shall represent maximum steady state conditions; for example, maximum motor torque and brake unit weight, and maximum brake unit reaction and motor weight, or the worst combination (brake blending) of both.

Under these conditions combined, the maximum stresses at any location in the truck frame and bolster shall not exceed 50% of the yield strength of the material. Local zones greater than the allowable, will be reviewed on a case-by-case basis as long as it does not affect the overall stability of the truck. Based on this review, DART will determine the acceptability of these areas.

The fatigue design of the truck frame and bolster shall be based on the above conditions with a design load equal to the AW2 weight minus the weight of the trucks. The mean vertical load on a truck shall be the truck’s share of the design load and the vertical load shall vary about the mean vertical load by ±25%. The lateral load shall vary between 15% of the mean vertical load acting towards one side of the truck and 15% of the mean vertical load acting towards the other side of the truck. The longitudinal load shall vary between 15% of the mean vertical load acting towards one end and 15% of the mean vertical load acting towards the other end. The lateral and longitudinal loads shall act as if they were applied at the center of gravity of the carbody at AW2 with resulting vertical loading applied to the bolster or truck frame as appropriate. Accessory loads shall vary between ±100% of their maximum steady-state values: motor under maximum braking torque and brake unit tractive effort reaction under Full Service Brake application plus maximum track brake tractive effort load. All loads shall be applied with the phasing to produce the worst possible stress combination. Under these conditions, stresses shall not exceed the allowable fatigue values.

Fatigue allowable stress levels for truck materials shall be limited to published endurance stress values for smooth, flat, tension-tension specimens or recent Contractor tests with
sufficient individual tests to establish the endurance stress value for 95% survival at the 84% confidence level as defined in ASM Metals Handbook, latest edition. Fatigue allowable stress levels for welded connections shall not exceed the requirements of AWS D1.1 for Dynamic Structures or Contractor tests of the specific connection establishing its endurance stress (load) value for 95% survival at 69% confidence level. The Contractor shall submit its chosen static and fatigue allowable values, whether published or test values, to DART for review and approval with the Truck Stress Analysis and Testing Plan and finalized in the Stress Analysis Report.

The use of UIC 515-4 and UIC 615-4 as a basis for design conditions of the trucks may be permitted at the discretion of DART provided it is shown that the truck design conditions will aim to produce a truck that will meet the more severe track conditions, speeds, and truck weights in the U.S. In no case will the requirements of Section 11.4.2 be exempted.

A Truck Stress Analysis and Testing Plan shall be submitted not later than 120 days after NTP. (CDRL 11-7) It shall include an outline of the procedure the car builder Contractor will use to analyze and test the design of the truck.

The Truck Stress Analysis and Testing Plan shall include the following:

- Table of loads to be used for static analysis and test, with load magnitudes and points of application
- Derivation of the static loads to be applied
- Table of loads to be used for fatigue analysis and test, with load magnitudes, points of application, and phasing
- Derivation of the fatigue loads to be applied
- Diagrams of load applications
- Table of allowable stress levels

The Truck Stress Analysis and Testing Plan must be approved prior to the submittal of the Truck Stress Analysis Report required by Section 11.13.2.

11.13.2 Stress Analysis

The Contractor shall submit, prior to truck and bolster static and fatigue testing, a stress analysis of the motor truck frame and bolster and the center truck assembly. (CDRL 11-8) The stress analysis shall show the calculated stresses, allowable stresses, and margins of safety for all elements for all specified loading conditions. The stress analysis shall consist, as a minimum, of a finite element analysis of the global structure and a classical analysis of all connections, supplemented as necessary by manual or computerized calculations.

The Contractor shall submit and receive approval of its finite element model prior to performing the Finite Element Analysis (FEA). (CDRL 11-9) The Finite Element Model (FEM) Report shall include the element grid, all assumptions, and all input data, such as loads, section properties, boundary conditions and material properties. This information shall be included as part of this preliminary submittal and again as part of the complete analysis. The input shall have each page numbered, and columns of data shall be clearly labeled on each page using terms, symbols, abbreviations, and units defined in the report. A key to all symbols and colors shall be included. Boundary reaction forces of the truck under its own weight shall be included.
The Contractor shall submit a separate analysis of welds and welded connections that includes the fatigue classifications of each weld according to AWS D1.1. This analysis shall account for all welding on the finished truck frame, including welds attaching brackets, studs, and holders for all truck accessories. It shall include drawings of the truck welding locations, or FEM mesh plots with the weld locations indicated, with the AWS classification indicated. (CDRL 11-10)

The FEA input data and output data shall also be submitted on electronic media as approved by DART. (CDRL 11-11) Submittal of the input files is required with the model and at any time the file is changed, but not more often than monthly. Submittal of the output files is required with the FEA report and at any time the file is changed. Criteria for final approval of the stress analysis shall include the Contractor's submittal of the fully configured input data files as required by this paragraph. Each revision shall be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report as a result of the change.

All Reports shall have each page numbered, and columns of data shall be clearly labeled on each page using terms defined in the analysis.

The FEA report shall include color plots showing the following:

- Deflections in all three axes separately plotted and imposed over the deflected shape
- von Mises, or other approved combination stresses
- Maximum and minimum principal stresses
- Direction of maximum and minimum principal stresses
- Meshing accuracy index

The analysis shall also include at least the following:

- Table of Contents.
- A structural diagram (layout) of the truck frames and bolster showing all member locations and shapes, and indicating the material and thickness of each. The methods of joining shall be completely defined, including AWS D1.1 weld classifications for fatigue for all welds. Connections between the truck, bolster, and carbody shall also be clearly shown.
- Diagrams displaying external loads and supports applied to the truck frames and bolster.
- A summary of the results of calculations of stresses in all members. The locations where calculated stress levels equal or exceed 85% of the allowable stress criteria approved by DART in Section 11.13.1 shall be shown in a separate table along with the design or operating conditions (loads) which cause them. Calculated stresses shall be supported, where available, by the results of actual tests of trucks of identical design.
- An analysis of all critical connections of the truck frames and bolster major structural elements under all specified loading conditions.
- A tabulation of the Contractor's selection of allowable truck frame and bolster static and fatigue stresses and assumed applied fatigue stress ranges for the truck frames and bolster members that are fatigue critical. Allowable stress levels
shall be substantiated by the Contractor's test data or by citing published sources.

- Critical welds shall be as identified by the truck manufacturer and approved by DART, and shall include, as a minimum, all welds or portions of welds which, based on the results of the stress analysis and truck tests, are expected to be critical in fatigue.

- A table showing the engineering properties of each grade and temper of each material. This table shall include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension and compression, and shear elastic moduli. In each case, minimum-guaranteed values from the specifications for the corresponding grade and heat treatment of the material shall be used.

For those portions of the proposed designs which are based on a service-proven truck, fabricated by the same manufacturer at the same manufacturing facility, the Contractor may, with DART's approval, provide data from previous tests, historical data from operations, or stress analysis, as required above, to satisfy the corresponding portion of these requirements. (CDRL 11-12)

The information derived from the analysis shall be used to determine strain gauge locations and other criteria for the truck tests. The locations of all strain gauges shall be shown on plots of the FEA truck and bolster mesh with dimensions. The analysis shall be updated as the truck design proceeds.

11.14 Truck Serial Number

Each truck shall be provided with a serial number plate located in a conspicuous place. The figures shall be not less than 3/4 inches (20 mm) in height.

11.15 CDRL

The following documents shall be submitted for approval:

11-1 Calculations demonstrating carbody-to-truck connection strength (Section 11.4.2)
11-2 Journal bearing L10 life calculation (Section 11.5)
11-3 Strength calculation for axles (Section 11.6)
11-4 Axle press fitting procedures (Section 11.8)
11-5 Pressing graphs (Section 11.8)
11-6 Truck stress analysis and testing plan (Section 11.13.2)
11-7 Stress analysis report prior to testing (Section 11.13.2)
11-8 Request for approval of the Finite Element Model Report (Section 11.13.2)
11-9 Separate analysis of welds and welded connections (Section 11.13.2)
11-10 FEA input and output data on electronic media (Section 11.13.2)
11-11 Data from previous tests, historical data from operations, or stress analysis for a service-proven truck (Section 11.13.2)

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FRICION BRAKE SYSTEM

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SECTION 12
FRICION BRAKE SYSTEM

12.1 General

This section establishes the requirements for the vehicle friction brake system and control.

The friction brake system may be spring, hydraulically, or electrically actuated. Friction braking shall be provided on each independent wheel and on each axle. It is DART’s preference for the streetcar to utilize friction braking only as a stopping brake below the dynamic brake fade point in normal service operation. DART will consider streetcars which require supplemental friction braking to achieve the braking rates specified in Section 2.6.4 if sufficient braking effort cannot be supplied by dynamic braking alone and separate independent brake controllers are provided.

Within 180 days after NTP the Contractor shall prepare a friction brake system design report for DART’s review and approval. When data is requested in this Section for design review it shall be included in this report unless otherwise specified. (CDRL 12-1)

12.2 System Description

The friction disc brake system shall perform the following basic functions:

- Provide service and emergency braking in the event of dynamic brake failure
- Provide emergency braking with the assistance of dynamic brakes, track brakes and sand
- Act as a parking brake system
- Supplement dynamic braking to provide service braking, if required.

In the event of a dynamic brake failure in a single traction system, the friction braking shall provide equivalent maximum braking effort, but may do so with a different distribution of braking effort among the wheels/axles.

12.3 Brake System Configuration

The friction brake system shall have the following configuration:

- Each truck shall be controlled by a separate control unit, independent to the extent that the other trucks function fully if the control for one truck has failed.
- Each control unit, if provided separate from the propulsion control, shall independently interpret all trainline commands, propulsion interfaces, load signals and wheel slide signals.
- Separate, independent hydraulic pressure control units (HPCUs) shall be provided for each truck. If mounted to the truck frame, the HPCUs shall be resiliently mounted.
- Brake disc(s) and calipers shall be provided on each axle. The calipers for each truck shall be controlled independently by their respective controller and HPCU.
Disc braking shall either use spring pressure to apply the service and parking brakes with release by hydraulic pressure or use hydraulic pressure to apply the service brakes and spring pressure to apply the parking brake.

Two electromagnetic track brakes shall be provided per motor truck, for a total of four per vehicle. The track brakes shall function in maximum brake (MB) (Section 5.1.1.3), emergency braking (Section 2.6.6) and by manual control from the operator's console (Section 5.3.4). Track brakes may also be used to control wheel slide on severe downgrades.

A sanding system shall be provided that deposits sand immediately in front of the wheels. Sanding shall be automatically provided during emergency braking (Section 2.6.6), after detection of severe spin or slide conditions (Section 2.6.7), and by manual control by the Operator (Section 5.3.12).

Pressure switches, transducers, indicators, and auxiliary valves shall be provided, as necessary, to provide specified functions.

12.4 Friction Brake Power Source

The friction brake control equipment shall use the vehicle low voltage dc power system as the power source. Hydraulic pumps may use the ac power supply if redundant auxiliary power inverters are provided to maintain operation of all pumps in the event of a single inverter failure.

12.5 Performance and Control

If separate friction brake controllers are provided, the friction brake system shall directly and independently interpret the rate and brake mode selection signals generated by the master controller as specified in Section 5.1.1.1, the propulsion interface signals communicating dynamic effort produced and wheel slide control, and the emergency brake signal to provide the desired brake system response.

12.5.1 Load Compensation

Load weighing shall be used as the primary load compensation control input for all braking modes, including emergency brake tractive effort control, except track brake. The load compensation system shall adjust the braking effort to compensate for varying passenger loads on a per truck basis. Sensors and associated circuits shall be continuously or periodically checked to verify that they are functioning properly. Refer to Sections 2.6.11, 10.6.2 and 11.3.7 for additional information.

In the event a load sensor failure is identified the system shall default to AW0 braking effort on the effected truck.

12.5.2 Dynamic Brake Interface

A dynamic brake feedback signal shall be utilized by the ECU for each truck to reduce disc brake effort in response to the presence of dynamic braking on that truck.

12.5.3 Parking Brake

A spring-applied parking brake shall be provided for each wheel or axle.

The parking brake control signal shall be configured to release the parking brakes when energized (Section 5.3.10). A parking brake applied anywhere on a vehicle shall inhibit the propulsion and brake release indications as described in Section 12.5.6.
In pressure-released systems, parking brakes shall be controlled by application and release of the service brakes.

12.5.4 Track Brake Control

Track brakes shall be applied during maximum braking, emergency braking, and when commanded by the operator. Track brake applications during maximum braking and emergency braking shall be interlocked with the no-motion detection circuitry and disabled below the no motion detection point.

Track brake control and logic may be provided by relays and contactors separate from the disc brake or propulsion control logic. Each truck's track brakes shall be controlled by a separate relay and contactor circuit, fed from a separate circuit breaker.

12.5.5 Disc Brake Cutout

The disc brake system design shall include a method to release and cutout the disc brakes, allowing a vehicle to be moved in the event of failure.

12.5.6 Disc Brake - Propulsion System Interlock

The disc brake system shall be interlocked with the propulsion system such that propulsion is removed if any disc brake remains applied on any truck for more than 7 seconds after the application of propulsion.

Complete disc brake release shall be possible at all vehicle speeds down to zero.

In hydraulic pressure-applied systems, the disc brake system shall be interlocked on a direct basis with propulsion control to prevent the application of propulsion in the event there is insufficient fluid available to complete an all-friction Emergency Brake stop from the maximum vehicle speed.

12.5.7 Storage Capacity

Under all specified environmental conditions, the disc brake system shall have sufficient storage capacity after loss of hydraulic pump power to provide at least three full brake applications and releases, keeping the brakes applied for at least 30 sec per application, and brakes released for 2 min between applications. Full brake applications shall be at the FSB level for an AW3 car weight. Normal brake modulation shall be available. It shall be assumed that the power loss occurs when the accumulator hydraulic volume is at the minimum hydraulic pump cut-in pressure level.

The brake controls shall be provided with a means to detect when the fluid level in the hydraulic fluid supply reservoir is below the level recommended by the friction brake supplier for continued safe operation. Means shall also be provided to detect whenever any hydraulic accumulator supply volumes and pressures are below the minimum value necessary to achieve an EB AW3 stop. The pressures shall be sensed with non-adjustable pressure switches and volumes by sensing switches in the accumulators, pump rate check or by use of pressure measurements by system transducers and charging time calculations. When a low fluid supply reservoir level or low accumulator supply volume or pressure is detected the controls shall inhibit propulsion and annunciate a friction brake fault via the TOD.

12.5.8 Thermal Capacity (Duty Cycle)

The friction brake system shall have the thermal capacity to provide continuous operation with the duty cycle specified in Section 2.6.13. Operation shall be verified at full schedule speeds with dynamic brake functional. During this operation the disk brake temperature
shall not exceed 600°F (316°C) or the design limit determined by the disk or brake pad manufacturer, whichever is lower.

The friction brake system shall have the thermal capacity to provide for the abnormal duty cycles of towing or a truck cut-out as specified in Section 2.6.13. Operation shall be verified at restricted speed and with any transfer of braking effort to remaining functional propulsion systems. During this operation the disk brake temperature shall not exceed 900°F (482°C) or the design limit determined by the disk or brake pad manufacturer, whichever is lower.

The Contractor shall submit the simulations and component thermal ratings for DART's review and approval. (CDRL12-2)

12.6 Friction Brake System Components

12.6.1 Disc and Hub

All discs and hubs shall have thermal characteristics and strength to resist warping and cracking due to thermal stress resulting from the specified duty cycle.

The power truck discs supplied on the car may be either one-piece, with the hub arrangement for split replacement discs or a two-piece design attached to a hub. Split discs shall be provided as spare parts. The hub shall be pressed on the axle or may be attached to the gearbox output shaft. The disc and hub together shall statically balance within 40 ozf-in (0.28 N-m). Brake disks shall be interchangeable between power truck axles.

The center truck discs, if provided, shall be a one-piece design, which bolts to a hub pressed on the axle outboard of the wheel or mounted directly to the wheel assembly. The disc and hub together shall statically balance within 40 ozf-in (0.28 N-m). Brake discs shall be interchangeable between center truck wheels.

All discs shall be vented with radial or circular ribs separating the two friction surfaces to provide sufficient cooling between stops. The ribs shall be arranged to avoid generation of pure tone noise.

Wear indication grooves shall be provided on both edges of each disc to indicate the minimum allowable disc thickness.

12.6.2 Calipers, Actuators, and Pads

Brake actuators shall be mounted to floating calipers designed to follow the disc regardless of lateral axle motion. The calipers shall also accommodate all other relative motions between the brake discs and the truck frame without binding, causing accelerated wear, or damage to truck or brake components.

Each disc shall be equipped with one hydraulic pressure-applied actuator, with an integral spring-applied parking brake actuation device or one spring applied hydraulic-released actuator. The brake actuator including parking brake portion, shall include an automatic slack adjustment feature, which shall compensate for brake pad wear as well as assure drag-free running.

The brake pads and holders shall be designed for quick pad replacement without disassembly of the caliper unit. Brake pads shall be interchangeable between all axles of the same type.

Motor truck actuators and calipers shall be interchangeable among all motor truck axles. Center truck actuators and calipers shall be interchangeable among all center truck wheel-
axle assemblies, except as required to accommodate speed sensors or hose locations required by the truck design.

The brake pad, caliper, and disc assembly shall not emit audible squeal, chatter, or other undesirable sounds.

12.6.3 Hydraulic Pressure Control Unit

Each truck shall be provided with a Hydraulic Pressure Control Unit (HPCU). Each HPCU shall be mounted near the truck that it controls to minimize brake response time. The units shall be mounted in a protected location to prevent damage from dirt, dust, road debris, wheel splash, and unusual heating conditions such as cooling air outlet from propulsion equipment or radiant heat from brake discs. The hydraulic secondary suspension system for that truck (if used) may be integrated with the friction brake hydraulic system.

The HPCU shall contain a hydraulic fluid reservoir, motor-driven pump, accumulator (may be separately mounted), and all necessary control valves, pressure switches, and pressure transducers. All control valves, pressure switches and pressure transducers shall be mounted on a common manifold to minimize piping within the HPCU. All external connections shall be made directly to the manifold plate using self-sealing, quick-connect couplings.

The hydraulic fluid reservoir shall be designed to minimize the potential for contamination from particles or moisture. A breather-filter and pressure release valve (opening at approximately 3 psig (0.2 bar)) shall be provided. The reservoir shall be provided with a drain plug, fluid level sight glass, and a self-sealing, quick-connect coupler for filling.

The brushless dc motor driven pump shall operate from the vehicle low voltage power supply and shall function properly over the range specified in Section 2.4.2. The motors may be operated from the ac power system if redundant ac power supplies are provided with automatic changeover to the other supply if the connected supply fails. Refer to Section 2.4.3 for ac power system information. The pump shall charge an accumulator with fluid from the reservoir for wheel slip control and service braking applications. Designs in which the pump motor operates continuously to maintain pressure will not be permitted. The pump motor shall use sealed bearings, and shall be totally enclosed, non-ventilated, and rated for wash-down applications. The motor mounting shall preclude the ingestion of hydraulic fluid or fumes.

A nitrogen-charged accumulator shall be provided to store the hydraulic energy. The pressure levels, volumes, and pressurized fluid levels shall be sufficient to meet the required performance and response times for brake applications and wheel slip control specified in Section 2.6 at all ambient conditions.

Pressure transducers shall be utilized for feedback, testing, and the failure monitoring system. Transducers shall be low drift, temperature compensated devices which shall not require calibration more often than once a year. Transducers shall be insulated and transient protected to allow them to pass a 1080 Vac, 60 Hz, 1-minute high potential test and otherwise survive in a high transient voltage environment.

12.6.4 Friction Brake Control Logic

The friction brake system control logic units (if provided) shall be microprocessor-based with associated peripherals and I/O, as required, to meet all of the specified functions and performance criteria. The control units shall provide self-diagnostic routines, fault monitoring of internal and external devices, and user programmable operating characteristics. Control
programs shall be stored in field-programmable, non-volatile memory. The friction brake controls shall comply with the design requirements of Sections 2, 9 and 16.

Within 180 days of NTP the Contractor shall submit a friction brake controller system design package. (CDRL 12-3) The submittal shall include both hardware and software control functions and their interdependencies and comply with the documentation requirements of Section 17.27.3.

Independent control logic units and logic power supplies shall be provided for each truck such that one truck can function if the friction brake equipment for the other has failed or has been cut-out.

Electronic control equipment shall be segregated from the power equipment. Control circuitry and control voltage sources shall be isolated from power circuitry and high voltage sources using opto-couplers or transformers.

The control unit shall provide continuous monitoring of critical parameters, including hydraulic pressures, vehicle weight, and external vehicle effort and control requests. The control unit and all related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions such that equipment damage is prevented or minimized. System faults shall be time stamped and stored in memory. The diagnostic system shall function with the vehicle Monitoring and Diagnostics System and comply with the requirements of Section 9.8.

12.6.5 Track Brake

The track brake system shall be effective at all speeds from maximum down to full stop over all conditions of curves and grades. Track brake force shall not be modulated by blending, load compensation, or other means.

The track brakes shall be fully watertight. Coils shall be enclosed in a non-magnetic, corrosion-resistant case with all coil voids filled to form a hermetically-sealed unit. Coils shall be electrically isolated from all grounds and shall be terminated in a built-in two pin connector or other approved connection. Connection to vehicle wiring shall be via flexible cable(s) with waterproof connectors at both ends.

All track brake forces shall be transmitted to the truck through bonded rubber elements. If it is necessary to remove the track brake to renew the rubber elements, they shall be applied to the track brake assembly rather than the truck. Track brake mounting which does not require rubber elements, but which provides for quiet operation, will be considered for approval by DART.

Track brake shoes and the pole filler material shall be readily replaceable. The wear surfaces shall be smooth and shall not wear grooves or ridges in the rail head throughout the life of the track brake shoe.

Track brakes shall not interfere with track, wayside, or truck components under all normal conditions and combinations of wear. In the area between the railhead and 2 in (51 mm) above top of rail, the track brake shall not extend laterally beyond the wheel tire cross section with fully worn track brake shoes.

In a de-energized state, the track brake shall be suspended above the rail by springs and shall be located laterally by resilient stops. Track brake motion while suspended shall not produce audible noise under any normal operating condition. Vertical clearance above top of rail, when de-energized, shall be maintained under all loading conditions. Provision for adjustment shall be provided to maintain proper clearances.
A separate track brake contactor and circuit breaker shall be provided for each truck. Tripped or open track brake circuit breakers shall cause annunciation of a friction brake fault.

12.7 Sanding System

Each vehicle shall be provided with electrically-heated sandboxes, pneumatic or gravity fed sand traps, and sanding nozzles arranged to deposit sand on both rails immediately in front of the streetcar's wheels.

Sanders may be operated from the streetcar's air supply system, if provided, or may be unitized sanding systems with integral pressurized sandbox, compressor, heater, and controls which provide the sanding functions described below.

The output of the trap shall be through piping or hose selected and arranged to permit the free flow of sand to the nozzles under all conditions of environment and truck rotation. Tees, elbows, or other restrictive fittings shall not be used.

Sanding nozzles shall be fastened to the truck frame and connected to the sand traps by flexible hoses. The nozzles shall be shaped and located to deposit sand directly in front of, and as close as possible to, the wheel/rail contact point. Nozzles shall be designed to reject water caused by wheel splash.

The sanding system shall be powered from the low voltage system through an independent circuit breaker per truck. The circuit breaker shall also function as the sander cut-out switch. Tripped or open sander system circuit breakers shall cause annunciation of a friction brake fault.

Sander control and logic may be provided by relays separate from the friction brake control logic.

12.8 CDRL

The following design submittals are required:

12-1 Friction brake system design report (Section 12.1)
   Friction brake system configuration
   Outline drawings and mounting of major components
   Hydraulic system schematics
   Hydraulic fluid specifications
   Truck cut-out and mechanical brake release
   Interfaces with propulsion system
   Track brake details
   Sanding system details

12-2 Abnormal duty cycle report (Section 12.11)

12-3 Friction brake controller design report (Section 12.6.4)
   System functional description
   Hardware design description
   Software design description
# SECTION 13

## VEHICLE COMMUNICATIONS

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SECTION 13

VEHICLE COMMUNICATIONS

13.1 General

The on-board communication system includes the public address (PA), passenger emergency intercom (PEI), cab-to-cab intercom, and closed circuit television (CCTV), automatic vehicle location (AVL), traffic priority, and automatic passenger counting (APC) systems.

The Contractor shall furnish all communication equipment specified below except for the train radios which will be provided by DART. The Contractor shall make all mounting provisions and provide all mounting hardware for DART-supplied equipment.

All communications and passenger information equipment shall be rated for continuous duty. Control and power circuits for all communications and passenger information equipment shall be isolated from the chassis and cabinets and shall be rated to pass the insulation tests specified in Section 16.2.

All communication equipment shall be powered from the low voltage dc system.

DART will consider alternate integrated designs based on Ethernet network communications.

13.2 Audio Communications Functional Description

The communications system shall be configured to allow the following audio communications:

- From the operator to passengers inside and outside the train
- Among cabs in a vehicle, and the cabs of a vehicle being towed
- Between passengers inside the vehicle and the operator
- From the passenger information system to passengers inside and/or outside the train via pre-recorded announcement sequences and destination sign displays
- From the door system to passengers inside and/or outside the vehicle
- Detection of failures and reporting to the MDS system described in Section 9.8

13.3 Audio System Control Head (ACH)

13.3.1 General

The ACH shall be furnished and installed in each cab as an integral part of the Operator's console. The ACH shall be subject to DART's review and approval. (Include in CDRL 13-1.)

The ACH shall consist of:

- Gooseneck microphone (mounted separately from the ACH)
- Mode or function switches with indicating lights (PA and Passenger Emergency Intercom)
• PA mode selector switch (interior, exterior, or both)
• Intercom chime
• Two loudspeakers per cab: one for two-way radio and one for PA/Intercom, mounted independently in the Operator's cab
• Intercom speaker volume control
• Automatic Announcement Control Panel (AACP) (may be integrated into ACH or mounted separately)
• Circuitry to implement the functional requirements specified herein

All audio circuits between control points, communications units, and the ACH shall be at the +7 dBm level.

The momentary pushbuttons shall be vandal resistant and shall be designed and type tested for ten million failure-free operations.

Alternative arrangements that integrate the control panel functionality with the Train Operator’s Display may be proposed and shall be subject to DART’s review and approval. (Include in CDRL 13-1.)

13.3.2 Gooseneck Microphone

The Contractor shall furnish a gooseneck microphone in each cab. The gooseneck microphone shall be usable for all intercom and PA modes. The gooseneck microphone shall comply with the following requirements:

• It shall be of rugged, weatherproof construction and shall be designed and constructed for transportation applications.
• It shall employ a noise-canceling, close-talking style of dynamic microphone.
• The microphone cable shall be enclosed in the flexible gooseneck microphone mount, which shall be securely attached to the console. The mounting at the panel shall be secured from the interior of the Train Operator's console.
• The gooseneck length shall permit a seated Train Operator in the fifth female to ninety-fifth male percentile height range to speak into the microphone without leaving the normal operating position or losing sight of traffic in front of the vehicle.
• The microphone cable shall terminate at a circular connector on the back of the ACH.
• The microphone shall be vandal resistant.

The selection and installation of the microphone shall be subject to DART’s review and approval. (Include in CDRL 13-1.)

13.3.3 Radio Interface

Interface connections shall be provided for the radio loudspeaker if the loudspeaker is mounted as part of the ACH.
13.4 Public Address System

The public address system shall permit the operator and the passenger information system to make audio announcements to passengers inside or outside the vehicle. The operator shall select the inside speakers, outside speakers, or both from the cab console.

Automatic door system signal tones and announcements may be enabled by receipt of a control voltage signal from door control system, which shall cause the audio system to enter the PA mode and for it to accept an audio signal from the door control system. Alternatively, the control signal from the door system may use the automatic station announcement system to generate the door signal tones and announcements.

Operator initiated PA messages shall override passenger information system and door system messages.

All messages shall be intelligible and acoustically pleasing under all operating conditions. Speech peaks shall be limited to approximately 8 dB above the average input level of +7 dBm.

Preceding any public audio announcement, including automatic announcements, a local tone annunciator shall be energized to alert passengers that an announcement is forthcoming. The tone volume shall be 3 dB above the normal speech level. The annunciator shall possess a pleasant, chime-like quality.

The PA system, from the input of the microphone (or digitized audio messages) to the output of the speakers, shall have a 90% intelligibility rating when tested according to ANSI S3.2, latest revision, “Method for measuring the intelligibility of speech over communications system.

The Contractor shall submit, within 180 days after NTP, a Public Address Design Package (CDRL 13-1) for review and approval by DART.

13.4.1 Amplifiers

All preamplifiers, mixer amplifiers and power amplifiers shall have a frequency response of at least 200 Hz to 10 kHz +1, -2 dB at rated output. All preamplifiers, mixer amplifiers, and power amplifiers shall be subject to DART’s review and approval. The frequency response of power amplifiers below 200 Hz shall fall off at a rate of no more than 6 dB per octave. The power amplifiers shall have a minimum of 50 W output power, continuous. The total harmonic distortion of all amplifiers, without compression circuits, shall not exceed 1 percent at 1 kHz and full output.

Compression circuits shall be provided to maintain output regulation of +1, -0.5 dB, no load to full load, measured at the loudspeaker terminals.

The power amplifier shall be a bridging, 70.7 V line, distribution, balanced amplifier.

The preamplifier shall be capable of delivering not less than +17 dBm to the passenger loudspeaker power amplifiers.

The radio output amplifier shall be used for driving the cab radio loudspeaker.

The intercom output amplifier shall be used for driving the intercom loudspeakers.

13.4.2 Automatic Volume Control

The PA system interior and exterior output levels shall be automatically adjusted in accordance with ambient noise levels prior to each announcement, regardless of origin.
The range of automatic adjustment shall be a minimum of 15 dB. The maximum output level shall be at least 15 dB above typical worst case ambient noise level at any location.

13.4.3 Interior Speakers

Interior loudspeakers shall be subject to DART’s review and approval and shall meet or exceed the following criteria: (Include in CDRL 13-1)

- A minimum of one loudspeaker for every 8 ft (2400 mm) of car length shall be located in the passenger areas inside the cars. They shall be mounted in the ceiling panels to provide even coverage in each body section. All loudspeakers shall be no more than 6 dB down, 50 degrees off axis with a test tone of 5 kHz.

- All passenger area inside loudspeakers shall have a nominal 6 inch (150 mm) or 8 inch (200 mm) outside diameter and nominal impedance of 8 ohms. The interior loudspeakers shall have an axial free-field sound pressure of 95 dB (minimum) re 0.0002 dyne/cm\(^2\) at a distance of 3.3 ft (1.0 m) with one watt input. They shall have a continuous power rating of at least 4 W.

- Loudspeakers shall be mounted in enclosures of 0.5 ft\(^3\) (0.014 m\(^3\)) volume or larger. The entire interior surface of the enclosure shall be covered with sound absorbing material. In its enclosure, the frequency response of the loudspeaker from 300 Hz to 8 kHz shall be no more than 7 dB below its response at 1 kHz. The enclosure shall include knockouts and gaskets for the dust tight entrance of the speaker connection leads. Alternative arrangements that mount the speakers on corner or ceiling panels and provide equal or better performance may be submitted for DART’s review and approval.

- The PA/intercom and Radio loudspeakers in the Operator's cab shall have a nominal dispersion angle of not less than 90 degrees. The cab speaker shall be designed to provide a good sound production in the voice frequency range from 300 Hz to 3000 Hz under noise conditions and shall be rated for a minimum of 5 watts. The Operator’s cab PA speaker shall have a volume adjustment control that can be adjusted by the Operator. The cab loudspeaker impedance shall be 8 Ohms.

- If required by the design, a transformer shall be an integral part of each passenger-area interior loudspeaker assembly to match a 70.7 V line to the loudspeaker impedance. The power delivered to the loudspeaker from the transformer shall be 0.5, 1.0, 2.0, or 4.0 W, selected by connecting the appropriate transformer lead wire to a screw terminal strip.

- A matching transformer shall not be used in conjunction with the cab loudspeakers.

- Each loudspeaker shall be protected by a perforated metal or plastic grill designed to adequately protect the loudspeaker from the effects of dust, moisture, and foreign objects while permitting sound transmission and coverage in accordance with these Specifications. Grilles for all loudspeakers in the inside passenger area ceiling panels shall be flush mounted, finished to match the panel, removable for access to the loudspeaker, and held in place with tamper-proof screws in a manner which allows for easy troubleshooting and maintenance.
13.4.4 Exterior Loudspeakers

Exterior loudspeakers shall be subject to DART’s review and approval and shall meet or exceed the following criteria: (Include in CDRL 13-1)

- The exterior loudspeakers shall have a minimum free-field sound pressure of 121 dB re 0.0002 dyne/cm² at a distance of 3.3 ft (1 m) from the loudspeakers at 15 W input power. They shall have a continuous power rating of 15 W, minimum. In its enclosure, the frequency response of each loudspeaker from 350 Hz to 8 kHz shall be no more than 7 dB below its response at 1 kHz. Arrangements with less sensitive speakers and more powerful amplifiers to provide the specified sound level will also be acceptable.

- The exterior loudspeaker sound level shall be no more than 6 dB down, 50 degrees off axis with a test tone of 5 kHz.

- The audio power delivered to each exterior loudspeaker shall be transformer adjustable and that transformer shall match the loudspeaker's impedance to a 70.7 V line. The power delivered to the loudspeaker from the transformer shall be transformer tap adjustable to 0.9, 1.8, 3.8, 7.5 or 15 W.

- A minimum of four external loudspeakers per vehicle, two per side, shall be located such that passengers at left hand, right hand or both side passenger station levels may be addressed as switched by the ACH and associated equipment. These loudspeakers shall be impervious to environmental conditions as outlined in Section 2.3.5.

- A waterproof method of mounting loudspeakers and routing the loudspeaker wires shall be utilized. The loudspeaker locations shall not violate the vehicle’s dynamic outline. They shall be immune to the chemicals and detergents normally used during car washing, shall not interfere with nor damage mechanical car wash brushes, and shall be designed to withstand forces generated by these brushes.

13.5 Intercom System

The intercom system shall allow calls to be initiated from either cab, with or without an active console, any passenger emergency intercom station in the vehicle, or either cab of a streetcar being towed. The Contractor shall submit, within 180 days after NTP, an Intercom System Design Report for review and approval by DART. (CDRL 13-2)

13.5.1 Cab-to-Cab Intercom

A cab-to-cab intercom call shall be annunciated in every cab, by means of a one-time call chime and an indicating light. The indicating lights shall stay on until the call is completed.

Provision shall be made for the connection of the cab-to-cab intercom system between vehicles during towing operations. A separate cable which attaches at either cab end through a weather-proof connector shall be provided as described in Section 4.6.

13.5.2 Passenger Emergency Intercom (PEI)

The passenger emergency intercom system shall allow communication between passengers in the vehicle and the operator. At least four units shall be installed in the vehicle, at locations determined by DART.

The system shall function as follows:
• Pressing the call request button at a PEI station shall cause each call request to enter a first-in, first-out queue in the PEI control system. A light on the PEI station shall illuminate, indicating acknowledgement of the call request.

• When the call request comes to the top of the queue, the operator is hailed via a tone and indicator lamp at the active cab console. The operator acknowledges the call by pressing an acknowledge button, which sets up a half duplex communication channel between the active cab and the PEI station. The operator may speak to the passenger when the microphone switch is pressed, and the passenger may speak to the operator when the switch is not pressed.

• Audio from the passenger is heard in the cab speaker. Audio from the operator is heard by the passenger via the speaker in the PEI station.

• When the conversation is finished, the operator terminates the call by pressing a button on the cab console and the active PEI station returns to an inactive state. If there are no more calls in the queue, the PEI session is terminated. Otherwise, the next call in the queue hails the operator in the same manner.

• If the operator activates other audio functions on the cab console, all PEI activities shall be placed on hold and the queue is maintained. The PEI indicator lamp on the cab console shall remain illuminated. The operator shall return to the PEI session by pressing a button on the cab console.

• Passenger emergency intercom stations (a minimum of two of the total four per car) shall be located in each wheelchair area so as to be easily accessible for wheelchair patron's use. The unit shall be flush mounted at a height of 48 inches (1220 mm) above the floor.

Audio from the passenger intercom shall be heard only in the active cab and at the active PEI station.

13.5.3 PEI stations

The passenger emergency intercom unit shall consist of a panel-mounted enclosure constructed from stainless steel, which shall enclose a loudspeaker, microphone, large pushbutton switch, an indicating light (which may be part of the pushbutton switch), and any necessary auxiliary components to make the system function. The units shall be of splash-proof, vandal-resistant construction.

The pushbutton shall be arranged to prevent unintended nuisance application during crowded conditions in the passenger area.

The passenger emergency intercom unit shall be marked with engraved graphics, in English text and Braille, to identify the unit as an "Emergency Intercom" unit. The instructions shall read, "To Contact Driver Push Button Once", or approved similar language.

13.6 Passenger Information System

The vehicle shall include a Passenger Information System (PIS) for automated broadcast of pre-recorded audible and visual announcements of transit system information such as train location and destination as well as destination information to passengers on the wayside.

The control of all destination signs, audio announcements, and controls, shall be interfaced using an Ethernet network, using a mesh topology, where a single point network failure shall not cause the system to fail.
The Contractor shall submit, within 180 days after NTP, a Passenger Information System Design Package for review and approval by DART. (CDRL 13-3)

13.6.1 Functional Description

Announcements shall be triggered automatically by route selection, vehicle position, door openings and manually via the operator’s console control. The system shall function automatically, after the starting location has been entered by the Operator, as the vehicle proceeds from station to station.

Audio announcements shall be broadcasted over the PA system, and corresponding visual announcements shall be displayed on the interior information signs. The message database structure shall include instructions to direct audio to the interior, exterior, or both speaker sets.

The system shall provide as a minimum the following passenger information:

- Station Arrival Information: Station identification may include station name, exit locations, and bus or train transfer information
- Next Stop Announcement: When leaving a station, the system shall broadcast next station and train destination information
- End of Line
- Destination/Route Description
- Public Service Announcements

13.6.2 User Programming, Message Formats

The system shall have enough capacity to store 50 routes, with a minimum of 100 stations for each route, 10 audio, and 10 text messages per station, and no less than 50 special messages, audio and text. Storage for audio messages shall assume at least 30 seconds per message. Text messages shall assume 100 characters each. Message capacity shall depend only on available memory. There shall be no inherent limitation built into the control software or algorithms. Message, station, and route data shall also be up-loadable via a common data protocol and connector, such as Ethernet.

Audio messages shall be encoded and stored in a common, publicly available, digital format such as MP3. Audio sample rates and compression levels shall be chosen for excellent human voice and good music fidelity at the speaker. Audible noise or distortion shall not be present in the message. The audio recording and playback processes shall be submitted to DART for review and approval.

All audio messages shall be recorded using an approved human voice and shall be submitted to DART for review and approval, include in CDRL 13-3.

The system shall use a database structure to store all data. Each audio and text message shall be stored with, or linked to, related information identifying the message type, destination device addresses, distance-on-route for automatic message triggering, and similar parameters.

The system shall provide for multi-lingual announcements. Multi-lingual announcements and visual displays shall be automatically produced by the pre-programmed selection of the desired languages. The system shall be capable of activating passenger information in English and Spanish with a provision for at least three additional languages.
The updating, creation, deletion, uploading, and downloading of PI system information shall be intuitive, database and/or list structured, and shall be contained within 1 program; recording of audio messages can be performed using different software. The approach will be submitted to DART for approval, include in CDRL 13-3.

A complete set of equipment for the recording and modification of the visual and audible messages, and routes shall be provided. The system shall be comprised of standard commercial off-the-shelf equipment. This equipment shall include everything required to reprogram the on-board systems with new messages, routes, and stations, include in CDRL 13-3.

### 13.6.3 Operator Controls

The operator shall be provided with a control panel which will allow:

- Initiating the system
- Entering temporary information such train ID, and operator ID
- Entering route ID
- Selecting specific messages
- Altering the normal message sequence, such as skipping stations
- Display of system status and other relevant information

The control panel shall include a keypad or similar input device with function specific keys. Entering commands via codes is prohibited. The panel shall include a display showing system states, entered information, system diagnostic and fault data, presently announced messages, and similar information. The display shall be a back-lit LCD or authorized alternative.

### 13.6.4 Initiation of Announcements

The system shall be initiated by the operator by entering a route ID number, which shall determine which message sequence and special features are to be used by the system. The present location of the vehicle in the route’s station sequence may also be entered if vehicle location is not known at initiation.

Once initiated, the system shall be self-controlling via a GPS system or knowledge of train position, calculation of distance, door openings, and the route definitions stored in the system.

System initiation shall also establish the settings for the end destination signs in each cab, and all side destination signs in the vehicle.

When the cab is activated, the system shall initiate itself to the last route ID, or to a default setting if the last active ID is not present. The route ID shall be stored when the cab is keyed off.

### 13.6.5 Announcement Alert

The system shall provide the means to alert passengers to a forthcoming announcement. The alert shall consist of an audible chime and a flashing visual message indicating a forthcoming message.
13.6.6 Destination and Information Signs

An electronic destination sign system shall be installed on each car, complying with all requirements of the Americans with Disabilities Act. The proposed destination signs shall be submitted to DART for review and approval, CDRL 13-4. The submittal will include a presentation to DART of an operating sample of each type of destination and information sign proposed.

All cars shall have a minimum of four interior and four exterior signs. The internally-viewed signs shall display the passenger information identified in this Section. The interior signs be installed in the rear wall of the operators cab and in the center of the passenger compartment at approved locations and display passenger information. The contractor may propose one double-sided display mounted to the ceiling in the center of the passenger compartment as an alternative to the two individual signs at that location for approval by DART. Externally-viewed side signs shall be located, one near each side entry door, and one above the cab windshield, displaying destination or route information. Alternate locations may be submitted for approval by DART. (Include in CDRL 13-4)

Visual display signs shall be either, single-line, back-lit LCD displays, yellow or amber on black, capable of scrolling a message, as approved by DART. The signs shall be, minimum, single-line displays 12 alpha-numeric characters. Interior signs shall have a minimum character height of 3 inches (75 mm), while exterior signs shall have a minimum character height of 5 inches (125 mm). The visual display signs shall be mounted behind polycarbonate windows, and shall be vandal-proof.

Cab front displays shall be visible at a distance of no less that 150 ft (46 m) in bright sunlight.

13.7 Radio Provisions

The radio set, one set per cab, consisting of radio transceivers, radio control heads, radio handset including hanger and hook switch, radio headset jacks, and radio antennas, all installation and integration into the vehicle will be supplied and provided under this contract. The radio set shall based on the Harris, Ma-Com 5300 family of equipment or approved equivalent. The radio shall be designed and configured for an “open sky” environment.

The Contractor shall furnish the radio power converter (one per cab), cab speakers, and all interconnecting cables and connectors between the radio transceiver and other communications equipment and install the complete radio systems in each vehicle. Each end of the vehicle shall have an independent radio set.

The Contractor shall prepare a train radio design report for DART’s review and approval. It shall include radio set, antenna mounting location and methods, radio dc-to-dc converter ratings and design, electrical schematic drawings, mechanical drawings, and the plans for installing and testing the radio set function. (CDRL 13-5)

The Contractor shall test the radio set and all equipment to verify it functions properly.

13.7.1 Vehicle-Mounted Antenna

A weatherproof, low profile antenna (one per radio transceiver) shall be mounted on the roof of the car near each radio transceiver. The antenna, cable, and matching cable connectors will be furnished by DART as part of the radio package. The antenna mounting location shall be subject to DART’s review and approval, submitted as part of the train radio report noted above. The antenna installation shall not exceed the dynamic envelope and the antenna
shall not protrude in such a manner as to be a safety hazard. The location shall not interfere with or damage mechanical car washer brushes and shall be designed to withstand forces generated by these brushes.

A waterproof method of mounting the antenna to the carbody surface shall be provided.

The antenna cabling shall be installed in 1.5 in (38 mm) diameter conduit.

13.7.2 Radio Power Converter and Protection

A dc-to-dc power converter, (one per transceiver), shall be provided to power the radio equipment. The dc-to-dc power converter shall be subject to DART’s review and approval, to be submitted as part of the train radio design report noted above. The power converter shall be of a proven design, with at least five years successful operating history, in revenue service, on rail transit or railroad vehicles. The output voltage of the converter shall be adjustable from 12 Vdc to 14 Vdc with a 13.7 Vdc nominal setting. The unit shall be rated for a continuous output current of 20% greater than the maximum load current drawn by the transceiver. The converter shall be powered from the vehicles’ low voltage dc power supply, with a dedicated circuit breaker for each converter.

Line and load regulation of the converter shall be 1% or less over the full range of the low voltage power supply and from 0 to 100% rated load. Output noise and ripple shall be 75 mV rms or less at full rated output.

The converter shall include as a minimum the following protective features: Input voltage transient protection with energy levels up to 140 J and peak currents of 2000 A; input-to-output isolation of 1500 Vdc; and the output shall be short circuit-proof.

The converter shall include output over-voltage protection and current limiting, with backup protection provided by a circuit breaker. The converter input shall be protected by a circuit breaker as specified in Sections 9 and 17.

The power converter shall be installed in close proximity to the radio. All wiring between the two units shall be sized to allow no more than a 1.0 Vdc drop in the wiring at maximum rated load.

13.7.3 Radio Control Head and Handset

The Contractor shall design the console to accommodate the radio control head, radio handset, handset hanger, and hookswitch. The Contractor shall install this equipment and associated interconnecting wiring. (Include in CDRL 13-5)

13.7.4 Radio Inter-Unit Wiring

The Contractor shall furnish and install wiring between the antenna and radio transceiver, radio control head, radio handset, radio loudspeaker, and power converter, and between the radio and the communications system ACH (one in each cab).

13.8 Video Monitoring and Recording

The Contractor shall submit a design report on the video monitoring and recording circuit television equipment for DART’s review and approval. (CDRL 13-6)

The contractor shall provide a high-resolution, color camera-based vehicle interior and exterior surveillance system. The system shall record all areas of the interior and the exterior areas seen by the forward facing and rear facing cameras when an active cab is established. Cameras shall be tamper proof and blend with the interior and exterior finishing
so that they are minimally apparent. Sensitivity shall be sufficient for any possible combination of ambient and vehicle interior or exterior lighting levels, including vehicle emergency lighting. LCD monitors are not required for the forward facing or interior surveillance cameras. The surveillance system shall consist of the following:

- A minimum of one Digital Video Recorder (DVR) shall be installed on the vehicle. The DVR shall include sufficient memory to record not less than the most recent 72 hours of activity from each of the interior and exterior camera at 30 frames per second, input ports for all vehicle cameras, and at least two spare input ports for future use. The DVR shall record, in addition to video, the time, date and vehicle number. Image storage capacity shall be adjustable via revisions to the recording speed, selective resolution, and drive size.

- A minimum of four ceiling mounted color cameras shall be installed inside the passenger compartment to provide 100% coverage. All video shall be recorded on the DVR.

- Rear facing exterior mounted cameras with City approved zoom lenses shall be installed on the exterior of the vehicle to provide 100% viewing of all doors. The signal from these cameras shall be of sufficient strength to provide clear video on both the monitors and DVR.

- A minimum of two forward facing exterior mounted cameras shall be installed on each end of the streetcar to provide 100% viewing of traffic signals and pedestrian crossing signals on both sides of the cab. All video shall be recorded on the DVR.

- A minimum of four LCD color, 7.0 inch (180 mm) minimum diagonal monitors, two per cab minimum, to display the video from the rearward facing exterior cameras. Signals from the left-side cameras shall be displayed on the left hand monitor or left side of the screen; signals from the right side cameras shall be displayed on the right. The monitors shall be backlit for night-time viewing and shrouded to prevent wash-out in bright sunshine conditions. The monitors shall be fully adjustable via the use of a swivel ball-joint mechanism. The ball-joint shall be loosened via a hand “wing nut” and re-tightened once the orientation of the monitor is acceptable to the Operator.

Each interior and exterior camera shall be housed within an enclosure that blends into the interior panel or exterior panel to which it is attached and shall not interfere with the cab door or any other vehicle device. Each camera shall be fully adjustable via the use of standard hand tools. One camera type, with different lenses, shall be used on the streetcar. This shall allow the use of the single-type camera at any interior or exterior location with the installation of the proper lens. Each lens, rear facing, forward facing and interior, shall be compatible with the single-type camera. The minimum camera resolution shall be 1.3 megapixels (1280 x 1024) and 16.7 million colors.

13.8.1 Viewing and Retrieving Recorded Video Images

The captured digital images shall be stored as color files and shall be capable of being taken from the DVR via a laptop PTU with the use of City-approved viewing/browsing software. The DVR shall connect directly to the laptop via an Ethernet connection or through a docking station to the laptop. The laptop shall use Windows 7 or approved equal. It shall be capable to download all recorded video images from the DVR and store these images on the laptop PTU. Once the stored video images are on the PTU, it shall be possible to copy
or transfer these to standard recordable media or USB Flash Memory Drives. These shall allow viewing of the copied or transferred images on standard Windows based personal computers.

The video recorder shall include an audio track to continuously capture interior and exterior sounds using a convert microphone in the active cab.

The DVR shall also provide for a removable storage medium, flash or disk drive, to enable the original video to be removed from the vehicle and stored in a secure location. An external drive may be used for this purpose.

13.9 Automatic Passenger Counting System

13.9.1 General

The Contractor shall provide each streetcar with an automatic passenger counting (APC) system. The system shall count the passengers that enter and exit the vehicle at each station and the passenger count, location, time, and car number shall be recorded in an on board database. The system shall automatically transfer the data to the wayside at the Operations and Maintenance facility via wireless LAN transceiver (Wi-fi) once every twenty-four hours at a time selected by DART.

The system shall count passengers with an accuracy of 95% or better for each round trip. Sufficient memory shall be provided to hold 8 days of data, assuming 20 round trips a day.

The Contractor shall provide the necessary operating software for the vehicle, and the software needed for PTUs to maintain the system and download and analyze the data. Software shall also be provided for the collection and analysis of the data transmitted to the Operations and Maintenance facility workstation running Windows 7. The Contractor shall provide DART with any necessary licenses to use the software for the design life of the vehicles.

The system shall consist of the equipment described below. The equipment shall conform to the material and design requirements of Section 17.

The Contractor shall prepare a design report on the APC system for DART’s review and approval. (CDRL 13-7) The report shall include:

- Functional specification for the system
- Mechanic specifications of the system hardware
- Electrical specifications of the system
- Software design description
- Mechanical assembly drawings with weights, dimensions, and parts lists
- Electrical wiring schematic drawings for system interconnections
- Electrical schematic drawings for each device and assembly
- Installation drawings

13.9.2 APC Doorway Equipment

Each doorway of the vehicle shall be equipped with multiple sensors and associated logic unit to sense passengers entering and exiting the vehicle. The combination of sensors and logic shall properly detect and indicate the correct passenger count regardless of whether
single or multiple persons are simultaneously entering or exiting at a doorway or any simultaneous or overlapping combination of entrances and exiting persons.

The APC doorway equipment shall function accurately regardless of the size of the passenger, from small child to large adult.

The APC doorway equipment shall not interfere with operation of the doors.

The APC doorway equipment shall receive an indication from the door system when the doors are open.

Direct connections shall be used to communicate between APC sensors and the APC doorway logic unit.

### 13.9.3 APC Logic Unit

An APC Logic Unit shall be provided to collect, process, and store the data from the APC doorway equipment described above when the doors are open and no-motion is detected. It shall determine the location of the vehicle via a GPS system. Alternate methods such as using the starting location from the Automatic Announcement and Display System and distance traveled information from the propulsion system may be proposed for DART's approval.

Logic shall process the door and location data and store it in non-volatile memory with sufficient capacity to comply with the requirements of Section 13.9.1.

The APC Logic Unit shall contain logic to detect system faults and receive fault data from the APC doorway equipment. A fault log shall be maintained in the APC Logic Unit. In addition to functioning with the PTU to permit manipulation and display of this data, the system shall communicate with the MDS subsystem to transmit the fault information.

### 13.10 CDRL

The following design submittals are required:

13-1 Public address design report (Section 13.4)  
Audio control head  
Integration of audio control head with TOD  
Cab microphone and speaker  
Public address amplifier  
Interior and exterior speakers  

13-2 Intercom design report (Section 13.5)  
System functional description  
Details and mounting of passenger intercom units  

13-3 Passenger information system design report (Section 13.6)  
System functional description  
Initial programming with audible announcements  
Software and hardware for modifications  

13-4 Destination and information signs (Section 13.6.6)
13-5 Radio installation provisions (Section 13.7)
13-6 CCTV design report (Section 13.8)
   Camera details and locations
   Viewing range of each camera
   DVR details
   Retrieval and viewing software
13-7 Automatic passenger counting design report (Section 13.9.1)

END OF SECTION
SECTION 14
AUTOMATIC TRAIN PROTECTION,
TRAIN STOP SYSTEM,
TRAIN-TO-WAYSIDE COMMUNICATION,
FARE COLLECTION EQUIPMENT AND
EVENT RECORDER

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SECTION 14

AUTOMATIC TRAIN PROTECTION, TRAIN STOP SYSTEM, TRAIN-TO-WAYSIDE COMMUNICATION AND EVENT RECORDER

14.1 General

This Section establishes the requirements for provision for an Automatic Train Protection system (ATP), the vehicle train stop system (TSS), and the event recorder.

The ATP and TSS systems are required for streetcar movement on the existing DART LRV right-of-way. Such operations will occur as the streetcar is moved from the streetcar system to the DART Operations and Maintenance Facility.

All ATP, TSS and event recorder equipment shall be powered from the low voltage dc system.

14.2 Automatic Train Protection (ATP)

14.2.1 General Description

The Contractor shall provide for installation of an Automatic Train Protection System (ATP) compatible with the DART wayside.

Note: This requirement is only for provisions for future installation of an ATP System. Supply of an ATP system and equipment is not required under this contract.

The ATP will receive information continuously from the wayside, process this information and display the permitted speed in an Aspect Display Unit (ADU) in the active cab. The ATP will be arranged to remove propulsion power and initiate service braking if the permitted speed is exceeded. A brake assurance function will be provided to call for emergency braking if the service braking fails to provide a specific level of retardation. To provide these functions, the vehicle systems shall be arranged to provide for control of propulsion, service braking and emergency braking by the ATP. The vehicle systems shall also be arranged to provide dedicated contacts in the master controller and transfer switch to provide information to the ATP.

The ATP System may be used in conjunction with the Train Stop System (TSS), and the interfaces with propulsion and braking shall be designed so that the more restrictive output of the two systems takes precedence.

The Contractor shall submit a design report detailing the provisions for the installation of the ATP system. (CDRL 14-1) The design report shall identify all hardware locations with mounting requirements, routing of all required wiring, and any modifications necessary to interface the propulsion and braking systems to the ATP system.

14.2.2 Equipment Location and Mounting Provisions

The Contractor shall make provisions for the installation of the Automatic Train Protection System (ATP). This includes, but is not limited to the following:

- Mounting points for supports for antennas at each motor truck. Size, weight and mounting requirements of these antennas will be provided by DART.
• Mounting locations in ground brush holders for speed sensors on all trucks. Definition of the type of sensor and wiring will be provided. These locations shall be covered by blanking plates bolted in place.

• Structure, supports and mounting for a standard 19-inch rack-mounted equipment in one of the electric lockers in the interior of the vehicle, referred to below as the ATP locker.

• Provision for interfaces with the propulsion and braking systems as described below.

• Provision for speedometer in each cab console to be replaced by an Aspect Display Unit which will include a speedometer display. See Section 5.1.2.2.

• Two contacts in the master controller which shall be dedicated for use by the ATP system.

• Two contacts in the reverser switch which shall be dedicated for use by the ATP system.

• Provision in the console in each cab for controls to acknowledge an overspeed condition and to initiate an automatic test function.

• Space in the Cut-out and Bypass panel of one cab for a sealed bypass switch for the ATP.

• A circuit breaker to supply battery voltage power to the ATP system. This breaker shall be designated the ATP Circuit Breaker.

• Wiring from the ATP Circuit Breaker to the ATP locker.

• Wiring from the ATP Speed sensors to the ATP locker. This wiring shall be physically separated from other wiring. The quantity and specific characteristics of the wires/cables to be used will be provided.

• Wiring from the ATP locker to the console area in each cab. This wiring shall be for the Aspect Display Unit and all ATP controls and indications in the cab and shall be physically separated and shielded. At the articulation, bulkhead connectors of an approved type shall be provided in each vehicle Unit, and jumpers shall be provided across the articulation. The quantity and specific characteristics of the wires/cables to be used will be provided.

• Wiring from the ATP locker to all necessary interfaces with propulsion and braking systems. If any part of this wiring crosses an articulation, bulkhead connectors of an approved type shall be provided in each vehicle Unit at the articulation, and jumpers shall be provided across the articulation. The quantity and specific characteristics of the wires/cables to be used will be provided.

• All conduit and wireways required for wiring of the ATP.

14.2.3 Automatic Train Protection System Interfaces

The design of the propulsion and braking control systems shall provide for the necessary interfaces with the ATP including:

• Circuit provision for removal of propulsion when requested by the ATP;
• Circuit provision for application of full service braking when requested by the ATP;
• Circuit provision for application of emergency braking when requested by the ATP; and
• Each of these provisions shall be arranged so as to meet the requirements for safety-critical circuits.

14.3 Train Stop System (TSS)

The Contractor shall provide and install Train Stop System (TSS) equipment that is equivalent to the components installed on the DART LRVs and fully compatible with the existing DART wayside TSS system. The DART wayside components are Siemens S25000-Q5697-85.

14.3.1 General

The TSS shall be used to enforce compliance when a more restrictive signal aspect is received from the wayside signal system. It shall function through magnetic coupling between the vehicle-borne receiver and the wayside device. There shall be no external moving parts and no mechanical contact between the wayside device and vehicle-borne device.

The TSS shall function at all vehicle speeds up to the vehicle’s maximum design overspeed. The TSS shall be considered to meet the necessary safety requirements, in that provision shall be made for checking the operation of all parts of the system during service, as required by Section 14.3.7.

The TSS shall comprise all necessary vehicle-mounted equipment, including but not limited to receivers, and associated control and display devices, activated by the close coupling of a magnetic field from the wayside device.

The Contractor shall integrate the TSS receiver into the vehicle control circuits to meet the operational requirements of Section 14.3.7.

The Contractor shall submit a TSS system design report (CDRL 14-2) including a detailed description of the equipment being provided, mounting locations on the vehicle, wiring diagrams, and operational description.

14.3.2 Equipment Location and Mounting

Each end of each vehicle shall be equipped with the following mounted equipment:

• TSS receiver;
• TSS Power supply;
• Control switches;
• Counters; and
• Illuminated indicators.

Details regarding the location and mounting of these devices are provided in the Sections below. The TSS equipment shall be properly installed in accordance with the instructions and directions of the supplier. The design and installation shall provide proper magnetic coupling between the TSS receiver and the wayside, while insuring electromagnetic compatibility between the TSS and other systems, both onboard and wayside.
14.3.3 TSS Receiver
Receiving units shall be mounted on the vehicle at each end of the vehicle, at locations and within tolerances appropriate to function with the wayside equipment, as required by DART. The Contractor shall coordinate with DART to determine the actual location of the TSS receiver on the car. The TSS carbody mounting bracket shall be adjustable to compensate for wheel wear and primary suspension variations. The receiving units shall be installed so as to be effective only in the forward direction of travel from a given end.

14.3.4 TSS Power Supply
The Contractor shall supply a dc-to-dc converter powered from the vehicle’s low voltage distribution network. The TSS system shall be protected by a dedicated circuit breaker. The power supply shall be capable of continuous operation while supplying TSS receiver(s) with isolated power, consistent with the receiver’s input power requirements.

14.3.5 TSS Control Panel
Each cab shall be equipped with a TSS control panel incorporated into the cab lower control panel described in Section 5.1.3. This panel shall contain the following controls and indicators:

- Trip Counter;
- Key-By Counter;
- TSS Key-By switch; and
- TSS Reset switch.

14.3.6 Cab Annunciator Panel
Each cab annunciator panel described in Section 5.1.2.2 shall be equipped with the following indicators:

- A red TSS BYPASSED indicator lamp;
- A red TSS TRIP indicator lamp; and
- A green TSS ON indicator lamp.

14.3.7 Train Stop System Operation
The TSS equipment shall be interconnected with the vehicle control systems such that only the TSS equipment associated with the controlling cab shall be activated in the forward direction of travel from that cab.

The activation and proper operation of the TSS equipment shall automatically occur whenever a train is activated. The vehicle-borne TSS equipment shall contain self-checking circuitry which shall illuminate the TSS ON indicator described in Section 14.3.6 when a successful self-check has been completed.

In order to prevent a vehicle Operator from attempting to avoid a TSS trip by placing the reverser switch in REVERSE, the TSS shall remain active for 10 seconds after the reverser switch has been placed from FORWARD into NEUTRAL or REVERSE. If the control transfer switch is also placed in OFF, and the control transfer switch in another cab has been placed in AUX or RUN, the balance of the time delay shall be negated.
14.3.7.1 Stop Signal Protection

The STOP signal from the wayside will be given by allowing a wayside-mounted permanent magnet to inductively couple with the TSS receiver.

A permissive signal aspect on the wayside signal system will energize a quenching coil and effectively neutralize its permanent magnetic flux so that it does not couple with the vehicle-mounted TSS receiver. This, in turn, shall allow the receiver relay to remain in the normal position, permitting the Operator to retain control of the vehicle.

A stop signal aspect on the wayside signal system will de-energize the wayside device quenching coil and allow its permanent magnet flux to act on the vehicle-mounted TSS receiver to reverse the equivalent of a polarized relay, effecting a modified emergency brake application on the train.

When a train passes a stop signal on the wayside, the TSS in the controlling, lead cab shall respond as follows:

- All propulsion power shall be removed and the vehicle shall be placed into a modified emergency brake. The modified emergency brake application shall be identical to a normal emergency brake application except that the track brake shall not be automatically applied. Track brakes shall not be applied unless the function is manually initiated by the Operator. The TSS shall prevent the brakes from being released until the vehicle speed is below the no-motion detection level and until after the system has been manually reset by the Operator.
- The TSS trip counter shall be indexed one count.
- The TSS TRIP indicator shall be illuminated in the operating cab until the trip is reset by the TSS reset switch.

14.3.7.2 Signal Key-By

The vehicle controls shall provide a method for circumventing the TSS, to allow the vehicle to pass a single trip-stop without a brake application. This process shall be referred to as “key-by”. The key-by process shall function as follows:

- A momentary contact pushbutton shall bypass the stop signal protection for any stop-signal that is detected within a period of 20 seconds, ±3 seconds, from the time that the key-by button is depressed. This pushbutton shall function only if operated at a vehicle speed less than the no-motion detection point. The circuitry shall be arranged to prevent operation resulting from a “stuck” key-by switch.
- The TSS key-by counter shall be indexed one count.
- The TSS trip counter shall not record passing an active wayside device within the key-by time period.

14.3.7.3 Counters

Two, tamper-proof, rugged, visual read-out counters shall be provided. One counter shall record the number of “key-bys” and the other counter shall record the number of trip-stops sensed. Each counter shall record only the counts from that end of the vehicle for each function. The counters shall be electromechanical and shall retain the count in the absence of control power. The counting circuitry shall be arranged so that activation of the TSS does not generate false counts. Counters shall not be resettable.
14.3.7.4 TSS Bypass

A sealed bypass switch shall disable the on-board TSS for the respective cab, and prevent the TSS system from inhibiting normal operation of the vehicle. The TSS BYPASSED indicator lamp shall be illuminated while the TSS is disabled in the controlling cab. For example, TSS BYPASSED shall be illuminated under the following conditions:

- While the TSS is bypassed;
- During TSS key-by;
- While the controlling cab is commanding REVERSE; and
- During the self-check sequence when the vehicle TSS is first activated.

14.4 Train-to-Wayside Communication System

DART’s wayside Contractor’s will be installing train-to-wayside communication (TWC) loop antennae and interrogators at various locations along the Streetcar line. The wayside portion will be Vetag® equipment as originally developed by Philips NV. The Contractor shall provide the carborne TWC equipment and shall be responsible for coordination of the carborne system with wayside parameters and the wayside equipment Contractor. The carborne portion of the TWC system shall provide bi-directional data transfer and be completely compatible with the wayside loops and interrogators, both installed on the streetcar wayside and existing on the DART LRV wayside.

The Contractor shall submit a design report on the train-to-wayside communication system, including compatibility with the existing DART infrastructure for DART’s review and approval. (CDRL 14-3)

14.4.1 System Description

Each end of the vehicle shall be equipped with car borne components of the TWC system to transmit digital information from the Streetcar to the wayside, or wayside to Streetcar, at certain points along the route. Fixed wayside loop antennas placed in the trackway send out an interrogation signal several times a second. When a car passes over the loop antenna and an activated car borne TWC transponder receives the interrogation signal it shall transmit a message to the wayside in the form of high-speed serial digital data.

Vehicle TWC equipment shall be installed to provide for the accurate, secure transmission of a 19-bit data message to/from wayside loop antennas. Transponders shall transmit when properly located over the loop and polled by the wayside interrogator. However, the format of the data message to be transmitted shall be a function of vehicle status. The Streetcar shall be configured to provide the TWC system with inputs representing active cab status and end-of-train status.

The TWC system shall transmit the following information from the vehicle to the wayside:

- Train Number
- Route Number
- Car Number
- Switch Call (Left or Right)
- Active Cab (on for active cab)
- End-of-train
Additional TWC transmission requirements, which may include, but not be limited to, signal pre-emption, triggering of station platform announcements, limits of a wireless section and messages transmitted from the wayside, will be covered during system design. The exact assignment of bits, including start/stop bit will be furnished to the Contractor by DART after contract award.

14.4.2 Carborne Equipment

Each car set of TWC equipment to be furnished and installed shall consist of:

- Two transponder assemblies (one per end)
- Two cab control panels (one per end)
- Interconnection cables and hardware to mount and connect transponders and cab control panels.

All carborne TWC equipment shall be identical in all cabs. The TWC system shall function from the low voltage power supply with the voltage range and conditions specified in Section 2.4.2. A dedicated circuit breaker shall be provided in the circuit breaker panel of each cab.

Each transponder shall be mounted under the vehicle on the centerline of the carbody, so as to minimize offset on curves. The transponder location, mounting height, and height adjustment capability shall be coordinated with the wayside TWC equipment Contractor.

Transponder mounting brackets shall be suitable for the operating environment and shall include any vibration dampening features necessary for a long-term integrity of the system. A multiple conductor cable suitable for exposed use in an undercar environment shall be provided to connect the transponder to the bulkhead connector.

The transponder shall:

- Receive a 100 KHz interrogation signal via the ferrite antenna to activate the transponder and cause it to transmit or receive a data message via the same antenna.
- Activate the lights in the console panel switches when an interrogation signal is received to indicate that the transponder is located over a wayside loop.
- Transmit or receive a 19-bit data message as requested by the cab control panel and the wayside interrogator.

14.5 Event Recorder

14.5.1 General

Independent of the monitoring and diagnostic system described in Section 9.8, each car shall be provided with a fully electronic data recorder system which shall store times, speeds, distances traveled, and both analog and digital events as described further below. The event recorder shall be a self-contained unit with data storage and retrieval capabilities as described in Section 14.5.2. Unless explicitly stated otherwise, the event recorder shall comply with the requirements of IEEE 1482.1, “Standard for Rail Transit Vehicle Event Recorders.

The primary purpose of this recorder is to provide documentation in support of accident investigations. It must be a tamper-proof, self-contained design capable of withstanding high shock.
Detailed environmental and mechanical requirements are described in Section 2.

The event recorder shall be based on a family of service proven designs, with at least 5 years successful operating history in revenue service on rail vehicles. The equipment shall be subject to DART's approval. The Contractor shall prepare a design report on the event recorder equipment, interfaces, and installation for review and approval by DART. (CDRL 14-4)

14.5.2 Functional Requirements

The event recorder shall record at least the following information:

- All applicable signals referenced in Table 1 of IEEE Std. 1482.1-1999;
- Signal A8 of Table 2 – wheel spin/slide;
- Signal A12 of Table 2 – horn activation;
- Signal A13 of Table 2 – bell activation;
- Signal A18 of Table 2 - door close command;
- Signal A19 of Table 2 – door open command;
- Application of sand;
- Car number;
- At least six spare digital channels; and
- At least two spare analog channels.

Signal sampling and recording rates shall comply with IEEE Std 1482.1.

The recorder shall be able to store in non-volatile memory a minimum of 7 days of data, including signals from the spare channels. This memory shall not require battery backup for data retention and shall remain intact for a period at least one year after removal from the car.

The event recorder time base shall be independent of other vehicle systems.

Event recorder functional status and failures shall be reported to the monitoring and diagnostic system described in Section 9.8.

The following data retrieval capabilities shall be provided:

- Event data memory module removal
- Data retrieval via a USB or Ethernet port using a laptop computer

Downloaded data shall be capable of being evaluated on an office computer. It shall not be possible to erase the data via the USB or Ethernet port on the recorder. The contractor shall supply all necessary cabling and software to transfer, evaluate, display, and print the data in either tabular or graphic form.

14.5.3 Installation Considerations

The event recorder shall be located in the car interior in an electric locker which shall require a crew key (Section 15.2.10) for access. The installation shall be such that the event recorder is tamper resistant and waterproof; however, installation shall be such that the USB or Ethernet port are readily accessible once the recorder is installed.
A terminal board with locations for all event recorder signals, including spares, shall be provided.

Connections to the event recorder inputs shall be made at this terminal board. The Contractor shall provide a list of signals to be made available at this terminal board for DART’s approval. (Include in CDRL 14-9)

14.5.4 Construction Requirements

The event recorder shall be constructed in accordance with the requirements of IEEE Std 1482.1. These requirements may be met by the design of the data storage devices themselves, by placing the device in an enclosure meeting the requirements, by judicious placement of the device within the carbody envelope, or by a combination of these methods.

14.6 Fare Collection Equipment

The Contractor shall provide and install all necessary provisions for the installation, power and operation of one (1) Fare Collection Equipment (FCE) unit in the center (low floor) section of the Streetcar. The FCE should be installed in the vicinity of one of the doors, at the side of the section. The location and interior layout of the sections should allow for easy accessibility to the FCE for all passengers without affecting passenger flow through the section. The orientation and mounting of the FCE shall be ADA compliant. The FCE unit should be based on the GenFare “Odyssey – Validating Farebox” or approved equivalent. The Contractor shall prepare a design report on the FCE, interfaces and installation for review and approval by DART.

14.7 CDRL

The following design submittals are required:

14-1 ATP Installation design report (Section 14.2.1)
14-2 TSS system design report (Section 14.3.1)
14-3 TWC system design report (Section 14.4)
14-4 Event recorder design report (Section 14.5.1)
14-5 Fare Collection Equipment design report (Section 14.6)

END OF SECTION
## SECTION 15
### INTERIOR AND EXTERIOR APPOINTMENTS

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SECTION 15
INTERIOR AND EXTERIOR APPOINTMENTS

15.1 General
This section describes interior and exterior finishing, including insulation, floor covering, seats, windows, liners, and other such features and appurtenances.

Within 60 days after NTP the interior and exterior color scheme, finishing, and general appearance of the vehicle shall be subject to review and approval by DART. (CDRL 15-1) The initial submittals may be in the form of accurately colored renderings and models. Samples of all finishing materials and the material specifications shall be submitted with the initial submittal.

15.2 Interior Finishing and Accessories
The vehicle interior shall be finished with high durability, low maintenance materials. All surfaces shall be free from tooling marks, gaps, distortions, and other visible defects. All surfaces shall be rigid and supported to prevent sagging, drumming, and vibration.

All materials used in the interior of the vehicle shall conform to the flame, smoke, and toxicity requirements of Section 17.

Color shall extend all the way through all materials except for FRP and melamine, where specified.

Interior linings shall be mechanically fastened to their supporting surfaces. The mounting shall be designed to accommodate the dynamics of vehicle movement without transmitting stress to the liners. Interior linings shall be designed to have a minimum 1 inch (25 mm) radius cove at intersecting adjacent surfaces.

All exposed stainless steel except for floor covering shall be given an approved brushed finish. Grain direction shall be arranged to be consistent with the decorative scheme.

Walls shall have a graffiti resistance rating of “one”, per APTA Transit Security Guidelines Manual, Section 21. The ceiling shall have a rating of “two”.

The vehicle interior shall be free of sharp corners or edges by design, and as a result of poor workmanship. Gaps between apparatus that are not absolutely rigid shall be wide enough to prevent injury when the apparatus moves, or rigid spacers shall be provided to prevent the gap from closing.

The articulation section flooring, walls, and other moving components shall move without audible noise under all conditions. All gaps between articulation section wall and ceiling panels shall be designed and sized to prevent injury. Gaps in the articulation portion of the passenger compartment shall not increase or decrease in width, so as to be hazardous to persons, under any conditions.

15.2.1 Acoustical Insulation
A vibration and sound damping material shall be applied to inner surfaces of all areas of the structural shell, including sub-floor pans, ends, roof, and side frames, and one side of air duct splitters (if used). It shall be resistant to dilute acids, alkalis, greases, gasoline, aliphatic
oils, and vermin and shall comply with the Flammability and Smoke Emission requirements in Section 17.

Alternatives which provide insulation between interior panels and the exterior wall as a unitized replaceable assembly will be considered.

15.2.2 Thermal Insulation

The vehicle shall be insulated to insure that the thermal requirements of Section 7 are met.

Fiberglass insulation shall be manufactured from long, textile-type glass fibers drawn from a calcium borosilicate mixture to an average diameter of nine microns. Insulation shall be bonded together with a thermosetting phenolic resin which shall not exceed 6% by weight. The fiberglass shall not mold, rot, or sustain vermin. It shall not corrode any metals or settle as a result of car vibration. It shall not have an odor or be capable of absorbing odors. It shall be capable of performing to a high temperature limit of 450°F (230°C).

The roof, sides, and ends of the cars, including the inside faces of posts and structural members, shall be insulated with fiberglass which shall fill the entire volume of the available cavity. The density of the fiberglass insulation shall be selected by the Contractor consistent with the estimated carbody transmission heat gain given in Section 7. The roof insulation shall be retained by stainless steel wires or strips. Side and end wall insulation may be retained by spears or other approved method, provided steps are taken to ensure that sharp, pointed ends will not be a hazard to personnel or maintenance equipment.

The floor shall be insulated with two layers of equal thickness of fiberglass separated by a vapor barrier. This insulation shall be placed in the structural floor between the transverse floor beams and shall fill the entire volume of the available cavity. Floor insulation shall be compatible with the material used at the affected locations in the car structure. The density of the fiberglass insulation shall be selected by the Contractor consistent with the estimated carbody transmission heat gain given in Section 7.

15.2.3 Urethane Foam

The use of urethane foam insulation is prohibited anywhere in the construction of the car. See Section 17 for other prohibited materials.

15.2.4 Floor Covering

The floor covering, and its accessories, shall provide a durable, watertight, textured covering for the floor panels and other car structures. The floor covering shall comply with the material and Flammability and Smoke Emission requirements in Section 16. The material shall be water and chemical resistant.

The floor covering shall have a static coefficient of friction of not less than 0.5 if measured in accordance with ASTM D 2047, using leather and rubber shoe materials. Leather shoe material shall be in accordance with Federal Specification KK-L-165C. Rubber shoe material shall be in accordance with ASTM Method D 1630.

Each step shall be provided with a safety nosing running the full width of the step and which contrasts visually from the stair tread and riser covering by 70%, as determined by the following formula:

$$\text{Contrast} \quad \frac{(B1-B2)}{B1} \times 100$$

Where:
B1 = Light reflectance value of brighter area
B2 = Light reflectance value of darker area

Floor covering at exposed removable floor access panels and at the edge of the articulation section shall be peripherally trimmed with stainless steel or aluminum molding.

Contractor shall propose the material, manufacturer, and model. Actual flooring color and pattern will be determined by DART during the design review process.

15.2.5 Windows

All windows shall be of the single-glazed, fixed-type, laminated, tempered safety glass tested in accordance with ANSI Z26.1 or approved equivalent standard. Glazing shall be mounted directly to the car structure by bonding or with neoprene glazing strips. Any tinting shall not preclude passengers from being seen from outside the vehicle or limit their vision when looking out the side windows.

Glazing strips, if used, shall be laced from the outside of the vehicle. The ends of the glazing strip shall be joined together by the hot vulcanization process or a gluing process approved by DART to form an endless glazing strip.

Bonding, if used, shall allow for easy replacement of damaged glass. Window replacement including bonding time shall not exceed 8 hours from the time work begins to availability for revenue service.

The heated windshield shall be designed and installed to minimize external glare as well as reflections from inside the vehicle when the vehicle is operated at night with the passenger interior lighting in use. The upper portion of the windshield may cover the end destination sign.

All passenger compartment windows shall be supplied with an optically clear, distortion-free layer of polyester film on the interior facing surface. The polyester film shall be Vandal Shield or approved equal. The Vandal Shield shall be installed such that it can be removed and replaced without removing the glass from the window frame or glazing rubber.

All glass products shall be readily available in the U.S. from U.S. suppliers, in the sizes and thicknesses provided on the delivered vehicle.

15.2.6 Passenger Seats

Passenger seats shall be heavy duty transit-grade upholstered seats with removable cushion inserts. All materials shall be, to the greatest extent possible, vandalism and graffiti-resistant.

The minimum total seat depth measured from the seat's forward edge to the forward surface of the seat back shall be 16 inches (405 mm). Minimum seat spacing shall be 29 inches (735 mm). Minimum seat back-to-back of seat ahead shall be 25.2 inches (640 mm). Each seat shall be 18 to 19 inches (460 to 480 mm) in width which may be achieved through the use of spacers placed between individual seats.

Passenger seats shall be designed using recognized ergonomic and human factors principles to provide a safe and comfortable ride for the short distance local patronage anticipated for the streetcar. Materials shall be consistent with the intended use and performance requirements, with special consideration for passenger safety, comfort, durability, and maintainability.
Replacement of seats shall be easily accomplished through removal and reinstallation of no more than six mounting bolts per seat. Mounting bolts shall be hidden by inconspicuous snap-in covers where exposed to passenger view.

The seat construction and its attachments to the carbody shall withstand, without permanent deformation, the loads to be expected in transit operation, but in no case less than the following:

- The seat design and installation shall withstand a longitudinal force (acting in either direction from front of seat to back, and back of seat to front, and equally distributed along the grab handle) of 300 lbf (1330 N) per sitting position (total 600 lbf (2670 N) for two-passenger seat) with deflections everywhere less than 0.75 inches (19.0 mm) with no failure. A permanent set of 1/8 inch (3 mm) or less will be permitted under these conditions.

- The seat design and installation shall withstand a downward vertical load applied uniformly along the front edge of each sitting position of 400 lbf (1780 N) (total 800 lbf (3560 N) for two passenger seat). A permanent set of 1/8 inch (3 mm) or less will be permitted under these conditions.

- The transverse seat attachment to the floor, side structure, and seat boxes as appropriate for the design shall be constructed to resist the load resulting from two 95th percentile adult males being thrown against the seat with a longitudinal force of 5g. The loads shall be applied both from the back and front of the seat. Seat distortion shall be allowed; however, the seat shall not tear loose from its fastenings.

Upholstery material shall be flat woven transportation quality 90% wool, 10% nylon blend back coated fabric. The fabric color and pattern shall be determined by DART during the design review process. (Include samples in CDRL 15-1)

**15.2.7 Mobility Impaired Accommodations**

Accessibility to the vehicles for mobility impaired persons confined to wheelchairs shall be provided through all double width doors on each side of the vehicle. Wheelchair spaces shall be provided in each vehicle as described in Section 2.2.2. The spaces shall be designed to locate the wheelchair longitudinally (end facing) in the vehicle. Each wheelchair accommodation space shall provide for a minimum clear floor space of 48 inches (1220 mm) by 30 inches (760 mm). Seat arrangement and stanchion placement shall provide for a minimum of 32 inches (815 mm) wheelchair passage width and allowance for turning movements between the accessible door and designated wheelchair locations. Each wheelchair space shall be provided with at least one horizontal handrail conforming to Section 15.2.8 and positioned 27 inches (685 mm) above the floor. In addition each wheelchair space shall include a means whereby the wheelchair user may activate the passenger stop request.

Mobility impaired accommodations shall comply with the latest FTA interpretation of the Americans with Disabilities Act (36 CFR 1192 and 49 CFR 27, 37, and 38). Within 180 days after NTP the mobility impaired accommodations shall be submitted for review and approval by DART. (CDRL 15-2)

**15.2.8 Stanchions, Handrails and Windscreens**

At each passenger door location, windscreens shall be provided to define the boarding area and prevent drafts of external air from annoying passengers near the door and outside of
the boarding area. Where a windscreen may interfere with accessible boarding, the Contractor may eliminate the windscreen with DART’s approval. Windscreens shall be transparent above the lower side window edge level.

Vertical stanchions shall be provided within 30 inches (760 mm) of any standing AW3 passenger position. Stanchions connecting the top of the seat back or the horizontal seat back rail to the ceiling, or vertical hand holds, shall be provided in the interior standing areas where no other passenger stabilization aid is available. Vertical stanchions shall not be placed in the boarding area between windscreens. Stanchion and handrail spacing and placement shall be submitted for approval. (CDRL 15-3) Each wheelchair space shall be provided with at least one horizontal handrail positioned 27 inches (685 mm) above the floor.

All stanchions, grab rails, and fittings shall be made of stainless steel with an approved circumferential finish. The grab rails shall be designed without the need for any lateral supports. All surfaces shall be smooth and free of sharp edges which might injure passengers. Knuckle clearance shall be 1.50 in (38 mm) minimum. All fasteners shall be tamper-resistant, stainless steel.

All stanchions and grab rails shall withstand applied loads of 300 lbf (1330 N) in any direction without permanent deformation and without transient deformation that would pinch or injure.

All stanchions and grab rails shall have a diameter of 1.25 to 1.5 inches (32 to 38 mm) and comply with the latest FTA interpretation of the Americans with Disabilities Act (36 CFR 1192 and 49 CFR 27, 37 and 38).

15.2.9 System Maps and Display Panels
At least four (4) suitably designed frames or holders shall be provided for the installation of system route maps, alignment maps or advertising signage in locations easily visible to both seated and standing passengers.

15.2.10 Keys and Locks
Two different types of keys shall be provided for access to various car equipment or controls. The two types are:

- Master Controller Key: Shall operate the master controller key switch, as described in Section 5.1.1.1. The master controller key shall be an ACE type key. DART will provide the part number and lock serial number directly to the Contractor after NTP.

- Crew Key: Shall permit access to all lockers, cab door, exterior forward door manual release, all overhead access panels, interior and exterior access panels, and all side skirts and coupler covers. The crew key shall be J.L. Howard part number JLH #2400.

The Contractor shall submit samples of each of the two keys and all lock locations to DART for review and approval. (CDRL 15-4)

The Contractor shall provide ten (10) master controller keys and twenty (20) crew keys with the delivery of the first vehicle.

15.3 Exterior Finishing and Accessories

15.3.1 Roof Surface
All roof surfaces on which a person can walk shall be treated with anti-skid paints or mats.

15.3.2 Painting and Striping

The exterior color scheme streetcar shall be submitted to DART for approval in CDRL 15-1 as described in Section 15.1.

The Contractor shall provide two exterior colors on the sides and ends of the vehicle. Additional graphics such as stripes or logos shall be a 3M vinyl film or approved equivalent. The roof and roof-mounted equipment shall be painted dark gray, as approved by DART. Samples of all paints and films shall be submitted to DART for approval prior to application. (CDRL 15-5)

All primers, fillers, paints, and striping materials shall be applied as specified in Section 16.

15.3.3 Exterior Rear View Cameras

Closed circuit television shall enable the Operator to supervise the loading and unloading of passengers at all doorways of the streetcar when the doors are open, and to verify that the doors are clear of passengers. Refer to Section 13.8 for technical requirements.

15.3.4 Rain Gutters and Water Drainage

Rain gutters or other devices shall be installed to prevent water drainage over the sides of the main body sections and cab ends. Gutters may be separately formed and attached or may be integral with the roof structure via roof sheet corrugations or similar configurations.

The gutters shall empty into concealed drainage conduits having screens at the water entry points, which shall empty below the floor line of the vehicle. Drainage conduits shall have no sharp bends and shall be designated for easy clean-out. Drainage conduits that run inside the carbody structure shall be fully insulated to prevent condensation or leakage. Drainage conduits shall not run through equipment lockers except as reviewed and approved by DART during the design review process.

The gutter system and drainage conduits shall be sized to prevent accumulated water from overloading the system during car acceleration and braking or on grades and to accommodate the maximum rainfall rate for the Dallas area, as provided in Section 2.3.5.

15.4 Equipment Enclosures

15.4.1 General

All exterior and interior equipment enclosures shall be constructed to NEMA Type 4 and NEMA Type 12 standards, per NEMA 250 Enclosure standards, respectively and as described below. Where conflicts exist, this document shall prevail.

Equipment enclosure walls and covers of large boxes shall be stiffened with the stiffeners welded in place. Stiffening criteria shall conform to high quality commercial practice and shall be submitted for approval.

The interior of all equipment enclosures and covers shall be primed and painted with white paint. Exteriors shall be painted or finished according to the car color scheme or as required elsewhere in this specification. Refer to Section 17.13 for paint requirements. Seals and cover hardware shall not be painted.
Equipment enclosure cover openings shall have a NEMA-type formed lip which provides a bearing surface for the cover seal. The portion of the lip bearing on the seal shall be flat and no less than 0.125 in (3.2 mm) wide.

Seals shall be attached and retained in a channel near the periphery of the cover. Seals shall be closed cell neoprene foam at least 0.375 in (9.5 mm) thick and shall remain resilient and watertight for at least 10 years. The seal shall be compressed no more than 50% with the cover securely fastened, with cover making hard contact with the frame or a stop, to prevent over compression of the gasket. The sealing system shall pass the water test in Section 16.

RFI gasketing with continuously conductive contact strip shall be installed on all equipment boxes and covers for all equipment that could produce RF, including auxiliary power supplies and traction inverters.

15.4.2 Exterior Equipment Enclosures

Exterior equipment enclosures shall be constructed of low-alloy, high-tensile steel or, where approved, fiberglass reinforced plastic (FRP) or stainless steel. Enclosures constructed of steel shall have continuous welds or approved spot welds with fillers along all seams.

Underfloor- and roof-mounted equipment enclosures shall be watertight when subjected to pressure wand cleaning and driving rain or snow accumulations. The enclosures shall contain drain holes fitted with cotter keys or other approved, simple drain clearing mechanisms for discharge of condensation and leakage due to damaged or deteriorated seals.

Equipment shall be arranged for the maximum ventilation of parts and the minimum restriction of cooling air. The high temperature air exhausted from one piece of equipment shall not be directed to the air intake of another piece of equipment. Equipment enclosures that are provided with air from the forced air ventilation system shall be equipped with a manometer test fitting in an accessible location on the box to allow easy measurement of box pressurization.

All underfloor equipment shall be arranged to allow ready access from the side of the vehicle, from the maintenance pits, and when the vehicle is on lifts. Access to roof mounted equipment shall be from the top of the enclosure. Labels and warning indicators shall be applied as required by Section 15.5.

Equipment installed in underfloor- or roof-mounted boxes shall not be attached directly to the box by bolts or other fasteners through the enclosure walls, top or bottom sheets. They shall be attached to standoffs or subplates which are in turn welded to the box. In addition, sufficient clearance (1/2 in (13 mm)) minimum) shall be provided between the exposed sides and covers of the equipment enclosure and the internal equipment to protect the internal equipment from damage due to minor impacts.

All underfloor and roof mounted enclosures shall be grounded to the carbody, as specified in Section 9.1.2.

All hardware, including hinges, used to secure access covers or access plates on equipment enclosures shall be made of stainless steel.

All access covers shall be provided with quick-release, spring-loaded latches which operate with a toggling-type action. The latches and latch catches shall be arranged so that they do not protrude beyond the bottom or edge of the box or cover in the latched position. The latches shall not violate the vehicle dynamic clearance outline if not engaged. The latches
shall compensate for seal relaxation considering the worst case condition of hard contact between the cover and box. In this extreme case, the latch shall hold the cover firmly to the box without rattling. The latch and all its components shall be fabricated from stainless steel. Prior to delivery, cover latches shall compress the cover seals no more than 50% of the compressible height of the seal and shall be watertightness tested. The latches shall not have separable or non-retained parts.

A spring-loaded safety catch shall be provided at the center of each underfloor box cover. The safety catch shall be designed to retain the cover within the vehicle dynamic clearance envelope at all operating speeds without the cover latches engaged.

All hinged covers shall be readily removable without the use of tools. Openings provided upon removal of covers shall be of sufficient size to permit removal and replacement of any component in the box and easy access to equipment in the box for inspection and maintenance. A minimum of 15 in (380 mm) of clearance shall be provided perpendicular to the opening face plane.

All top-hinged underfloor covers and all roof mounted enclosure covers shall have an internal "hold open" feature. The "hold open" feature shall in no way interfere with or impede the easy removal or replacement of the cover, nor shall the "hold open" mechanism present the possibility of shorting or grounding internal electrical parts when the cover is opened or closed. The "hold open" mechanism shall be designed such that it will stay with the cover when the cover is removed; however, it shall also be easily removable from the cover for replacement.

Doors, covers, and access panels on underfloor- and roof-mounted boxes shall be interchangeable between boxes of the same size and type within a vehicle and between vehicles.

Underfloor- and roof-mounted equipment boxes shall be waterproof except where equipment must be ventilated. Equipment vents shall be arranged to minimize water entry and deflect direct water spray. Stainless steel screens welded to the inside of the enclosure shall cover all vents. Vents may be provided in the top of underfloor enclosures where necessary and shall be provided with internal baffles to prevent water from falling onto equipment.

The arrangement for conduit, cable, wire routing, connections to equipment enclosures, and equipment contained in enclosures shall be configured so that structural, electrical and environmental integrity is maintained, and so that the removal and replacement of the equipment enclosure are facilitated.

All control and power cable terminations shall be made internal to the enclosures or in waterproof, gasketed junction boxes. Cable entry shall be by means of watertight sealing glands. Glands and cable terminations shall provide for cable replacement without removal of lugs, terminals, or connectors from the wires.

Conduit shall be connected to underfloor and roof equipment enclosures using watertight connectors. The entrance of conduit or cables in the top and bottom of equipment boxes will not be permitted.

15.4.3 Interior Equipment Enclosures

The use of interior equipment enclosures shall require review and approval by DART during the design review process. All electric or electronic equipment located inside the vehicle shall be mounted in approved, dust-proof, water tight, underseat equipment enclosures or in electric lockers in the cab, adjacent to the articulation or in the ceiling cove area. All
equipment so mounted shall be readily accessible and shall be removable through the access cover. The access cover shall be secured with quarter-turn locks, except as reviewed and approved by DART during the design review process, operable with the maintenance key or crew key. The access covers shall be designed to be rattle-free during the operation of the vehicles.

Interior enclosures may use access panels for covers if a full dead front is provided. All interior enclosures shall include a metal top, sides, and bottom.

Equipment enclosures located under seats shall be constructed of a stainless steel structural frame, and faced with sheets of rigidized stainless steel. Access to underseat enclosures shall be by removal of the seat or through access panels in windscreens. Seat boxes shall have a removable access cover. A stainless steel cove molding shall be provided where the seat box meets the floor covering.

15.5 Graphics

Graphics shall be provided throughout the vehicle to provide passengers and operating personnel information regarding operation of the vehicle.

All controls and devices intended for operating personnel use shall be clearly labeled with text. All equipment intended for passenger use, however infrequent, shall be labeled both with text and graphical figures or icons in full compliance with ADA standards.

ADA compliant graphics shall designate priority seating for persons with disabilities. ADA compliant graphics shall indicate designated areas for wheelchair or mobility aid accommodation.

The car number shall be clearly displayed to aid operating personnel and passengers in reporting car locations or incidents. On the interior, the car number shall be displayed inside each vehicle body section. On the exterior, the car number shall be displayed on both vehicle ends above the windshield, the side of the vehicle, and on the roof at each end. Car numbers located at interior ends and on the roof shall include the designation “A” or “B” as appropriate.

Safety warnings and advisories shall be provided at doors, at the articulation sections, and at any access points to hazardous equipment. Identifications and instructions shall be provided for all passenger interactive devices such as door push buttons, stop request buttons, and passenger emergency intercoms.

All equipment boxes shall be labeled with safety warnings for High Voltage, as appropriate.

All text and graphic layouts shall be submitted by the Contractor for approval by DART. (CDRL 15-6)

15.6 CDRL

The following design submittals are required:

15-1 Interior and exterior color scheme, finishing, general appearance and seating arrangement (Section 15.1)
15-2 Mobility impaired accommodations (Section 15.2.7)
15-3 Stanchions, handrails, and windscreens (Section 15.2.8)
15-4 Key and lock report and samples (Section 15.2.9)
15-5 Paint and film color samples (Section 15.3.2)
15-6 Graphics including car number (Section 15.5)

END OF SECTION
SECTION 16  
TESTING

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SECTION 16
TESTING

16.1 General
The vehicle and all its components shall be tested to verify compliance with all specified
design, performance, reliability, and maintainability requirements.

All conformance and acceptance tests described in this Section shall be performed as
indicated.

DART may, at its option, witness all tests. At least 30 days prior to each test, the Contractor
shall notify DART in writing of the date, time, and location the test will be performed.

Material test requirements may also appear in Section 17. Other test requirements may
appear in other sections of these Technical Specifications.

16.1.1 Requirements
The Contractor shall perform all Qualification Tests specified herein, except as determined
by DART, unless the Contractor can furnish data and test reports acceptable to DART,
which indicate that equipment furnished under this Contract is substantially identical to
equipment which has been service proven for the same application, and that those tests
demonstrated compliance with the requirements of this Specification. DART will be the sole
judge of acceptability of the data. Should submitted data not be acceptable to DART, the
Contractor shall complete the tests as specified with no increase in contract cost or
extension of the delivery schedule.

DART may also relieve the Contractor of the testing requirements if the Contractor
successfully tested similar system and/or system hardware and software in the last two
years prior to receiving NTP, and meets Service Proven Design requirements outlined in
Section 2.12.

Within 120 days after NTP the Contractor will present the list of tests it would like DART to
waive, the test procedure used, the results obtained from the testing, and the similarities and
differences between the specified system or specified hardware and software and the
proposed system and/or system hardware and software, including the manufacturer and
manufacturing process to DART for approval. (CDRL 16-1)

DART shall be the sole judge of acceptability of the data. Should submitted data not be
acceptable to DART, the Contractor shall complete the tests as specified with no increase in
contract cost or extension of the delivery schedule.

DART considers the tests specified herein to be an absolute minimum. The Contractor shall
be responsible for assuring that each design and performance requirement of this
Specification is assigned to a specific test effort. The Contractor shall furnish a
comprehensive test plan as described in Section 16.1.3. The Contractor and its
subcontractors may perform additional testing, as they deem necessary.

16.1.2 Test Classifications
The required tests are categorized as follows:
• **Qualification Tests** shall be conducted to demonstrate compliance with design requirements at operating and environmental extremes. These tests shall be performed on selected production components, systems, and completed cars, at the highest level of assembly that will allow demonstration of design compliance. Design conformance tests are limited to the number of units needed to demonstrate design compliance, typically one or two. These test requirements are described in Sections 16.3, 16.4, and 16.5, and include both performance and operational tests.

• **Production Conformance Tests** shall be conducted to demonstrate that each unit produced operates within specified limits and is in compliance with the requirements of these Technical Specifications. Production Conformance Test requirements may vary from an inspection and functional demonstration for a simple component to full static tests each system or vehicle manufactured. These tests are routinely performed at ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation. These tests are described in Sections 16.6 and 16.7.

• **Vehicle Acceptance Tests** shall be conducted to demonstrate that each fully assembled vehicle is ready for revenue service, both functionally and aesthetically. The acceptance and post-delivery tests are described in Section 16.8.

### 16.1.3 Master Test Plan

Within 120 days after NTP, the Contractor shall submit to DART for review and approval a Master Test Plan (MTP) covering all tests required by this Section and elsewhere in these Technical Specifications (CDRL 16-2). The MTP shall include a proposed schedule and location for each test.

The submittal, CDRL 16-2, shall also include copies of qualification test reports for the qualification tests that the Contractor accepted based on previous testing. DART will either accept or reject the existing qualification test reports in response to this submittal.

### 16.1.4 Test Procedures and Reports

The Contractor shall prepare a detailed test procedure for each test described in the MTP, and for any other tests conducted by the Contractor in connection with its own Quality Assurance program. Each test procedure shall be submitted to DART for review and approval. Test procedures shall identify all specification sections relevant to the system or component under test, including those sections from which the test acceptance criteria were derived. The Contractor shall submit, as part of each test procedure, forms to be used to record data accumulated in that test. Such forms shall also contain a step-by-step format for data reduction, formulae used in deriving the format, criteria for acceptability, and justification for the criteria set forth.

Each detailed test procedure shall be submitted to DART in advance of the initial conduct of a planned test so as to provide at least 30 working days to review and approve the procedure. No testing shall occur, and no results shall be considered valid, until approval of the test procedures by DART.

Test reports shall be provided which follow the format of the test procedure to the extent possible. All test reports shall include a copy of the test procedure used. Test reports of conformance tests which are performed on all cars or all components shall be included in the appropriate Car History Book. The report shall include a description of the test, all raw
data collected in the performance of the test, all data reduction forms, and a summary of the results.

16.2 Insulation Testing

When an insulation test is required to be performed in Sections 16.4, 16.5, 16.6, and 16.7, it shall be conducted in accordance with the requirements stated in IEEE Std 16-2004 part 5.9.

The integrity of electrical insulation shall be confirmed where specified below by performing insulation resistance tests (megger test) and high potential tests on individual devices and apparatus, and then on the completed vehicle.

16.3 Component Design Qualification Tests

The following design conformance tests shall be performed as indicated.

16.3.1 Flammability and Smoke Emission

All materials supplied for this car shall be tested to the Flammability and Smoke Emission requirements of Section 17. The Contractor shall assemble all materials, procedures and test reports for all materials into one package for DART review and approval. (CDRL 16-3)

16.3.2 Ac Traction Motors

The ac traction motor shall be given a "type" test in accordance with IEC Publication 60349. The determination of the characteristics and efficiency of the traction motor shall be in accordance with a mutually acceptable method from IEC 60349 and IEEE Standard 112, adapted to include testing at minimum frequency, base speed, maximum slip-limited speed, and maximum speed. (Procedure: CDRL 16-4) (Report: CDRL 16-5)

16.3.3 Ac Auxiliary Motors

One motor of each type of ac auxiliary motor shall be given an IEC Publication 60349 or IEEE Standard 112 "type" test, including a heat run, by the manufacturer to demonstrate its capabilities and power rating. Each model shall be tested at its continuous rating. The Contractor shall assemble all procedures and test reports for all ac auxiliary motors into one package for DART's review and approval. (CDRL 16-6)

16.3.4 Traction Gear Unit

The traction gear unit shall be subjected to a 100 hour test, and shall be mounted with torque load simulation. The test shall subject the units to conditions that are, in general, 20% more severe than would occur under the most extreme operating conditions (i.e., power increased by 20%). (Procedure: CDRL 16-7) (Report: CDRL 16-8)

The test shall be started with the unit at a temperature from 60°F (15°C) to 90°F (32°C). A fan or other device may be provided so that in-service air flow conditions are simulated. The temperature rise measured in the oil sump shall not exceed the gear oil supplier's recommendations for maximum temperature consistent with the life between oil changes, as stated in the Contractor's maintenance manuals. The direction of rotation shall be reversed every successive 8 hrs until the 100 hr test is completed. Noise and vibration tests shall also be performed to verify the requirements of Section 2.

After completion of the test, the gear unit shall be disassembled and all parts examined. Gear tooth mesh and tooth pattern shall be checked and recorded before and after the test. The test report shall include test records of running time, oil temperatures, and vibration and
sound level readings taken at such intervals as required to verify compliance with this Specification.

16.3.5 Auxiliary Power Supply

The auxiliary power supply design qualification tests shall be performed on a production unit, based on the “Type Test” requirements of IEC 61287-1. (Procedure: CDRL 16-9) (Report: CDRL 16-10)

These tests shall include all aspects of the following for the design requirements, environmental ranges, and supply voltages given in Sections 2 and 9 and as listed herein:

- All output and control requirements
- Performance and capacity requirements
- Combined system test demonstrating the capability to start up all ac loads, especially the HVAC compressors, under the worst case loading scenario possible, not including load failures
- Fault detection and annunciation requirements
- Insulation, isolation, and transient rejection requirements
- Heat run, designed to test the system for the worst case heat loadings for:
  - Maximum rated output current at the lowest operational input voltage
  - Lightest possible load, at the highest operational input voltage
- Noise measurements shall be made sufficient to demonstrate compliance with Section 2.7.
- Radiated EMI generated and EMI susceptibility

16.3.6 Low Voltage Power Supply and Battery Charger

Low voltage power supply and battery charger qualification tests shall be run on a production unit, based on the “Type Test” requirements of IEC 61287-1. (Procedure: CDRL 16-11) (Report: CDRL 16-12)

The design conformance tests shall include the following:

- A continuous heat run of the unit at rated input voltage and rated output voltage and current. The heat run shall be of sufficient duration to allow all critical elements to stabilize in temperature. Temperature rises over ambient shall be within Contractor's limits as set forth in the test plan.
- The unit under test shall be run for one hour at an input voltage at the upper limit of the specified operating range, and at rated output current and voltage.
- The unit shall be run for one hour at an input voltage at the lower limit of the specified input range for which rated output voltage and current is to be delivered, at rated output voltage and current.
- The unit, when connected to its rated load, shall be cycled OFF and ON by interruption of the source voltage supply external to the unit under test. Rate of cycling shall be approximately one second on, one half second off, and shall continue for 2 minutes.
• The unit shall be started into an open circuit five times in succession.
• The unit shall be started into a short circuit five times in succession.
• The unit shall be started while connected into an overload at 120% of rating. The overload shall then be removed and the unit shall automatically provide rated output voltage.
• Noise measurements shall be made sufficient to demonstrate compliance with Section 2.7.
• At operating points representing the full range of conditions for delivery of rated output voltage and for routine current limit operation, output voltage and output voltage waveforms shall be monitored by an oscilloscope to determine compliance with the specified regulation and levels of ripple.

16.3.7 Truck

The truck frame shall be given a static load test and a fatigue endurance test. The Contractor is responsible for selecting test loads and conditions that will develop a high level of confidence in the adequacy of the truck design. (Procedure: CDRL 16-13) (Report: CDRL 16-14)

A test procedure shall be prepared for each test. The procedure shall include, but not be limited to, a description of the test, the purpose, a clear description as to how the test specimen is to be loaded, the load increments, a description of the equipment to be used to load the specimen, the type and location of strain gauges, the location of deflection gauges, complete description of all instruments, and details of the data acquisition system. Drawing and sketches shall be included to clarify the text. Also included shall be the drawings showing the test fixture, the specimen installed in the fixture, and location of load application points. The procedure shall include a list of the steps to be performed. Test procedures for all truck tests shall be combined and shall be submitted not less than 90 days in advance of the test date, and approvals of the test procedure and stress analysis are necessary prerequisites for testing.

The test procedure shall include a copy of the current calibration for every instrument and gauge to be used during the test. The calculation of the accuracy of the test system shall be included. Typical logging sheets, print-outs, plotting forms, and examples of any other data sheets that will be used during the test or in the final report shall be submitted as part of the test procedure. Tables shall be included which show the maximum allowable gauge reading for each gauge and loading condition. There shall be a table listing for each strain gauge, the strains calculated by the FEA at the gauge location, so that the output of the strain gauge reading is readily comparable to the information in the table. Other tables, showing the acceptable criteria for all other test results, shall be included in the test procedure.

Not less than 75 rosette strain gauges shall be applied to the truck frame and bolster for the tests described in Sections 16.3.7.1 and 16.3.7.2 at locations of expected high stress and other areas of interest. Location of strain gauges shall be based on the stress analysis, the Contractor’s experience, at the direction of DART. Drawings and sketches showing the location of every strain gauge shall be prepared by the Contractor and submitted as part of the test procedure. DART will review and approve strain gauge locations. The strain gauges shall be SR-4 type, or other approved gauges specifically suitable for the application. The gauges shall be calibrated in accordance with the manufacturer’s instructions for the material being measured. The gauges shall be compensated for temperature. A load cell
shall be installed at each point of load application. All load cells shall be recorded simultaneously with all strain gauges.

16.3.7.1 Static Load Test

The purpose of the static load test is to verify that the maximum allowable static stresses selected by the Contractor are not exceeded under the maximum expected static loads and to verify the predictions of the finite element analysis. The truck and bolster shall be loaded twice, with complete release of the load between applications. Strain gauges shall be re-zeroed after the first load application and the offset from zero recorded and reported. All required data shall be taken during both load applications. The methods and points of test load application and reaction shall simulate as closely as possible the actual loading conditions to which the truck will be subjected in service.

The vertical test load shall be the truck's share of completed vehicle plus an AW4 passenger load minus the weight of the truck. The lateral load shall be 15% of the vertical component. The longitudinal load shall be the maximum possible instantaneous braking effort (friction and dynamic plus track brake) and 50% adhesion at the wheels at AW4 load. The lateral and longitudinal loads shall act as if they were applied at the center of gravity of the completed vehicle plus an AW4 passenger load. Accessory loads, such as brake units, track brakes, and traction motors, shall represent maximum steady state conditions; for example, maximum motor torque and brake unit weight, and maximum brake unit reaction and motor weight. All loads shall be applied to produce the worst stress conditions on the truck.

The truck will be compliant with this specification if all of the following are met:

- Maximum stresses calculated from strain readings in any gauge during the second load application do not exceed 50% of the material's yield stress.
- Indicated residual strains following removal of the second loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There are no permanent deformations, fractures, cracks, or separations in the truck.

If any of the above criteria are not met, the truck design shall be corrected and the truck retested at the Contractor's expense, and this process shall continue until these criteria are met.

16.3.7.2 Fatigue Test

To demonstrate that the truck has adequate fatigue strength under dynamic loading, the truck frame and bolster shall be subjected to not less than two million cycles of dynamic loading. The truck and bolster, which undergoes this test, shall not subsequently be used on a production vehicle, and shall be permanently marked or destroyed.

Prior to the test, the test truck shall be given a wet, fluorescent magnetic-particle or fluorescent dye-penetrant inspection for cracks and other defects that might impair the performance of the truck during the test. Magnetic particle and dye penetrant inspections shall be in accordance with the requirements of Section 17. Any such defects found shall be recorded, and if required, repaired using an approved procedure. The type, size, location and repair of each defect shall be documented by photographs and drawings, and all such documentation shall be included in the truck fatigue test report.

The mean vertical load shall be the truck's share of completed vehicle plus an AW2 passenger load minus the weight of the truck, and the applied vertical load shall vary about
the mean vertical load plus and minus 25%. The lateral load shall vary between 15% of the mean vertical load acting towards one side of the truck and 15% of the mean vertical load acting towards the other side. The longitudinal load shall vary between 15% of the mean vertical load acting towards one end of the truck and 20% of the mean vertical load acting towards the lateral and longitudinal loads shall act as if they were applied at the center of gravity of the carbody at the AW2 load, with resulting vertical loading applied to the bolster. Accessory loads shall vary between plus and minus 100% of their maximum steady state values: motor under maximum braking torque and brake unit tractive effort under maximum service brake application with not less than 50% adhesion and maximum track brake tractive effort reaction. The phasing of the loads shall be selected by the Contractor and shall be such as to produce the worst case stresses at critical locations.

The truck will be compliant with this specification if all of the following are met after two million cycles:

- Stresses calculated from strains measured at critical locations do not exceed fatigue allowables. Critical locations and fatigue allowables shall be as selected by the Contractor and approved by DART. This stress range shall be within the allowable fatigue endurance limit for non-redundant structures obtained from AAR Section C-Part 2, Clause 2 or AWS D1.1/D1.1M:2010, or the Contractor's own tests if more appropriate and conservative.
- Indicated residual strains at strain gauges on principal structural elements following removal of all loads do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There is no permanent deformations, fractures, cracks, or separations in the truck.

At the conclusion of two million cycles, a magnetic particle or dye-penetrant inspection shall be made for cracks. The post-test inspection procedure shall duplicate the pre-test inspection procedure. If cracks are found which were not present before the test, or cracks have propagated from original recorded dimensions, the design shall be corrected, and the test rerun from the beginning with a new test specimen at the Contractor's expense. This process shall continue until these criteria are met.

### 16.3.8 Carshell Structural Tests

#### 16.3.8.1 General

The first carshell shall be tested by the Contractor to show that the critical portions of the carbody structure comply with this specification. The tests shall not begin until the stress analyses have been approved. (Procedure: CDRL 16-15) (Report: CDRL 16-16)

The test shell shall be structurally complete, consisting of both shell halves with the articulation joint installed, but excluding such items as exterior and interior trim, windows, doors (except those used in the vertical load test), bridgeplates (except those used in the vertical load test), seats, lights, interior linings, insulation, or other parts that would obscure any structural member from view or that would interfere with the performance of the test. Equipment shall be simulated by equivalent weights at their respective locations. All structural tests shall be conducted on the same specimen.

A test procedure shall be prepared for each test. The procedure shall include a description of the test, the purpose, how and with what equipment the specimen is to be loaded and in what load increments, the type and location of strain gauges, the location of deflection
gauges, complete description of all instruments and gauges, and details of the data acquisition system. Annotated copies of catalogue cuts may be used to provide some of this description. An explanation of the accuracy of the instrumentation shall be provided. Drawings and sketches shall be included to clarify the text. The test procedure shall include a step-by-step instruction describing how load is applied, the load at each step, when to record data, and the place where authorization to proceed is to be obtained from DART representative. Test procedures for all carbody tests shall be combined and shall be submitted not less than 90 days in advance of the test date, and approvals of the test procedure and stress analysis are necessary prerequisites for testing.

The test procedure shall include a copy of the current certification for every instrument and gauge to be used during the test. It shall include a calculation of the accuracy of the test system for each test. Typical logging sheets, print-outs, plotting forms, and examples of any other data sheets which will be used during the test or in the final report shall be submitted as part of the test procedure.

Tables shall be included which show the maximum allowable gauge reading for each gauge and loading condition. Other tables shall be included which show the requirements for all other test criteria.

Each test procedure shall contain a table of predicted strain (or stress) at selected strain gauge locations. This table shall list the strain gauge number, predicted strain (or stress) from the stress analysis, the location of the strain, a space to enter the actual strain (or stress) and a space to enter the calculated percent difference, defined as:

\[
\text{Percent Difference} = \frac{\text{Actual} - \text{Predicted}}{\text{Actual}} \times 100
\]

The percent difference between the actual and predicted values shall be within 15% for a minimum of 75% of the measurements recorded. For any of the remaining 25% where the analytical values disagree with the test value by more than 15%, and the test value is equal to or greater than 35% of the yield strength of the material, a detailed explanation of the reasons for the excessive variance shall be included in the carbody test report.

If the analysis results do not agree with the test results within the above-specified tolerance, the Contractor shall revise the stress analyses, update the finite element model, and re-run all finite element analyses. The process shall be repeated until agreement of the results is within the specified tolerance. All manual analyses using data from the finite element analysis shall be recalculated using the corrected values. The stress analysis report shall be revised and re-submitted. All results from re-analysis shall meet the requirements of this specification and, if they do not, the design shall be corrected.

A minimum of 300 rosette strain gauges shall be applied to the car structure for the end-compression load tests. A minimum of 300 rosette strain gauges shall be applied to the car structure for the vertical load tests. A minimum of 300 rosette strain gauges shall be applied to the car structure for the diagonal jacking tests. Gauges may be used for more than one test if located on the structure appropriate to more than one test, but readings from at least 300 rosette strain gauges in locations as described below for each test. Linear gauges may be used instead of rosettes where it can be shown that the stress is in one direction only and that direction has been identified. The location of the strain gauges shall be based on the Contractor's experience, the stress analysis, and DART recommendations. Half of the
gauges shall be place in areas where the stress may be critical and the other half shall be placed in locations to validate the stress analysis.

Drawings and sketches showing the location of every strain gauge shall be prepared by the Contractor and submitted as part of the test procedure. These drawings shall dimension the location of every gauge showing the distance from edges, connections and bends. The location on the upper or lower, inner or outer surface shall be noted on these drawings.

The strain gauges shall be bonded resistance (SR-4) type or other approved gauges suitable for the application. Gauges used on FRP shall be appropriate for that material. The gauges shall be calibrated in accordance with the manufacturer’s instructions for the material being measured. The gauges shall be compensated for temperature.

For each collision and corner post load test, there shall be a minimum of 100 rosette strain gauges applied to the post and car structure. Gauges may be used for more than one test if located on the structure appropriate to more than one test, but readings from at least 100 rosette strain gauges in locations as described below shall be obtained for each test. Linear gauges may be used instead of rosettes where it can be shown that the stress is in one direction only and what that direction is. Half of the gauges shall be placed in areas where the stress may be critical and the other half shall be placed in locations to validate the stress analysis.

16.3.8.2 Vertical Load Test

The carbody specimen, supported on trucks, or a simulation thereof, shall be subjected to a vertical load test. A test load equal to the complete, ready-to-run carbody weight (complete car minus trucks) plus a subsequent AW4 passenger load shall be applied to the specimen. The latter passenger load shall be applied in three approximately equal increments, resulting in a total of four vertical load increments. One of these increments shall be equivalent to a ready-to-run carbody weight plus a passenger load of AW2. The test load may be applied by means of weights or jacks, but shall be distributed in proportion to the distribution of weight in the finished car. The specimen shall be unloaded in the increments that it was loaded, in reverse order.

During the vertical load test, a measurement of carbody vertical deflection shall be made on the carbody shell with each test load applied.

All side doors and bridgeplates on one side of the car shall be installed. The doors shall be complete with operators, thresholds, and all sealing and weatherstripping. All door and bridgeplate equipment shall be production equipment installed in accordance with production drawings and procedures. At each increment of test load, the doors shall be opened and closed and the bridgeplates shall be extended and retracted electrically by means of the operators. The opening and closing time of each door leaf and bridgeplate shall be measured and recorded electrically. Failure to operate at the prescribed speed or any indication of binding shall require corrective action to be taken by the Contractor to the car structure or the door arrangement, or both. The vertical load test must then be repeated in its entirety.

The car will be compliant with this Specification if all of the following are met:

- Stresses are in accordance with the requirements of Section 3.5.1.
- Vertical deflection readings plotted against load do not vary by more than ±5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at that point which represents the measured deflection for maximum vertical load.
• Strain readings plotted against load do not vary by more than ±5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.

• Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.

• Recorded residual vertical deflection between bolsters following removal of the maximum vertical test loading does not exceed 0.04 inches (1.0 mm).

• Recorded residual car transverse width and/or opening diagonal dimensions following removal of the maximum vertical test load do not exceed 0.04 inches (1.0 mm).

• Indicated residual strains at strain gauges on principal structural elements following removal of the maximum vertical loading do not exceed the maximum error resulting from the accuracy of the instrumentation.

• Carbody side sill deflection, under a load equal to the passenger load of AW4, as measured from the datum line drawn from the transverse center line of the carbody bolster at the truck through the transverse centerline of the articulation joint shall not deflect more than 0.35 inches (9 mm).

• Carbody vertical deflections measured at the side sill during the test at AW2, AW3, and AW4 shall agree with the analysis calculated deflection within +/-10%.

• There are no permanent deformations, fractures, cracks, or separations in the car structure. Broken welds and bonds shall be jointly inspected by the Contractor and DART to determine if the failure is the result of weld quality or stress.

• The side doors open and close at speeds and operating force levels as required without binding at all test loads.

### 16.3.8.3 Compression Load Test

The ability of the carbody structure to resist the compression loads specified in Section 3.5.2 shall be tested.

During the compression test, the car shell shall be supported on trucks or a simulation thereof to allow longitudinal movement.

The force of the testing machine shall be applied by hydraulic power and the force measured by a means independent of those producing the force. The compression test load shall be applied by means of a controlled hydraulic ram. Cushioning means, such as lead sheets, shall be provided to assure uniform bearing. The test load shall be applied horizontally on the car longitudinal centerline. No allowance shall be made for camber of the body. The load shall be applied in increments of 25, 50, 75, 87.5, and 100% of full load. The load shall be reduced to not more than 2% of full load after each step. Strain gauge and deflection readings shall be taken at each load increment and at each relaxation of load. The ram shall be supported at the car end but shall remain free to move longitudinally with respect to the car end.

The test load shall be applied to the anticlimber. This load shall be distributed over an area not to exceed 6 inches (150 mm) in height by 12 inches (300 mm) in width.
The car will be compliant with this Specification if all of the following are met:

- The vertical deflection of each side of the test structure shall be within a ±10% of the value determined by the analysis.
- Vertical deflection readings plotted against load do not vary by more than ±5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- Strain readings plotted against load do not vary by more than ±5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection, at maximum load.
- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to starting the test program as part of the stress analysis.
- Recorded residual vertical deflection between bolsters following removal of the maximum test load does not exceed 0.04 in (1.0 mm).
- The residual horizontal deflection between ends following removal of the maximum load does not exceed 0.04 in (1.0 mm).
- Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
- There are no permanent deformations, fractures, cracks, or separations in the car structure or in the carbody sheathing. Broken welds and bonds shall be jointly inspected by the Contractor and DART to determine if the failure is the result of weld quality or stress.

16.3.8.4 Diagonal Jacking Test

The car shell shall be loaded to its AW0 weight, with all trucks (or an equivalent weight) hanging from the body bolsters. The car shell shall be supported symmetrically at the minimum number and placement of jack pads necessary to support the car safely. The jack in the position that, when lowered, subjects the carbody structure to worst-case diagonal loading, shall then be lowered in five equal increments until the load on the jack is 10% of its original value. All gauges shall be recorded at each increment of jack position. The procedure shall be reversed until the load on the jack is returned to its original level.

The test described in the prior paragraph shall be repeated using the car jack socket adapters.

The car will be compliant with this Specification if all of the following are met:

- Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses approved prior to the start of the test program as part of the stress analysis.
- Strain readings plotted against load do not vary by more than ±5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point which represents the measured deflection at maximum load.
- The vertical deflection of each side of the test structure shall be within ±10% of the value determined by the analysis.
- Indicated residual strains at strain gauges following return to original level do not exceed the maximum error resulting from the accuracy of the instrumentation.

- There shall be no permanent deformation, fractures, cracks or separations in the car structure. Broken welds and bonds shall be jointly inspected by the Contractor and DART to determine whether the failure is the result of weld quality or stress.

### 16.4 System Design Qualification Tests

The following system design qualification tests shall be performed by the Contractor, or under its direction, to demonstrate conformance to the requirements of this Specification.

#### 16.4.1 Propulsion System and ESS Test

A laboratory test shall be conducted on one set of propulsion equipment, including motors, power conditioning, protection devices, logic, controls, and master controller, using a dynamometer which simulates vehicle inertia by means of flywheels or programming of a motor-generator, and which simulates train resistance by means of a motor-generator. The physical layout of car components and cabling for this test shall simulate actual car conditions. This test is for the purpose of demonstrating that the propulsion functions properly and meets all requirements of Sections 2 and 10 prior to installation on the vehicle. (Procedure: CDRL 16-17) (Report: CDRL 16-18)

The propulsion qualification test shall utilize the laboratory’s primary power supply and verify operation at the wayside voltage limits in Section 2.4.1. Additionally, the operation and capacity of the energy storage system (ESS) shall be verified. The ESS system shall used during simulated operation over the wireless segment with recharging occurring from the laboratory’s power supply during the specified portion of alignment only. Simulation of sequential starting of the HVAC units on the vehicle and continuous operation of all other control and auxiliary loads shall be simulated to verify the ESS meets the required HVAC inrush currents and steady state vehicle loads while drawing maximum propulsion current. The ESS system shall be tested in a production enclosure, including control unit, and shall be operated at both the minimum and maximum temperature conditions.

#### 16.4.2 Friction Brake System

The complete friction brake system and all components shall be given a qualification test on a dynamometer to confirm braking capability, thermal capacity, response, and wear rates. These tests may be included with the propulsion system laboratory tests. Testing shall include hot and cold retardation, wet and dry retardation, actuation energy storage, and control response. (Procedure: CDRL 16-19) (Report: CDRL 16-20)

#### 16.4.3 Door System

Door, door operator, control, and sensitive edge qualification tests shall include an accelerated life test of 1.5 million cycles for one complete set of door equipment. The door equipment shall be assembled as a unit for the test. The test fixture used shall accurately represent the actual carbody and installation. (Procedure: CDRL 16-21) (Report: CDRL 16-22)

#### 16.4.4 Unitized HVAC System

One self-contained HVAC unit of each type, complete with all controls, shall be given a qualification test to confirm air flow, water elimination, heating capacity, cooling capacity
control, extreme operating conditions, unit noise, and power consumption. (Procedure: CDRL 16-23) (Report: CDRL 16-24)

Test setup shall be according to the latest revision of ANSI/ASHRAE Standard 37. The instrumentation accuracy and tolerances shall comply with Standard 37 requirements. All data required by Standard 37 shall be recorded using an appropriate data acquisition system.

16.4.4.1 Scan Test

The temperature control components shall be exposed to the temperature environments they will experience on the car. All points of temperature control shall be verified on temperature rising and temperature falling. The temperature of applied load, as appropriate for the control system shall be varied slowly to reflect natural temperature lags, as close as practical simulating the actual operation.

The simulated vehicle interior and ambient rooms shall be instrumented with temperature measuring devices to determine when various control switching points are reached. The contactors coils shall be connected to the event recorder or other suitable recording instrumentation to determine which contactors are picked up to verify control response. The simulated vehicle interior and ambient temperatures shall be cycled up and down, at least 20 times, through the operating range of the temperature sensors.

Any malfunction of the system or components at any temperature shall constitute a failure of the test. The use of test switches or potentiometers to control the unit independent of the temperature sensors is not permitted.

16.4.4.2 Control Stability Test

Under steady state operation at design conditions, the low-voltage dc power supply voltage shall be varied between the limits allowed by Section 2.4.2 to show the effect of such change. The system shall be shut down and restarted while the control voltage is at its minimum value.

16.4.4.3 Cooling Capacity

Cooling capacity shall be verified at the design conditions listed in Section 7.2, following the procedure of ANSI/ASHRAE Standard 37, Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment. In addition to test "A", one of the secondary applicable test methods "B" shall be selected by the manufacturer from Table 1 of the Standard.

16.4.4.4 Maximum Operating Conditions

A system functional test shall be performed at 105°F (40.5°C) DB, and 84°F (29°C) WB at the condenser and fresh air intakes ambient and evaporator air mixture based on this ambient and interior car temperature at 75°F (24°C) DB and 60% RH.

A successful test shall consist of continuous operation of the system at these conditions for one hour without shutdown due to high pressure, modulation, circuit breaker trip, compressor motor overload, or any device failure. A shutdown for any reason while operating at these conditions shall constitute a failure of the test. All data shall be recorded every five minutes during the steady state of operation.

At the end of one hour of operation, the system shall be momentarily stopped and then restarted. The system shall continue to function properly with all components safe from
malfunction. There is no capacity to be met. This test shall be conducted at nominal supply voltage, 10% over voltage and 10% under voltage.

16.4.4.5 Modulation Pressure Switch Test

A test with air entering the condenser higher than 105°F (40.5°C) DB, and at the evaporator air mixture based on the conditions of Section 16.4.4.4 shall be used to demonstrate pressure modulation capability. As the condenser outlet air dry bulb temperature rises, pressures and temperatures shall be recorded and the system shall be allowed to cycle due to the modulated. The frequency of pressure switch cycling shall be recorded. All system pressures and temperatures and the state of compressor oil in its sight glass shall be recorded.

A successful test shall consist of one hour of continuous operation of the system without shutdown due to high pressure, cutoff, circuit breaker tripping, compressor motor overload, or any device malfunction.

16.4.4.6 High Pressure Cut-Off Switch Test

Upon conclusion of the modulation pressure switch test, the condenser air temperature shall be slowly increased to 115°F (46°C). The system shall operate at least one hour continuously at this condition while maintaining the interior mixture conditions defined in Section 16.4.4.4 without operation of the high pressure cut-off device. Following this, the condenser/fresh air ambient shall be slowly raised to the point when the high pressure cutoff switch activates and shuts off the system. Record pressures and temperatures of the pressure switch cutoff and reset conditions. This test shall be repeated four times.

16.4.4.7 Low Temperature Operation Test

A low temperature operation test shall be conducted at air temperature entering evaporator coil based on the mixture of the recirculated air at 72°F (22°C DB), 50 percent RH and ambient conditions determined from the control chart to be 2°F (1°C) higher than the compressor lock-out point. After attainment of the specified temperature conditions, the unit shall be operated continuously for a period of four hours. During the test, the unitized air cooling system shall operate without damage to the equipment and without the formation of any ice or frost on the evaporator coil or piping. The data shall be recorded every 10 minutes (or more frequently) during steady state operation.

16.4.4.8 Insulation Efficiency and Condensate Carry-Over Test

The unit insulation efficiency shall be tested with ambient and evaporator entering air temperature at 80°F (27°C) DB, 75°F (24°C) WB. The unit shall be operated continuously for a period of four hours at the specified conditions. During the test, no condensed water shall drop, run, or blow off the unit's casing.

All condensation from the evaporator coil shall be retained inside the drain pan. No condensate shall spill from the drain pan.

16.4.4.9 Refrigerant Sample Test

A sample of refrigerant and oil shall be taken from the air conditioning system of the tested unit and analyzed for contaminants in accordance with ARI Standard 700 by an approved laboratory, except that moisture level of up to 30 mg/kg is allowed and the high boiling residue requirement is not applicable.
16.4.4.10 Watertightness and Water Eliminator Test

The HVAC equipment system shall be watertightness tested as specified in Section 16.6.14. The testing shall be conducted with power to the unit (blowers functioning).

16.4.4.11 Noise Test

The HVAC equipment shall be noise tested to determine conformance to the requirements of Section 2.6.

16.4.4.12 Abnormal Heating Condition, Restricted Air

During this test, the ambient temperature shall be maintained at approximately 70°F (21°C) with the system heaters activated independent of the thermostat and with the air conditioning compressor not operating, and with the air flow switch bypassed. The test shall be conducted by slowly restricting the mixed air inlet so that heater unit temperature rises 2°F (1°C) per minute, but not faster, until the high limit switch cycles off. The restriction shall be eased to the point where the high limit switch stays closed. The heating test shall continue, to simulate a dirty filter condition. The system shall operate until a steady condition is reached.

The test shall be performed at nominal, low, and high supply voltage specified limits. The test shall be successful when the following criteria are met:

- The back-up protection did not activate during the test
- The temperature inside the unit did not cause damage to the equipment and components
- There was an absence of any smoke and odors
- The high limit switch opened at the design set point ±10°F (±6°C)

16.4.4.13 Abnormal Heating Condition, with No Air

The ambient temperature shall be maintained at approximately 70°F (21°C). The air conditioning compressor shall not be operating and the air flow switch shall be bypassed. Power shall be applied to the heaters with no air blowing over the heaters. The system shall be operated as the high limit switch cycles.

The criteria of Section 16.4.4.12 shall apply for supply voltages at nominal, low, and high specified limits.

16.4.4.14 Back-Up Protection Test

The ambient temperature shall be maintained at approximately 70°F (21°C). The air conditioning compressor shall not be operating. Prior to power application to the heaters, the high limit switch and air flow switch shall be bypassed. The heaters shall be energized and the activation temperature of the back-up protection device shall be observed. The equipment interior temperatures shall be measured and recorded, at least once per minute, from the start until all recorded temperatures start decreasing.

The test shall be performed at nominal, low, and high supply voltage specified limits. The test shall be successful when the following criteria are met:

- The temperature inside the unit did not cause any damage to wiring, electrical components, motor, and unit insulation
• There was an absence of any visible smoke
• There was an absence of any detectable odors

16.4.4.15 Start-up Current Draw
The start-up current draw profile (current versus time) characteristics of the unit shall be recorded under the following conditions:
• Design Cooling Conditions
• Maximum Operating Cooling Conditions

For these tests the data-sampling rate shall be no more than 10 milliseconds.

16.5 Vehicle Qualification Tests

16.5.1 General
Vehicle qualification tests shall be performed on the first car to establish that the overall car design meets the requirements of these Technical Specifications. The Contractor shall submit all procedures for the systems described in Sections 16.5.3 through 16.5.17 before conducting any testing under this section (15 procedures in one submittal package). (Procedure: CDRL 16-25) (Report: CDRL 16-26)

All of the tests shall be performed on the Contractor’s track or facilities unless otherwise approved by DART. Before any testing on is performed on public right-of-way, a safety test must be conducted where braking and all other safety systems are verified to be functioning with specified parameters. The Contractor shall select, with DART’s concurrence, a suitable test segment and determine where each test will start.

Locations shall be such that the opposite direction test run shall be run over the same portion of the alignment. The start location for each test shall be marked.

As a minimum, two runs in each direction shall be made for each running test. This series of tests shall be used to determine the equipment settings and calibrations for the car acceptance program. After the successful completion of the car level design qualification test program, the car used in the test shall be restored to its original configuration and restested with the complete car acceptance program instrumentation package.

The relationship between torque (or motor current) vs. the load weigh signal, and brake cylinder pressure vs. load weigh signal, shall be developed for a continuous range of passenger loadings from empty to fully loaded, and referenced to evaluate the acceptance testing of all other cars, which may then be tested without load during acceptance testing.

All recorded data shall be corrected for voltage and grade as part of the Contractor’s test report.

Test reports shall be forwarded to, and become the property of, DART. All strip chart and recordings taken during the vehicle level design conformance testing shall become the property of DART.

If the car or apparatus fails to satisfy the specified performance and design criteria, the car, with the necessary adjustments, shall be redesigned and restested at the Contractor’s expense. If modifications are necessary, they shall be affected on a fleetwide basis.
16.5.2 Instrumentation

For these tests, each car shall be instrumented with a Contractor furnished multi-channel data acquisition system which shall produce a permanent test record (both electronically and hard copy). The Contractor shall supply all recorders, sensors, transducers, pickups, equipment racks, test wiring termination panels, calibration equipment, wiring, and inverters to operate this instrumentation using the car low voltage power system supply. Internal combustion engines driving a generator or use of the car inverter power will not be permitted.

A proof of the calibration of all instruments, traceable to a master at the national standards organization of the applicable country, shall be submitted to DART for approval, prior to testing.

The equipment shall function over the low voltage power system voltage range described in Section 2.4.2. Isolation amplifiers and voltage dividers shall be provided as part of the instrumentation package to isolate the inside car instrumentation wiring and equipment from high voltages; no exposed terminals with potential differences greater than 50 V will be permitted.

Each procedure for each system under test shall include the instrumentation used for that specific procedure only.

Test wiring termination panels shall include test jacks and switching for each channel to permit calibration signals to be injected into each recorder channel without requiring wiring or connectors to be disconnected and shall be arranged so that calibration signals cannot be fed back into the monitored equipment. All equipment used must be calibrated.

The accuracy and response of the instrumentation shall be sufficient to determine compliance with the Specification and design criteria.

For each test, the following channel assignments shall be permanently recorded simultaneously, as specified:

- Acceleration (positive and negative). The signal shall be provided by an independent accelerometer (acceleration/deceleration rates calculated by the propulsion and/or friction brake system will not be considered acceptable for this requirement)
- Traction motor current/torque or effort (each truck)
- Spin slide system operation (each truck)
- Brake cylinder pressure (each truck)
- Brake disc temperature on one motor truck axle using thermocouples embedded in the brake pads.
- Catenary voltage
- Total catenary current drawn by each car
- Speed
- Propulsion and braking trainline command signals (or multiplexed to a single analog channel)
- Auxiliary inverter voltage and frequency outputs
- An independent time base with one second time intervals
Such channels as the Contractor feels necessary to record the voltage transients of Section 9

Five spare analog and 10 spare digital channels for additional signals which may be requested by DART

16.5.3 Propulsion Tests
The first series of tests shall be run at AW0, and a second series of tests shall be run at AW2. Performance requirements shall be as noted in Sections 2 and 10 for test conditions described below. Braking shall be monitored during all propulsion tests.

16.5.4 Braking Tests
The first series of tests shall be run at AW0, the second series of tests shall be run at AW2, and a third series of tests shall be run at AW3. Braking runs shall be made for both normally configured stops, in which both dynamic and friction brake are blended to provide the specified performance, and for all friction brake stops. In all friction stop tests, for each run, brake discs shall be cooled to a maximum of 250°F (120°C) as measured by thermocouples before initiation of any test. Compliance with the performance requirements in Sections 2 and 12 shall be demonstrated.

16.5.5 Thermal Capacity Tests
One car shall be fully instrumented and used to verify compliance with the duty cycle requirements specified in Sections 2.6.14, 10.3 and 12.5.8.

16.5.6 Wheel Spin/Slide
All power and braking modes shall be used in verifying compliance with all wheel spin/slide provisions given in Section 2.6.7. Each axle shall on the vehicle shall be monitored and recorded.

16.5.7 Auxiliary Inverters
The Contractor shall operate auxiliary inverter test instrumentation throughout all car performance testing to verify consistent, reliable inverter performance. Chart recordings which contain representative samples of inverter operating characteristics, taken during the auxiliary inverter design conformance test and these car performance tests, shall be copied and included in an auxiliary inverter test report.

16.5.8 Parking Brake
A parking brake system test shall be performed on the first car. Compliance with Section 2.6.13 shall be demonstrated.

16.5.9 Noise and Vibration
Sound level and vibration tests shall be performed on one car, at AW0 car weight, to confirm that the readings are compliant with Section 2.7.

Sound measurements shall be taken on at grade, newly-ground, welded rail and where reflections from nearby walls, floor, or other equipment will not influence the directly radiated sound by more than 2 dB. Measurements shall be made with an ambient sound level not less than 10 dB below the sound level produced by the equipment being measured when evaluated using the same scale or octave band.
16.5.10 Horn and Bell
The horn and bell, as mounted on a completed car, shall be tested for conformance to the requirements of Section 5.2.1. This requires testing of both ends of a car.

16.5.11 Electromagnetic Compatibility
An electromagnetic compatibility test shall be performed on the first car to verify compliance with the requirements of Section 2.8 and compatibility with the DART wayside signal system.

16.5.12 Ducting Watertightness Test
The fresh air and electric equipment ventilation intake ducts in the car roof shall be water tested with the ventilating fans running at full speed to determine the effectiveness of the water-excluding features of the duct work. At the conclusion of the test, there shall be no evidence of moisture in the ducts downstream of the water excluding features.

16.5.13 Air Leakage
To assure positive internal carbody pressurization, the first car shall be given an air leak smoke bomb test with the interior pressurized to a minimum of 0.5 inches of water (125 Pa). All openings related to ventilation shall be sealed during this test. All apparent leaks shall be evaluated and a fleetwide correction implemented by the Contractor.

16.5.14 Air Balance
The air balance test and a car pressurization test shall be performed to verify conformance with the requirements specified in Section 7, with "dry" evaporator coil condition. The volumes of fresh, recirculated and exhaust air, and the total volume of air delivered by the circulating blowers, shall be measured and recorded, along with the conditions of the air (dry and wet bulb temperature, and barometric pressure).

The blower motor current, volts, power consumption and speed shall conform to the HVAC manufacturer's design data and motor specifications.

The Contractor shall make all necessary adjustments to conform to the fresh air volume requirements of Section 7 and the HVAC manufacturer's total airflow design.

16.5.15 Vehicle HVAC System
The test of the vehicle HVAC system shall be conducted by the Contractor, with the assistance from the HVAC unit manufacturer, to verify vehicle HVAC system compliance with the requirements of Section 7. This test may be conducted in a climate room, or in an enclosed facility, such as a paint booth, where the “ambient” temperature requirements specified in Section 7 can be achieved. Electric baseboard heaters and humidifiers shall be used to simulate the passenger, sensible and latent, and solar loads inside the car. Portable data logging equipment shall be used to record temperature at a minimum of 30 locations throughout the car, representative of seating and standing passengers, including operator’s cab and articulation section.

The car shall be exposed to an agreed-upon high ambient temperature condition for a minimum of six (6) hours, without HVAC system operation. Following this "soaking", the pull-down test shall be performed, and time required for achieving and stabilization of the required car interior temperatures shall be measured for information.
Testing shall include a cooling test at the design conditions of Section 7 and the cooling tests required by Section 16.4.4, except that actual interior passenger and solar loads shall be simulated inside the car, instead of regulating the return air temperature.

Following stabilization for each test condition, the temperatures shall be recorded every minute for 30 consecutive minutes in order to determine temperature swing as the HVAC equipment cycles. Car interior temperatures shall not vary by more than 5.5°F (3°C) per the following:

- At any given time, except during pull-down and warm-up, among all points in the same horizontal plane from one end of the car to the other, except for the articulation section
- At any given time, except during pull-down and warm-up, in the plane 67 inches (1700 mm) above the floor and any point directly underneath, 4 inches (100 mm) above the floor
- At any given point within the car after stabilization, with the doors closed, due to cycling of HVAC equipment

All significant events and data (such as refrigeration and heating equipment cycling) shall be recorded, with corresponding temperatures and pressures as applicable for each test. The test shall also verify proper operation of HVAC equipment during cooling and heating operation.

16.5.16 Door Operation

Before shipment, the first vehicle shall have all doors operated for 1,000 continuous trouble-free cycles.

Any door or door control failure occurring prior to completion of the test on the first car will nullify the test, and the test shall be re-run completely after the fault has been corrected.

16.5.17 Light Intensity

Light intensity readings shall be taken (without light from other sources) on the first car to verify conformance with the requirements in Section 8.

16.6 System Conformance Tests

All equipment on each of the cars shall be given conformance tests at the Contractor's facility prior to shipment. The test to be performed on each component, system or the car shall be in accordance with the standards listed in this specification or an approved test plan for the component, system or car. The test reports of all conformance tests shall be included in each Car history book. The test report for each procedure on each streetcar shall be submitted to DART for review and approval immediately after completion of the test. CDRLs for test reports will be closed after the test reports for each streetcar have been received and approved.

16.6.1 Electrical Apparatus

Each component that is separately assembled, housed, and wired into a package unit prior to installation in the car shall be tested at its point of manufacture and a certified test report, signed by the responsible Quality Assurance representative of the manufacturer, shall be furnished to DART. Control and communications equipment shall be tested for function according to a procedure prepared by the manufacturer. Each test of electrical equipment shall include an insulation test as specified in Section 16.2.
Copies of the manufacturer’s test reports shall be assembled into one submittal package for each streetcar and submitted to DART for review and approval. (CDRL 16-27) The original test reports shall be incorporated into the car history books.

16.6.2 HVAC Unit

Each air conditioning unit shall be tested with a heat load applied to both the evaporator and condenser coils.

The unit shall be given a complete functional test to verify capacity modulation, control points of all pressure switches and all return air and fresh air thermostatic control points. Power consumption of all motors, evaporator and condenser fan motor speeds, system pressures and temperatures, and the applied loads to the evaporator and condenser shall be recorded. The system refrigerant charge and the refrigerant condition (wet or dry) shall be recorded. The oil level in the compressor shall be recorded. Any abnormal condition shall be corrected and the associated test repeated.

The unit heat staging and the functioning of the overheat protection devices, as specified in Section 6, shall be verified.

The manufacturer shall conduct insulation resistance and high potential tests on each unit as specified in Section 16.2. (Procedure: CDRL 16-28) (Report: CDRL 16-29)

16.6.3 Motors

Each traction motor, ac auxiliary motor, and dc motor shall be given a "routine" test by the manufacturer in accordance with IEC Publication 60349, IEEE Standard 11, or IEEE 112, as appropriate. Motor balance shall be dynamically tested in accordance with NEMA MG 1-12.06. (Procedure: CDRL 16-30) (Report: CDRL 16-31)

16.6.4 Traction Gear Units

Each traction gear unit shall be given the manufacturers "routine" test. (Procedure: CDRL 16-32) (Report: CDRL 16-33)

The test shall include, as a minimum, the following:

- Gear tooth mesh shall be checked to verify that it is within the manufacturer’s tolerances before the gear unit is operated.
- No load operation at 42 mph (70 km/h) equivalent car speed for 10 minutes in each direction. Noise and vibration produced by each gear unit and gear sump oil temperature shall be continuously monitored. All gear units which produce abnormal oil temperature or noise shall be rejected.

16.6.5 Traction Inverter

Each traction inverter shall be given a "routine" test by the manufacturer in accordance with IEC 61287-1 or IEEE Std 16. (Procedure: CDRL 16-34) (Report: CDRL 16-35)

With control power connected and tractive power disconnected, each tractive power control and reverser system shall be tested for correct sequences of operation in both powering and braking modes by simulating the operation of the control lock and master controller and observing the functioning of the various pieces of apparatus involved.

Insulation shall be tested per the requirements of Section 16.2.
16.6.6 Auxiliary Inverter

Each auxiliary inverter shall be given a "routine" test by the manufacturer in accordance with IEC 61287-1 or IEEE Std 16 to verify compliance with all aspects of the following for all nominal conditions defined in Section 2:

- All output and control requirements
- Performance requirements
- Fault detection and annunciation requirements

Insulation shall be tested per the requirements of Section 16.2. (Procedure: CDRL 16-36) (Report: CDRL 16-37)

16.6.7 Low Voltage Power Supply and Battery Charger

Each low voltage power supply shall be given a "routine" test by the manufacturer in accordance with IEC 61349 or IEEE Std 16 to verify compliance with all aspects of the following for all nominal conditions defined in Section 2:

- All output and control requirements
- Performance requirements
- Fault detection and annunciation requirements

Insulation shall be tested per the requirements of Section 16.2. (Procedure: CDRL 16-38) (Report: CDRL 16-39)

16.6.8 Battery

Five percent of the batteries supplied shall be given a capacity test at the point of manufacture. The test shall be at the 5 hr rate, at 68°F (20°C) ambient temperature in accordance with section 4.2.1 of IEC Publication 623. (Procedure: CDRL 16-40) (Report: CDRL 16-41)

16.6.9 Friction Brake Equipment

The friction brake equipment shall be given a "routine" test by the manufacturer. (Procedure: CDRL 16-42) (Report: CDRL 16-43)

The testing shall be conducted in accordance with the manufacturer’s recommendations and shall include;

- All electrical and electronic assemblies shall be subjected to an insulation resistance and high potential test per Section 16.2.
- Each hydraulic pump unit shall be given a functional test and a capacity test.
- All valves shall be functionally tested and certified for performance in accordance with manufacturer’s specifications and test codes.
- All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with manufacturer's specifications and test procedures.
16.6.10 Communication System

The communication system equipment shall be given a "routine" test by the manufacturer. (Procedure: CDRL 16-44) (Report: CDRL 16-45)

All electrical and electronic assemblies shall be subjected to an insulation resistance and a high potential test in accordance with the requirements of Section 16.2.

All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with manufacturer's specifications and test procedures, including City supplied equipment.

16.6.11 Truck Quality Testing

All production truck welds, including the frame, bolster and any other primary structural members, shall be subjected to magnetic particle or dye penetrant inspection. (Procedure: CDRL 16-46) (Report: CDRL 16-47)

Critical welds shall be inspected by radiography, or by section and etch, on 5% of the trucks chosen at random. Magnetic particle inspection shall be in accordance with ASTM E 709. Dye penetrant inspection shall be in accordance with ASTM E 165. Cast trucks shall be 100% magnetic particle inspected.

If defects are found during sampling inspection, the Contractor shall positively locate the beginning of such defects in previous truck frames and apply appropriate corrective action.

16.6.12 Wheel Back-to-Back Dimensions

All wheel-axle assemblies shall be measured to verify conformance with back-to-back distance requirements. (Procedure: CDRL 16-48) (Report: CDRL 16-49)

16.6.13 Shunt Resistance

All wheel-axle-wheel and wheel-axle-ground brush assemblies shall be measured to verify a minimum resistance of 0.01 ohms when measured between the treads of any two wheels on opposite sides of the vehicle. (Procedure: CDRL 16-50) (Report: CDRL 16-51)

16.6.14 Vehicle Watertightness Test

For each car, all areas of the car sides, ends, and roof, including doors and windows, shall be given a complete test for watertightness. (Procedure: CDRL 16-52) (Report: CDRL 16-53)

Tests shall be made before installation of sound deadening material, thermal insulation, and interior finish and again after assembly of the vehicle is complete. Water shall be sprayed from nozzles which are spaced no more than 39 inches (1 m) from, and aimed directly at, the surface being tested. Not less than 7 gallons per minute (26 liters per minute) shall be delivered to each square meter of surface being tested, and the nozzle velocity of the water shall be not less than 150 ft/sec (45 m/sec).

All spray applications shall run for 10 minutes before inspection for leaks begins, and shall run continuously during the inspection. The watertightness test shall also be performed on individual underfloor boxes required to be watertight during the test of each complete carbody. During test of the boxes, spray shall be directed at the exposed sides and ends of the boxes as would normally occur during car washing operations and as a simulation of water spray from the wheels.
16.7 Vehicle Static Tests

The tests listed in this section shall be performed by the Contractor on each assembled car prior to the vehicle acceptance test. All tests shall be incorporated into one procedure with the sub-sections of this section, Section 16.7, segregated into individual sections of the procedure. The procedure shall be designed to allow verification of maintenance repairs of each system during revenue operation. (Procedure: CDRL 16-54) (Report: CDRL 16-55)

16.7.1 Vehicle Wiring

Vehicle wiring acceptance testing shall be performed at the Contractor's facility on all cars after the wiring and equipment installation is completed and shall consist of the tests described below. The integrity of electrical insulation and connections shall be confirmed where specified below by performing continuity, insulation resistance, and high potential tests on the completed vehicle.

16.7.1.1 Wiring Continuity Checks

All circuits shall be tested to ensure continuity and correct polarity of equipment and devices. All frame grounds and terminal connections shall be checked for tightness.

16.7.1.2 Insulation Resistance Testing

Insulation resistance tests shall be conducted before high potential tests are conducted in accordance with the requirements of Section 16.2.

16.7.1.3 High Potential Tests

A high potential test shall be conducted after the insulation resistance tests are completed and passed. The high potential test shall be conducted on all circuits within the vehicle in accordance with the requirements of Section 16.2.

16.7.2 Vehicle Functional Tests

A complete, orderly, and comprehensive test of each and every vehicle system shall be performed to verify proper and faulted operation and interface. The tests shall follow a logical sequence to assure safety and proper equipment operation prior to the application of any power to the vehicle. Individual sections of the procedure shall be organized according to the system being tested to the maximum extent possible.

In addition to the basic functional tests, the following shall be included:

- All doors shall be operated a minimum of 100 consecutive, successful cycles. Initiation of the cycling shall be through the control line. Proper forces for opening/closing, operating speed, and obstruction detection shall be verified on every door before and after the above cycling.
- The HVAC system shall be functionally tested by simulation of inputs with the Portable Test Unit in all cars. The operation of the thermostatic control system shall be demonstrated by using the PTU. Levels of refrigerant and compressor oil shall be recorded.
- Friction brake tests shall include, as a minimum, verification of brake cylinder pressure settings, control and indicator verification, system leakage tests, response to dynamic brake feedback signals, and a functional test of the brake fault detection system.
- Load leveling system tests shall include leveling of the carbody and confirmation the system indicates the actual vehicle weight.
- The public address system, passenger information system and each Passenger emergency intercom shall be tested for clarity (intelligibility) of voice transmission and reception.

16.7.3 Truck Quality Testing

All production truck welds, including the frame, bolster and any other primary structural members, shall be subjected to magnetic particle or dye penetrant inspection. Critical welds shall be inspected by radiography, or by section and etch, on 5% of the trucks chosen at random. Magnetic particle inspection shall be in accordance with ASTM E 709. Dye penetrant inspection shall be in accordance with ASTM E 165. Cast trucks shall be 100% magnetic particle inspected.

If defects are found during sampling inspection, the Contractor shall positively locate the beginning of such defects in previous truck frames and apply appropriate corrective action.

16.7.4 Wheel Back-to-Back Dimensions

All wheel-axle assemblies shall be measured to verify conformance with back-to-back distance requirements.

16.7.5 Shunt Resistance

All wheel-axle-wheel and wheel-axle-ground brush assemblies shall be measured to verify conformance to shunt resistance requirements.

16.8 Vehicle Acceptance Testing

The following acceptance tests shall be performed by the Contractor prior to shipment to DART.

Prior to the initiation of acceptance testing, the vehicle shall be jointly inspected by DART and the Contractor. The Contractor shall make such adjustment, repair, or replacement as required for proper operation or as deemed necessary by DART.

The following tests shall be performed by the Contractor, or under its direction, as a condition of acceptance of the cars.

16.8.1 Vehicle Performance Test

The Contractor shall demonstrate that each car's tractive power, dynamic braking, friction braking, and track braking systems, at AW0 weight is compliant with the requirements of Section 2.6. (Procedure: CDRL 16-56) (Report: CDRL 16-57)

The Contractor shall provide instrumentation as specified in Section 16.5.2 for the vehicle performance testing. For each test, the following channel assignments shall be permanently recorded simultaneously, as specified:

- Acceleration (positive and negative). The signal shall be provided by an independent accelerometer (acceleration/deceleration rates calculated by the propulsion and/or friction brake system will not be considered acceptable for this requirement)
- Traction motor torque or effort (each truck)
• Spin-slide system operation (each truck)
• Brake cylinder pressure (each truck)
• Catenary voltage
• Total catenary current drawn
• Speed
• Propulsion and braking trainline command signals (or multiplexed to a single analog channel)
• An independent time base with one-second time intervals
• Five spare analog and 10 spare digital channels for additional signals which may be requested by DART

Any adjustments required as a result of the performance tests to obtain values corresponding to the performance levels shall be made by the Contractor prior to delivery and shall be noted the Car History Book.

16.8.2 Post-Delivery Testing

The Contractor shall perform the testing in this section after arrival at DART's streetcar maintenance facility and prior to revenue operation of the vehicle. (Procedure: CDRL 16-58) (Report: CDRL 16-59)

The Contractor shall perform the static functional test described in Section 16.7.2 after arrival and operational preparation of each vehicle at DART maintenance facility. The Contractor shall also perform dynamic testing to ensure proper vehicle operation on public right-of-way.

Each vehicle shall be given an operational test of a minimum of 500 kilometers prior to final acceptance. The operational tests shall be performed on the intended alignment in mixed traffic. During the last 100 kilometers, there shall be no failures of equipment. If a failure occurs in the last 100 kilometers, the 100 kilometer test will be restarted after correction of the problem.

Vehicles shall be operated as necessary for overhead contact wire adjustment, substation protective relay adjustment, and signalization verification.

16.9 CDRL

The following submittals are required:

16-1 Test waiver requests (Section 16.1)
16-2 Master test plan (Section 16.1.2)

Qualification Tests:

Component and System Level

16-3 Flammability and Smoke test procedures and reports (Section 16.3.1)
16-4 Ac traction motor qualification test procedure (Section 16.3.2)
16-5  AC traction motor qualification test report (Section 16.3.2)  
16-6  AC auxiliary motor qualification test procedures and reports (Section 16.3.3)  
16-7  Traction gear unit qualification test procedure (Section 16.3.4)  
16-8  Traction gear unit qualification test report (Section 16.3.4)  
16-9  Auxiliary power supply qualification test procedure (Section 16.3.5)  
16-10 Auxiliary power supply qualification test report (Section 16.3.5)  
16-11 LVPS and BC qualification test procedure (Section 16.3.6)  
16-12 LVPS and BC qualification test report (Section 16.3.6)  
16-13 Truck frame qualification test procedures (Section 16.3.7)  
16-14 Truck frame qualification test report (Section 16.3.7)  
16-15 Carbody structural test procedure (Section 16.3.8.1)  
16-16 Carbody structural report (Section 16.3.8.1)  
16-17 Propulsion system qualification test procedure (Section 16.4.1)  
16-18 Propulsion system qualification test report (Section 16.3.4.1)  
16-19 Friction brake system qualification test procedure (Section 16.4.2)  
16-20 Friction brake system qualification test report (Section 16.4.2)  
16-21 Door system qualification test procedure (Section 16.4.3)  
16-22 Door system qualification test report (Section 16.4.3)  
16-23 Unitized HVAC system qualification test procedure (Section 16.4.4)  
16-24 Unitized HVAC system qualification test report (Section 16.4.4)  

Car Level  
16-25 Vehicle qualification test procedures (Section 16.5.1)  
16-26 Vehicle qualification test report (Section 16.5.1)  

Conformance Tests:  
Component and System Level  
16-27 Electrical apparatus conformance tests reports (Section 16.6.1)  
16-28 HVAC unit conformance test procedure (Section 16.6.2)  
16-29 HVAC unit conformance test report (Section 16.6.2)  
16-30 Motor conformance tests procedure (Section 16.6.3)  
16-31 Motor conformance tests report (Section 16.6.3)  
16-32 Traction gear unit conformance test procedure (Section 16.6.4)  
16-33 Traction gear unit conformance test report (Section 16.6.4)  
16-34 Traction inverter conformance test procedure (Section 16.6.5)  
16-35 Traction inverter conformance test report (Section 16.6.5)
16-36 Auxiliary inverter conformance test procedure (Section 16.6.6)
16-37 Auxiliary inverter conformance test report (Section 16.6.6)
16-38 LVPS and battery charger conformance test procedure (Section 16.6.7)
16-39 LVPS and battery charger conformance test report (Section 16.6.7)
16-40 Battery conformance test procedure (Section 16.6.8)
16-41 Battery conformance test report (Section 16.6.8)
16-42 Friction brake equipment conformance test procedure (Section 16.6.9)
16-43 Friction brake equipment conformance test report (Section 16.6.9)
16-44 Communications system conformance test procedure (Section 16.6.10)
16-45 Communications system conformance test report (Section 16.6.10)
16-46 Truck quality conformance test procedure (Section 16.6.11)
16-47 Truck quality conformance test report (Section 16.6.11)
16-48 Wheel Back-to-Back conformance test procedure (Section 16.6.12)
16-49 Wheel Back-to-Back conformance test report (Section 16.6.12)
16-50 Shunt Resistance conformance test procedure (Section 16.6.13)
16-51 Shunt Resistance conformance test report (Section 16.6.13)
16-52 Watertightness conformance test procedure (Section 16.6.14)
16-53 Watertightness conformance test report (Section 16.6.14)

**Vehicle Static Tests:**
16-54 Vehicle static test procedure (Section 16.7)
16-55 Vehicle static test report (Section 16.7)

**Vehicle Acceptance Testing**
16-56 Vehicle performance test procedure (Section 16.8.1)
16-57 Vehicle performance test report (Section 16.8.1)
16-58 Post-delivery test procedure (Section 16.8.2)
16-59 Post-delivery test report (Section 16.8.2)

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SECTION 17
MATERIALS AND WORKMANSHIP

17.1 General

17.1.1 Quality
Material and workmanship shall be in accordance with the stated specification or description, unless written approval for substitution is obtained. Approval of substitution requests will be based on the equivalency of the proposed substitution, experience of the manufacturer with the proposed substitution, and demonstrated satisfactory performance in revenue service.

Inclusion of a material or method in this Section does not indicate approval for application or use in a specific situation. When a material or method is specified in this Section, this Section shall be applicable; however, specific requirements detailed in appropriate Technical Specifications take precedence over this Section.

17.1.2 Standards
The standards and specifications referenced herein define materials for this contract. Where other or foreign standards are proposed by the Contractor, the Contractor shall submit documentation to DART for review and approval demonstrating that the proposed standards are the equivalent of the foregoing standards and specifications. Proposed substitute specifications shall be submitted in English. (CDRL 17-1)

17.1.3 Marking and Storage
All materials intended for use on these vehicles shall be marked or stored so as to be readily identifiable, and shall be adequately protected during handling and storage.

All stored material subject to corrosion shall be protected by waterproof covers, coatings, or packaging.

Equipment covers, cable entrances, and openings shall be closed to prevent ingress of water or dirt.

All dated material shall have the expiration date clearly marked. Expired material shall not be used.

Material or components which require maintenance during storage shall be properly maintained per the component(s)-manufacturer's instructions. The Contractor shall document such maintenance, and provide these records as requested by DART.

Rejected material shall be clearly marked and stored in an area specifically designated for that purpose.

17.1.4 Cleaning Agents
A list of recommended cleaning agents shall be provided for all materials exposed to normal cleaning operations. The recommended cleaning agents shall be subject to DART’s review and approval. (CDRL 17-2) This information shall also be included in the maintenance documentation for the vehicle.
17.1.5 Prohibited Materials

The following materials shall not be used in the construction of the vehicle:

- PVC;
- Asbestos;
- Lead in brake shoes;
- Urethane foam;
- Chlorinated fluorocarbons that may cause environmental problems or handling hazards; and
- Materials that, in their normal installed state, emit products that are known to be toxic or irritants.

17.1.6 Material Reporting Requirements

Whenever a commercial material is not covered by a specification or standard, the Contractor shall identify the material by the commercial trademark, name, and address of the Supplier. The Contractor shall submit a description and the technical data specifications of the material composition for approval. (CDRL 17-3)

Single-source materials shall not be permitted unless approved. Approval shall be determined on a case-by-case basis. Specification equivalency/benefit data for any substitution to a cited standard shall be submitted to DART for review and approval. (CDRL 17-4)

The Contractor shall keep on file Material Safety Data Sheets (MSDSs) for all chemical materials (paints, solvents, adhesives, etc.) used in the manufacture of the vehicle, and provide MSDS information as requested by DART for any questionable material. A copy of each MSDS shall be submitted to DART for information. (CDRL 17-5)

The Contractor shall maintain records that trace all materials to their manufacturers and production lots, and shall help verify compliance with quality standards specified or cited in this Specification.

17.1.7 Units of Measure

U.S. inch-standard and metric measurement standards may be used in construction of the vehicle. Each major component and device on the vehicle shall be manufactured to a single standard, and their assembly into the vehicle shall minimize the intermixing of the two standards. U.S. inch and ISO metric parts shall not be intermixed between components of the same system located within the same equipment box, locker, or enclosure.

17.2 Joining and Fastening

17.2.1 Joining

17.2.1.1 General

Certain combinations of materials require particular care in joining to avoid the possibility of corrosion. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times where these combinations exist.
17.2.1.2 Joint Fitting

Joints shall be properly fitted, whether exposed or concealed. When not otherwise specified in drawings or specifications, gaps between joints shall be held to a dimension not greater than 10% of the thinner material being joined, or 0.002-in (0.05 mm), whichever is greater. Gaps shall be uniform in width. The edges of panels shall have a smooth, finished appearance.

Where excessive gaps (greater than those permitted by approved drawings or standards) are found to exist at the faying surfaces of structural bolted or riveted connections, metal shims of the same material as that of the deficient part may be used, but only with the written permission of DART. Shims, if used, shall be permanently fastened to one of the base parts being joined. The use of epoxy or other plastic filler at such locations is expressly prohibited.

17.2.1.3 Metal-to-Metal Connections

Where metals contact each other, the contact surfaces shall be free of dirt, grease, rust, and scale. Unless specified otherwise, the contact surfaces shall be coated with a metal based primer which conforms to Federal Specification TT-P-664. Metal primer may be omitted for like-stainless steel to like-stainless steel joints.

For proper treatment of a connection involving aluminum, refer to Section 17.6.4.

17.2.1.4 Wood-to-Metal Connections

Where wood and ferrous metal surfaces are placed together, the wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38, and the metal shall be coated with a primer which conforms to Federal Specification TT-P-664.

All bolts or rods passing through wood shall be coated with aluminum paint conforming to Federal Specification TT-P-38.

17.2.1.5 Wood-to-Wood Connections

Where wood and wood are placed together, both abutting surfaces shall be coated with aluminum paint conforming to Federal Specification TT-P-38.

17.2.1.6 Metal to FRP Connections

Where FRP panels are bonded to the car structure the metal contact surface shall be coated with an epoxy paint conforming to the requirements of Section 17.13.8.

17.2.2 Fasteners

17.2.2.1 General

The Contractor and Suppliers will be responsible for selecting fastener types, sizes, styles, lengths, materials, grades, and finishes that will meet the requirements of this Specification. The Contractor shall minimize the number of different sizes and styles of fasteners used.

A single standard, either inch-standard fasteners or ISO-Metric fasteners, shall be adopted for the fasteners used in the vehicle.

All fasteners used on this car shall be specified under one of three categories: electrical and electronic; structural and safety-related; or decorative. Fasteners internal to electrical or
electronic components are specified in appropriate Materials and Workmanship subsections for electrical devices and wiring. All structural and safety-related fasteners are specified under Structural Fasteners. Fasteners used to attach interior lining or trim and exposed to passenger view are specified under Decorative and Appearance Fasteners.

Safety-related fasteners include, but are not limited to, those applied to trucks, bolsters, brake equipment, couplers, and power collection devices. A fastener will be considered safety related if failures cannot be tolerated; that is, if even a single fastener fails there is a possibility of brake failure, derailment, or an accident. In the event of a dispute, DART will be the final arbitrator on which fasteners are safety related.

17.2.2.2 Threaded Fasteners

All inch-standard threaded fasteners shall conform to ANSI B1.1 Standard, Unified Inch Screw Threads, (UN and UNR Thread Form) or Industrial Fasteners Institute 1970 Fastener Standards.

Metric fasteners shall conform to ANSI B1.13M. Metric fasteners shall be marked as required in "Metric Fastener Standards", Industrial Fasteners Institute, latest edition.

Prevailing-torque type locknuts shall be nylon insert type, ESNA or approved equal, conforming to IFI Fastener Standards. Distorted thread locknuts shall only be used where there is insufficient clearance to install ESNA type locknuts, or where the locknut is exposed to temperatures above 90°C.

When making connections to heat-producing apparatus, thermal expansion of the components shall be taken into consideration for selection of fastener materials. If the joined components are high expansion alloys such as copper or austenitic stainless steel, austenitic stainless steel fasteners shall be used. If the joined components are low expansion materials such as carbon steel or ferritic stainless steel, zinc plated carbon steel fasteners of minimum Grade 5 shall be used. Cadmium plated fasteners shall not be used to connect heat producing apparatus.

When bolts are used to secure apparatus where the bolt head is not accessible, a reusable mechanical locking device shall be used to prevent the bolt head from turning when the nut is being turned.

At least 1-1/2 screw threads shall be visible beyond all nuts. When used without elastic stop nuts, bolts shall not project more than 1-1/2 threads plus 1/4 inch (6.4 mm) for bolts 1/4 inch (6 mm) diameter or less and shall not project more than 8 threads for larger diameter bolts. With elastic stop nuts, bolt threads shall not project more than 1/4 inch (6.4 mm), regardless of bolt size.

Undercar equipment shall not be supported by bolts in tension.

17.2.2.3 Structural Fasteners

All structural fasteners shall have documentation identifying manufacturer and purchase specifications available for examination by DART at the Contractor's QA department. This documentation shall include the fastener material or grade, and finish including plating material and specifications, when applicable. Whether the buyer is a Subcontractor, Supplier, or the Contractor, the Contractor shall obtain and hold this documentation for a period of not less than expiration of the last car's warranty period.
All safety-related fasteners shall either:

- Be manufactured, tested, and distributed in accordance with ASME FAP-1-1990, Quality Assurance Program for Fastener Manufacturers and Distributors, including the requirements of ASME accreditation.

- Have a representative sample of each production lot of fasteners tested for conformance to purchase specifications by an independent laboratory accredited by the American Association of Laboratory Accreditation (AALA), or approved equal. A production lot is defined as one size of fastener, from one manufacturer, and produced during one continuous production run.

Fasteners not meeting this definition of production lot shall be treated as separate lots. Testing shall be performed using sample quantities as proposed by the Contractor and approved by DART. Tests conducted shall confirm that fastener material meets specified chemistry and strength requirements. The buyer shall obtain certified test results from the testing laboratory and hold the documents for a period of not less than the expiration of the warranty period of the last car. (CDRL 17-6)

All safety-related fasteners that are plated or chemically cleaned shall have certifications showing freedom from hydrogen embrittlement. The certification shall be based on a representative sample of actual production fasteners which have been tested for hydrogen embrittlement by the OEM Contractor or a supplier following ASTM F519 procedures. An ASTM F606 wedge-test sample may be used in place of the F519 standard samples. Test loads shall be a minimum of 80 percent of yield strength or proof load and held for a minimum of 168 hours. Any failures shall result in the rejection of the entire lot.

All structural bolts for undercar and roof equipment shall be a minimum SAE J429 Grade 5 including marking and the bolt diameter shall be no less than 3/8 inch (10 mm), regardless of design load. Nuts shall be per SAE J995 Grade 5 and marked according to SAE Standards. Nuts shall match the strength of the bolts. Stronger fasteners shall be used if required for the application. The mounting and attachment bolts for undercar- and roof-mounted equipment and equipment support structures or brackets shall be sized to the design strengths for SAE Grade 2 nuts and bolts per SAE J997 and SAE J429 respectively.

17.2.2.4 Decorative and Appearance Fasteners

All interior fasteners exposed to passengers shall be either bright or finished to match the surfaces being joined, and installed such that the fastener head is flush with the mating surface. Bright finished fasteners used for stanchions shall be austenitic grade stainless steel. Bright finished interior fasteners may be either austenitic or plated martensitic stainless steel. Self-tapping screws will only be permitted where they will not be removed for normal maintenance more frequently than once in five years and shall be plated martensitic stainless steel.

All exterior fasteners visible to passengers shall be austenitic stainless steel for steel, LAHT steel, and stainless steel car bodies. Exterior aluminum shall be joined by austenitic stainless steel or aluminum alloy fasteners, as appropriate to the design and appearance requirements. Fasteners used on the side sill to attach heavy equipment brackets are structural fasteners specified under the structural fasteners section.

17.2.2.5 Torquing
All safety-related fasteners, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, shall be torqued to a minimum preload equal to 75% of their proof load and "torqued striped" after torquing by paint or other approved means. All other fasteners shall be torqued to a value appropriate to the application, so that they do not loosen in service.

Fastener installation torque for standard oiled or waxed bolts with standard or heavy hex nuts may be calculated from Industrial Fasteners Institute, Fastener Standards, 5th Edition, 1970 equations using values for "K" of 0.18 for unplated and 0.15 for plated threads. Locknuts shall be torqued in accordance with their manufacturer's recommendations or the Contractor may conduct tests to determine installation torque. For those nuts or bolts requiring "torque striping", DART may require bolt torque-tension tests to verify that installed preload is equivalent to 75% of proof loads.

17.2.2.6 Washers and Lock Washers

Washers shall be used under the heads of all bolts and under all nuts. Where high-strength fasteners are applied, washers shall be hardened and comply with IFI 1970 Fastener Standards.

Lock washers, when applied, shall conform to IFI 1970 Fastener Standards. Lock washers shall not be used for fatigue applications where the fastener must be torqued and marked (torque-striped). If applicable, prevailing torque nuts shall be used for these applications.

Other types of washers, including Belleville washers, may be used for special applications with DART approval during design review.

17.2.2.7 Rivets and Lock Pins

Rivets and lock pins exposed to passengers shall be austenitic stainless steel or aluminum, as appropriate to the materials being joined. Structural steel rivets shall conform to ASTM A 502 or American National Standard B 18.1.2 standards. Rivets may be hand driven when hot and shall completely fill the rivet holes. Rivets driven cold shall be mechanically driven. Exposed heads shall be concentric with the shank and free from rings, fins, pits, and burrs.

Swage-locking (Huckbolt type) fasteners shall conform to Military Specification MIL-P-23469. All rough surfaces of the collar end of these fasteners shall be machined or ground smooth where accessible to passengers, crew, or maintenance personnel performing routine maintenance functions. DART shall be the final arbiter in determining whether an application is hazardous to maintenance personnel.

17.2.2.8 Plating of Fasteners

All carbon, alloy, and martensitic stainless steel fasteners shall be plated with zinc, unless specifically waived by DART. Zinc plating shall conform to ASTM-B-633, Type II, SC2, SC3, or SC4.

Grade 8, Metric 10.9, or stronger fasteners shall not be plated if the original equipment manufacturer (OEM) finish is other than plating.

Alternate fastener coatings are permissible if qualified by testing per ASTM B117 with no red rust or visible corrosion products after 96 hours of exposure. The Contractor shall submit qualification results for each process used at each subcontractor applying the proposed coating. In order to use an alternate coating, the vendor shall submit:

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TS17-6
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RFP: P-1021774
• coating manufacturer’s product data including required thickness
• ASTM B117 test results from an accredited third party laboratory
• documentation of torque/tension characteristics
• a statement from the coating manufacturer regarding the propensity for the coating process to cause hydrogen embrittlement of the fastener during coating

Regardless of the coating’s propensity for hydrogen embrittlement, each lot of high strength fasteners, including OEM zinc plated bolts (Grade 5 or Metric Grade 8.8 or higher) shall be tested for hydrogen embrittlement in accordance with Section 17.2.2.3. Each lot of lower strength fasteners shall be tested for hydrogen embrittlement if the coating has the possibility of causing hydrogen embrittlement.

If the proposed coating results in a change in the K-value for the plated fastener to outside the range of 0.13-0.15, as defined by Industrial Fasteners Institute Standard IFI-543, the vendor shall use the alternate coating on all fasteners within that particular line replaceable unit (LRU). The LRU shall contain an indelible label identifying the coating type used within the unit and the required torque values for each size fastener used therein. Fasteners internal to a subcomponent within an LRU may use the standard coating system if they are not subject to removal during Owner’s maintenance activities.

17.2.2.9 Rivet and Bolt Holes
Rivet and bolt holes shall be accurately located and aligned, and, when necessary during assembly, holes shall be reamed round to specified size in position. Bolt hole clearances shall not exceed the requirements of the Industrial Fasteners Institute (IFI). All removed and replaced rivets shall have the holes reamed to the size required such that the next larger rivet may be driven securely.

17.3 Stainless Steel

17.3.1 General
Permitted uses of structural stainless steels are specified throughout this Specification. Ferritic stainless steels shall be painted where exposed to passengers or the weather. Austenitic stainless steels may be unpainted. Unpainted stainless steels exposed to passengers shall be a single grade of austenitic stainless steel in which both the color and surface finish of abutting pieces shall match, except where the design specifically requires a contrasting appearance.

17.3.2 Austenitic Stainless Steel
Structural austenitic stainless steel components assembled by fusion or resistance welding shall be of AISI Type 201L or Type 301LN and shall conform to the requirements of ASTM A666 except that the carbon content shall not exceed 0.03% and Type 301LN shall not exceed 0.25% nitrogen. Other stainless steels conforming to ASTM A666 are acceptable for non-welded applications.

Stainless steel used in structural applications covered by this Specification shall also conform to paragraph (f) from Section 2 of AAR "Specifications for the Construction of New Passenger Equipment Cars".
General requirements for delivery of stainless steel shall be as required by the Certification Provisions of ASTM A666, and stainless steel to be used in structural applications shall be tested for susceptibility to intergranular corrosion in accordance with ASTM A262, latest revision. Practice A of ASTM A262 can be used to accept material only; Practice E is required for final determination of acceptance or rejection of material that is not acceptable by Practice A.

17.3.3 Ferritic Stainless Steels
When specified, ferritic stainless steel conforming to ASTM A176 may be used for carbody structural sheeting up to 4 mm thickness. Ferritic stainless steel sheet shall have a ductile-to-brittle transition temperature (DBTT) or nil-ductility temperature (NDT) below 0°C. Weld heat-affected-zones shall also have a DBTT or NDT below 0°C. Ferritic stainless steel sheet shall have a balanced composition (low carbon and/or suitable titanium content) that will, for all conditions of fabrication and assembly into the carbody, inhibit formation of martensite and limit chromium depletion in weld-heat-affected zones so that material shall meet ASTM A736 requirements for resistance to intergranular corrosion.

General requirements for delivery of stainless steel shall be as required by ASTM A480.

Where ferritic stainless steels are welded to other structural steels, the less-noble steel shall be painted with weld-through primer.

17.3.4 Testing
The Contractor shall prepare (or have prepared), submit, and receive approval of a test and inspection plan for acceptance of all stainless steel to be used in welded applications prior to purchasing any such material. The tests and inspections shall verify that the stainless steel conforms to specified requirements. For austenitic stainless steels, the test and inspection plan shall include frequency of submittal of certifications in accordance with Certification Provision of ASTM A666 and frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A262. For ferritic stainless steels, the test and inspection plan shall include frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A763. (CDRL 17-7)

17.4 High Strength, Low-Alloy Steel
17.4.1 General
High-strength, low-alloy high-tensile (HSLA) steel structural shapes, plates, and bars shall, as a minimum, conform to the requirements of ASTM A588, where available. Plate steel may alternatively conform to ASTM A710, Grade A, Class 1 or Grade C, Class 1. Where not available in A 588, hot rolled or formed structural shapes conforming to ASTM A36 may be used for limited applications including equipment supports and jack pads. General requirements for delivery of HSLA shapes, plates, and bars shall be as required by ASTM A6. Welded HSLA steel shall develop 15 ft-lbs Charpy V Notch impact strength in the CGHAZ (Coarse grain heat affected zone) 1mm from fusion area at -20°F (-29°C).

Cold and hot rolled HSLA sheet and strip shall, as a minimum, conform to the requirements of ASTM A606, Type 4. General requirements for delivery of these products shall be as required by ASTM A568.

All HSLA steels shall contain a minimum of 0.2% copper to improve corrosion resistance.
Other high-strength, low-alloy steels which meet or exceed the above minimum requirements may be used for the proposed applications if the Contractor can demonstrate a minimum of ten years of successful revenue experience in their application. Other high-strength, low-alloy steels without the required service experience that meet the above minimum requirements or better may be proposed for DART’s approval.

Structural shapes, plates and bars shall conform, as a minimum, to the requirements of ASTM A588. General requirements for delivery of HSLA shapes, plates, and bars shall be as required by ASTM A6.

Hot rolled or formed structural shapes may be used for non-structural applications, including equipment supports, jack pads, and clip angles.

Cold and hot rolled HSLA sheet and strip shall, as a minimum, conform to the requirements of ASTM A606, Type 4. General requirements for delivery of these products shall be as required by ASTM A568.

All HSLA steels shall be applied according to their specification properties.

17.4.2 Testing

The Contractor shall prepare (or have prepared), submit, and receive approval of a test and inspection plan for acceptance of all structural steels in accordance with the requirements of this Section before purchasing any such material. The test and inspection plan shall include provisions for submission of reports and certification to DART for each shipment in accordance with the applicable requirements of Purchase Specification and specified CGHAZ impact tests. (CDRL 17-8)

17.5 Steel Castings

17.5.1 General

The Contractor shall be responsible for selecting casting grade, composition, strength and finishing. However, steel castings used in the truck structure, bolster, and center bearing arrangement shall, as a minimum, meet AAR Specification M-201 latest revision, Grade "B", plus 2% nickel. These castings shall be heat treated to develop a minimum tensile strength of 75,000 psi, a minimum yield strength of 48,000 psi, elongation of not less than 25% in 2 inches, and reduction of area of not less than 50%. Also, steel castings used for coupler drawbars and anchors shall meet AAR Specification M-201, latest revision, Grade "C" quenched and tempered.

17.5.2 Design Qualification of Structural Castings

One casting, selected by DART from the first lot of production castings, shall be subjected to a qualification test of the casting design by the Contractor. Qualification tests shall include radiographic examination for material soundness using reference radiographs to ASTM E 446 and any mechanical testing, including static and fatigue load testing of truck frames and bolsters.

Acceptance levels for the design qualification radiographic examinations shall be selected by the Contractor as appropriate for the service intended, subject to the approval by DART before any castings are produced. Radiographs shall meet the requirements of ANSI/ASTM E 94, and the quality level in the area of inspection shall be at least 2% (2-2T).
A qualification test report shall be prepared and submitted to DART for approval. (CDRL 17-9) The production of any castings before receipt of DART's approval of this report shall be at the Contractor's risk. All radiographs that resulted from the qualification test shall be made available to DART for review. In case the casting selected for qualification fails to qualify, a plan of action including details of how failed material will be handled shall be included in the qualification test report. Once a design is qualified and accepted by DART no changes shall be made in the casting pattern, technique, heat treatment, or material composition without requalification in accordance with the requirements of this Section.

17.5.3 Quality of Structural Castings

All structural castings supplied shall be equal to or better than the design qualification castings in all respects. The casting Supplier or Contractor shall test, inspect and accept castings in accordance with procedures described in AAR Specification M-201. In addition, the inspections below shall be performed, and a written report of the results of the tests and inspections shall be furnished for each lot of castings produced. (CDRL 17-10)

17.5.3.1 Magnetic Particle Inspection

Magnetic particle inspections of all surfaces of each casting shall be conducted according to ASTM E 709, by personnel certified to NAS-410. With respect to structural castings, including coupler, bolster, articulation (where applicable), and truck castings, the maximum permissible magnetic particle indications shall be 1/4 inch (6.4 mm) in the direction transverse to the usual direction of loading, and 1 inch (25.4 mm) in the direction parallel to the usual direction of loading.

17.5.3.2 Radiographic Inspection

Radiographic inspection shall be conducted according to the requirements of ASTM Standard E 94 using reference radiographs to ASTM E 446. A sampling frequency shall be proposed by the Contractor and submitted for DART's approval. (CDRL 17-11)

Structural castings shall not exceed severity Level 3 of ASTM E 446 in all critical areas of such castings and shall not exceed Level 5 in all other areas of the castings. During demonstration that the stated severity level requirements of ASTM E 446 have been met, successively-produced castings shall be re-inspected by radiography in the defective areas shown in the prior radiographic inspection. After such severity levels have been proved, the sampling frequency for structural castings shall be one casting out of each ten produced. If no castings are rejected by radiographic inspection, this frequency may be extended to one casting in 25.

17.5.3.3 Repair Welding and Cast-Weld Design

Repair welding of castings will be permitted, provided the casting Supplier performs all repair welds according to the structural welding requirements of Section 17.7. For cast-weld designs, the entire length of all assembly welds on any welded assembly of several separate castings selected for design qualification shall be radiographically inspected to ANSI/ASTM E 94, using reference radiographs from the International Institute of Welding's "Collection of Reference Radiographs of Welds", quality level Green. Those portions of assembly welds stressed in tension by service loads shall meet quality level Blue.

17.5.3.4 Disposal of Non-conforming Castings
If castings are found to be non-conforming to requirements determined by the design qualification castings, the material shall be repaired, re-tested, and re-inspected or destroyed at the Contractor's expense.

17.6 Aluminum

Aluminum alloy mill products shall be identified by Unified Numbering System designations and shall conform to the Aluminum Association, Inc. specifications contained in the Association's publication "Aluminum Standards and Data". Aluminum alloy castings used for door thresholds shall conform to ASTM Specifications B-26, B-85, or B-108 for, respectively, sand, die, or permanent mold castings. Aluminum alloy forgings shall conform to ASTM Specification B-247. Copies of all test reports for sheet, extrusion, and forgings used in the car structure shall be submitted to DART. (CDRL 17-12)

17.6.1 Design Stresses

All aluminum structural members shall be designed so that calculated stresses under the specified AW3 passenger load do not exceed the allowable stresses listed in the latest revision of the Aluminum Association, Inc. "Aluminum Design Manual" for bridge and similar type structures. Proper allowance shall be made for the effects of fatigue, for column and plate stability effects, and for strength reduction at welded regions. Permissible fatigue stresses under the specified AW3 passenger load shall be established, with approval based on available relevant research data or on prototype testing under the variable load patterns expected to occur in service.

17.6.2 Fabrication and Fastening

The forming of aluminum parts; joining of parts by bolting, riveting, and welding; and the protection of contact surfaces shall, as a minimum, conform to the requirements of the Aluminum Company of America's Technical Report No. 524, "Specification Covering Use of Aluminum in Passenger Carrying Railway Vehicles", except as otherwise specified herein.

Fabrication techniques shall be such that the strength and corrosion resistance of the aluminum shall not be impaired nor the surface finish permanently marred or discolored during construction.

17.6.3 Protection of Contact Surface

The specific measures to be taken by the Contractor to prevent the risk of direct metal-to-metal contact and resultant possible electrolytic corrosion shall be approved and shall depend upon the determination of the most suitable method which can be adapted to the design involved. The following instructions shall be the minimum protection.

Aluminum alloy surfaces shall not be secured to or make direct metal-to-metal contact with the surfaces of copper, copper-bearing aluminum alloy, brass, bronze, silver, nickel, nickel alloys, nickel-plated parts, lead, tin, or wood.

The contact surfaces of aluminum alloy with aluminum alloy shall be painted with zinc chromate primer before securing.

The surfaces of aluminum alloy parts secured to steel parts shall be protected with a one-part polysulphide sealant, zinc chromate paste, mica insulation joint material or an approved equivalent material which completely covers the faying surfaces. The insulating material shall be non-hygroscopic and, if fibrous, shall be impregnated with bitumen or an approved,
non-corrosive, water and moisture-repellant substance. After driving, fasteners shall be primed and painted with red oxide or aluminum paint.

Stainless steel and carbon steel fasteners plated with cadmium or zinc shall be coated with zinc chromate paste before installation. Where possible, only the head and the shank of the bolt shall be in contact with the aluminum part when secured in place. Suitable bushings may be used in place of the zinc-chromate paste.

17.6.4 Interior Trim

Where unpainted aluminum is exposed to contact by passengers, it shall have a clear (natural) anodic finish. The finish process shall be the Aluminum Company of America's "Alumilite 204" with a minimum coating thickness of 0.0004 in and a minimum coating weight of 21 milligrams per square inch, or approved equal process.

17.7 Welding and Brazing

The Contractor shall control the quality of all welding and brazing, including that of its subcontractors. Cleaning prior to welding shall be in accordance with applicable parts of Section 2, MIL-HDBK-132, "Protective Finishes".

17.7.1 Structural Welding

All structural welding practices not specifically covered in other sections of this Specification shall be in accordance with requirements of EN287-1 for steel, EN287-2 for aluminum, and the AWS Handbook. Resistance welding shall be in accordance with MIL-W-6858. Requirements for dynamically loaded structures shall have precedence over those for statically loaded structures.

All welds shall have established weld procedures and qualifications. Weld procedure and qualification shall be identified on shop drawings specifically for that purpose.

General welding, not specified elsewhere, shall be performed to the standards of AWS D1.1 or approved equivalent standard.

Structural welding of stainless steel by the fusion-arc process shall be governed by ASME Section IX and ASME Section VIII, Part UHA. AISI 201L and 301LN stainless steels shall be treated as P-No. 8, Group-No. 3 category for reference to ASME requirements. Weld heat affected-zones (HAZ) and weld metal shall be limited to maximum allowable stress values in ASME Section VIII, Table UHA-23 for UNS S20100 stainless steel and Table UW-12 rating of welds, regardless of strength level of the base metal. Ferrite number for welds shall be between WRC4 and WRC10, or as proposed by the Contractor and approved by DART.

Additional information on definitions, processes or other questions pertaining to welding shall be referred to AWS Welding Handbooks, latest edition.

The Contractor may propose the substitution of other standards as described in Section 17.1.2.

17.7.2 Welder Qualification

Welders shall make only those welds for which they have been qualified in accordance with the requirements of the AWS, ASME Section IX, EN 288, or other approved qualifying
procedures. Records of welder qualification tests shall be made available for review upon DART's request.

Critical strength welds shall be stamped with an identifying symbol which can be traced to the welder who performed the work.

**17.7.3 Weld Penetration**

Full penetration welds are required for all structural welds unless otherwise approved by DART. Where partial penetration welds are proposed for structural welds, the Contractor shall provide design calculations supporting the penetration required and conduct tests to prove that production welding achieves this required penetration with a margin of safety suited to the design application. Partial penetration welds in structural connections may be made only with approval of the Contractor's formal detailed proposal.

All full penetration welds made from one side without backup shall be considered partial penetration welds. In no case shall partial penetration welds be used where they experience alternating tensile or bending loads at the weld root.

**17.7.4 Inspection**

The Contractor shall visually inspect all structural welds according to AWS, EN, or JIS standards.

In addition to visual inspection requirements specified by the AWS welding code, nondestructive surface inspection (dye penetrant or magnetic particle methods, as appropriate) shall be used to inspect all first production welds, regardless of whether the assembly was presented for First Article Inspection. The Contractor shall specify additional nondestructive inspection requirements for subsequent welds.

**17.7.5 Weld Cleaning Requirements**

All welds exposed to passengers or on the surface of truck frames and bolsters shall be completely cleaned of all slag, weld spatter, sharp edges, and alkaline flux residue.

**17.7.6 Welding Rod or Wire**

All welding rod or wire shall be purchased to AWS, EN, or JIS Specifications. Where special materials are required that are not covered by these or other applicable AWS welding material specifications, the Contractor shall submit the purchase specifications for approval.

Welding rod and wire shall be purchased in packages of convenient size, which shall be marked with the manufacturer's name and the specification, diameter and net weight of the material.

The material shall be stored in accordance with recommendations to the AWS "Structural Welding Code" to protect it from damage, and so that it can be easily identified. Material shall be issued and handled in such a way as to prevent it from being mixed with that of another specification.

**17.7.7 Special Welding**

Procedures for structural welding of stainless steel to LAHT, or other combinations of metals or conditions not covered by AWS specifications or codes, shall be submitted for approval.
Austenitic stainless steel electrodes or wire shall be used to join carbon or LAHT steels to stainless steels.

17.7.8 Resistance Welding

Resistance welding of stainless or carbon steels shall be in accordance with MIL-W-6858, Class B for structural applications, and Class C for non-structural applications. The Contractor shall control current, time, electrode size, shape, and tip force to produce uniform welds of specified strength which are not subject to intergranular, stress-corrosion cracking. Resistance welds shall be arranged to avoid tension or "peeling" forces on the welds under any anticipated loading condition.

Surface indentation shall not exceed 20 percent of material thickness (t) or 0.01 inch, whichever is greater; however, for exterior resistance-welded areas exposed to passenger view, indentation shall not exceed 10 percent of t or 0.005 inch, whichever is greater. Surface burn and discoloration shall be removed by an approved method.

Any deviation desired by the Contractor from the MIL-W-6858 standards including, but not limited to, weld nugget diameter, tension shear strength, and minimum spacing, shall be submitted and approved prior to inclusion in the design or in production procedures.

17.7.9 Prohibitions

The following weld process and material restrictions shall apply in all car structure welding:

- High iron powder flux type rods such as E6024, E7024 and rods known as "jet rod" may not be used in any application.
- Short-arc MIG welding using hardwire with argon, or argon/CO2 shielding may only be used on sheet metal, gauges 12 and thinner. Welding of sheet steel shall be performed to AWS D1.3 or approved equivalent.
- Galvanized steel shall not be welded to stainless steel.
- Brazing shall not be used to join stainless steel to itself or to other metals unless specifically permitted by DART.

17.7.10 Resistance, Spot Weld and Intermittent Weld Spacing

Spacing of resistance and spot welds shall be appropriate to the design. Spacing shall not exceed 50 mm plus twice the weld nugget diameter for any structural application, including carbody side sheets. Intermittent weld spacing shall not exceed 5 inches (125 mm) for 2 inch (50 mm) weld length (40 percent minimum).

17.7.11 Torch Brazing

All brazing (above 840°F (450°C)) shall follow the recommendations contained in the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who perform brazing work shall be qualified in accordance with AWS B2.2-85, "Standard for Brazing Procedure and Performance Qualification".

Brazed joints shall present a workman-like appearance in accordance with AWS quality standards. The inner surfaces of air conditioning tubing shall be protected from oxidizing contaminants during and after brazing operations have been completed.
17.7.12 **Torch Soldering**

All soldering (below 840°F (450°C)) shall follow the recommendations contained in the AWS Welding Handbook, Volume 2, latest issue. Procedures and personnel who perform torch soldering shall be qualified through the preparation and testing of test samples, as follows:

- **Copper Piping into Fittings:** Each worker designated to perform this work shall prepare 3 copper piping connections in the vertical position. The sample joints shall present a smooth, workman-like appearance, without excess solder reinforcement. Each joint shall be pressure tested using a water or air system to confirm that it is leak-free.

- **Stainless Steel Lap Joints (Trim Seams):** One typical trim seam sample, using the same stainless steel materials, finish and thicknesses as used on the actual car, shall be prepared by each person doing this work. The seam for evaluation shall be a minimum of 915 mm in length, and shall be setup in the horizontal, flat position during soldering. Specimen width shall be selected, or the test setup arranged, so that premature overheating of the joint does not occur. Finished samples shall be saw-cut into 4 pieces so that 8 cross-sections of the joint may be examined. Exposed solder surfaces shall display a uniform, smooth contour and shall meet or exceed all applicable AWS quality standards.

17.7.13 **Toughness of Welded Assemblies**

The Contractor shall prove that all safety related welded structures such as, but not limited to, end underframes, fabricated truck frames and bolsters, and welded coupler components, have adequate toughness for the specified environmental exposure. Specifically, the weld heat affected zone (HAZ) and base metal shall resist service impact loads at the lowest specified operating temperature. Criteria for acceptance shall be shown by the Contractor to be adequate.

In the absence of prior operating history, and if no analysis requires greater toughness, the minimum impact value for Charpy V-notch specimens shall be 20 Joules of absorbed energy at the lowest specified operating temperature.

17.8 **Elastomers**

All elastomeric parts shall be of neoprene unless otherwise specified or approved. Elastomers shall be compounded and cured to perform as intended in the Dallas environment specified in Section 2.3.5. Elastomers shall have high resistance to ultraviolet and other solar radiation, all vehicle washing fluids, and long life. All elastomeric parts shall be resistant to ozone, oxidation, heat, oil, grease and acid.

All resilient mounts shall be of natural rubber. Synthetic rubber compounds will not be permitted without prior DART approval.

Elastomers shall have the longest possible life consistent with other specified characteristics. All resilient parts shall have a design life no less than ten years.

For all parts made by vulcanizing an elastomer to metal, any premature failure (less than five years) between metal and the elastomer or in the elastomer, occurring when the parts
are used in normal service and according to the provisions of this Specification, shall be considered as having been caused by defect of materials or workmanship.

17.8.1 Bonded Metal Parts

Metal parts to which neoprene or other such material is cured shall be made of SAE 1020 or 1045 hot-rolled steel or approved equal, suitable for brass plating after pickling.

The joining of elastomeric pieces shall be accomplished by a hot vulcanization process. Bonding of elastomers shall not be allowed unless the Contractor submits the application, bonding procedure and bonding agent technical data for approval prior to the purchase of any materials.

17.8.2 Seals

Glazing strips shall be of neoprene conforming to ASTM C 542, or approved equal material.

All door mating edges, door and window seals, and glazing strips shall be of neoprene material and shall be free of defects of material and workmanship. The durometer hardness measured with a Shore Type "A" durometer at a temperature between 70°F (21°C) and 90°F (32°C) shall be 70±5.

17.8.3 FRP Side Skin Bonding

The adhesives used for bonding FRP side skin material shall conform to all requirements of this specification for life and strength. The type of bonding material and the quantity of bonding material used shall be approved by the bonding material manufacturer as appropriate for the application.

For all parts made by vulcanizing an elastomer to metal, any premature failure (less than five years) between metal and the elastomer, or in the elastomer, occurring when the parts are used in normal service and according to the provisions of this Specification, shall be considered as having been caused by defect of materials or workmanship.

Metal parts to which neoprene or other such material is cured shall be made of SAE 1020 or 1045 hot-rolled steel or approved equal, suitable for brass plating after pickling.

All door mating edges, door and window seals, and glazing strips shall be of neoprene material and shall be free of defects of material and workmanship. The durometer hardness measured with a Shore Type "A" durometer at a temperature between 68°F (20°C) and 85°F (30°C) shall be 70±5.

17.9 Glazing Material

The manufacture of glass panes for use in the vehicles shall insure maximum safety, as well as considering comfort, economic use, and aesthetics. Safety glass shall meet the requirements under Item 1, Table 1 of the latest revision of American National Standard ANSI Z26.1, "Safety Code for Safety Glass for Glazing Motor Vehicles Operating on Land Highways" or other approved standards as appropriate for the application.

All safety glass shall be of the laminated sheet type. Windshield material may have thermal or other treatments, but shall meet federal visibility standards.

Corners and burrs shall be ground smooth and all edges shall be seamed.
The bond between the glass and the membrane shall be such that when the glass is broken by twisting or by direct impact, there will be no separation between the laminations.

Safety sheet glass shall produce minimal distortion on a line of 45 degrees to the plane of the glass. Safety plate glass shall meet the requirements under Item 2, Table 1 of the latest revision of American National Standard ANSI Z26.1, "Safety Code for Safety Glass for Glazing Motor Vehicles Operating on Land Highways".

All safety glass shall be marked with proper identification in accordance with ANSI Z26.1, and other appropriate designation.

Plastic or polycarbonate glazing is not permitted.

17.10 Floor Covering

The floor covering shall have a static coefficient of friction of at least 0.6 measured in accordance with ASTM D 2047, using leather and rubber shoe materials. Leather shoe material shall be in accordance with Federal Specification KK-L-165C. Rubber shoe material shall be in accordance with ASTM Method D 1630.

Rubber floor covering shall contain 20 percent (nominal, by weight of compound) butadiene styrene rubber, shall be non-staining, non-discoloring, and 100 percent non-oil extended. Only high quality hard clay shall be used as a filler.

No whitening (limestone) shall be used in the compound.

At room temperature, rubber flooring shall bend around a 3/4 inch (20 mm) diameter mandrel without breaking, cracking, crazing, or showing any change in color. Rubber flooring material shall be fully homogeneous throughout, and shall meet the requirements of Federal Specification SS-T-312.

Rubber flooring installation shall conform to the criteria below:

- A thin skinned blister is a blister, which, when finger_PUSHED, will collapse upon itself. Thin skin blisters of the indicated sizes are permitted as follows and shall be repaired as indicated:
  - Maximum Size: 0.03 inches (0.75 mm) height, 0.8 in\(^2\) (0.5 mm\(^2\)) area with longest dimension of 2 inches (50 mm).
  - Maximum Population: 3 blisters in a 12 inch (300 mm) by 12 inch (300 mm) area. There shall be only one other blister within 3 ft (0.9 m) of this area.
  - Repair Method: using a hypodermic needle, apply just enough Super Bond 420 or Bostik 1685 to bring to a flush surface.

- A thick skinned blister is a blister, which, when finger_PUSHED, will collapse and then return to its original condition. Thick skin blisters of the indicated sizes are permitted as follows:
  - Maximum Size: 0.03 inches (0.75 mm) height, 0.8 in\(^2\) (0.5 mm\(^2\)) area with longest dimension of 50 mm.
  - Maximum Population: 3 blisters in a 12 inch (300 mm) by 12 inch (300 mm) area. There shall be only one other blister within 3 ft (0.9 m) of this area.
o Repair Method: no repair authorized.

- A lump is a blister without a void, consisting of solid material. Lumps of the indicated sizes are permitted as follows:
  o Maximum Size: 0.03 inches (0.75 mm) height, 0.8 in² (0.5 mm²) area with longest dimension of 2 inches (50 mm).
  o Maximum Population: 3 lumps in a 12 inch (300 mm) by 12 inch (300 mm) area. There shall be only one other lump within 3 ft (0.9) m of this area.
  o Repair Method: no repair required.

- A hole is a defect which is 100% through the material. Holes of any size or population are not permitted nor shall holes be repaired.

- A thin area is a defect where the sheet is below thickness locally. Thin areas of the indicated sizes are permitted as follows and shall be repaired as indicated:
  o Maximum Size: 0.03 inches (0.75 mm) deep at the lowest point, 3 in² (19.4 cm²) area with the longest dimension of 5 in (127 mm).
  o Maximum Population: one thin area in a 1 m by 1 m area, and there shall not be another thin area within 3 ft (0.9 m) of this area.
  o Repair Method: rub with #00 steel wool to blend this area into the normal thickness material and then buff to a normal surface finish.

17.11 Piping and Tubing

17.11.1 General

All piping, valves, fittings, installation methods and testing shall be in accordance with the latest edition of ANSI B31.1 Power Piping.

Straight runs of pipe shall be continuous and without fittings unless otherwise approved.

All piping systems shall be cleaned after installation by flushing with an approved cleaning solution. All piping systems shall be pressure tested after installation in accordance with the latest edition of the Code for Power Piping, ANSI B31.1. All leaks shall be repaired and the system retested until leak free.

Piping shall be supported at least at every floor beam and at all bends and connections. Piping locations shall not interfere with access to, and removal of, other components. Clearances between piping and any other components shall prevent contact due to any combination of car loading and deflection, car dynamics and thermally induced movement. In no case shall a less than 4 mm clearance be provided.

Piping shall be rigidly clamped where it passes through holes in fixed members.

Clamps shall not be welded, brazed or otherwise permanently fastened to any piping. Piping clamps shall be insulated with an approved elastomeric or woven mineral fabric tape to protect and acoustically insulate the piping from structure. All pipe clamps shall rigidly clamp piping to support structure. Cantilevered or other piping supports with strength less than that of service-proven designs will be prohibited.
Piping connections to resiliently mounted or moving equipment shall be via hose or other resilient device, as appropriate. Piping shall be clamped within 2 inches (50 mm) of the resilient connection.

### 17.11.2 Hydraulic Piping, Tubing, and Fittings

All hydraulic pipes, tubing, and fittings shall be sized for the function intended without experiencing a pressure drop of more than 15 percent from control to function. All fittings shall be high-quality and produced by the same manufacturer. Fittings should all be a common type, readily available. All exposed tubing, piping, or fittings shall be stainless steel to SAE-AMS-T-6845 or MIL-T-8504 specifications. Wall thickness shall be Schedule 80 for truck mounted piping and sufficient to maintain a safety factor of 6 at the maximum system pressure. Wall thickness in other locations shall be sufficient to maintain a safety factor of 6 at the maximum system pressure.

Joints shall be welded, brazed, flared to an angle of 37 degrees in accordance with SAE J533b, or made with compression fittings, Swage-Lock, or equal. Connections to manifold ports, valve bodies, and other hydraulic system components shall use straight thread fittings with separate O-ring seals.

All hose utilized within the hydraulic system shall conform to SAE J517 standard and hose fittings shall conform to SAE J516 standard. All hose shall be rated to withstand four times the maximum operating pressure without bursting. Hose application limits shall conform to SAE J1273, SAE J343, and SAE J1405 standards. Hose shall not be used in locations where the temperature may exceed 200°F (90°C). Hose shall be supplied clean and with both ends capped.

There shall be no inaccessible joints. Tubing shall be bent utilizing a bending tool designed specifically for bending of the tubing to be used. All tubing and piping shall be deburred after cutting. All tubing, fittings, and subassemblies shall be cleaned and capped on all openings after fabrication. Caps shall remain in place until immediately prior to incorporation into the final assembly.

All pipe fabrication, including bending, cutting, deburring, flaring, and fitting, shall be by automatic machinery to ensure consistent quality.

Truck piping shall not be run on the bottom of truck side frames, transom, or bolster.

Connections to manifold ports, valve bodies, and other hydraulic system components shall use straight thread fittings with separate O-ring seals, unless otherwise approved.

Use of tapered pipe threads on any fluid-carrying system component is expressly prohibited.

Quick-connect couplings shall be double shutoff with valves built into both of the mating parts and conform to the requirements of MIL-C-25427A, latest revision, or commercial couplings that provide equivalent performance.

All cutout cocks shall be designed to automatically depressurize the portion of the system which is being isolated by the cutout cock.
17.11.3 Air Piping, Tubing, and Fittings

All air pipes shall be sized in accordance with the function intended and shall be either ASTM A 53 Schedule 80 pipe or seamless Type K annealed copper tubing per ASTM B 88, latest revision. All joints for copper tubing shall utilize fittings of wrought copper or non-porous cast brass in accordance with ASME B16.22 and B16.18.

Where ASTM A 53 piping is provided, its application shall also comply in all respects to AAR Specification No. 2518, Standard 400, latest revision. Approved copper tube shall comply with any relevant requirements of AAR Specification No. 2518.

All air piping shall be installed in a manner to provide drainage away from devices, or branch pipes leading to devices, when the function of those devices could be impaired by the accumulation of water or ice.

All air hoses shall conform to the latest revision of AAR Specification M-618 with AAR-approved reusable fittings meeting AAR Specification M-927.

All cut-out cocks shall be of the vented type, except where function prohibits.

Air piping on the trucks shall be 1/2 inch (13 mm) ASTM A 53 Schedule 80, or approved equal. Low spots (traps) will be strictly prohibited on the trucks.

Where steel piping is used on trucks, all connections and joints where disassembly for service may be required shall utilize swivel type butt-welded flange fittings with an “O” ring type seal. The use of threaded fittings is expressly prohibited.

17.11.4 Air Conditioning System Piping and Fittings

Air conditioning refrigerant lines shall meet the internal cleanliness requirements of ASTM B280. Tubing in nominal inch sizes shall meet the dimensional requirements of ASTM B280. Air conditioning refrigerant lines in nominal metric sizes shall be of seamless copper tubing as defined by ASTM B88M. Air conditioning refrigerant tubing shall be drawn to H58 temper or annealed to the O60 condition, and diameters and wall thickness shall be as appropriate for the size and application within the unit. Wrought copper sweat type fittings shall be used. Joints shall be kept to a minimum; wherever possible formed or bent tubing, bent utilizing a bending tool designed specifically for bending of the tubing used, shall be used in preference to fittings. All inaccessible runs of tubing shall be without joints, and all joints shall be readily accessible for inspection and repair.

Suction lines shall be designed and installed without traps. The suction line shall be sized for 3 psi (20 kPa) maximum system pressure drop and the liquid line shall be sized adequately to prevent flashing due to pressure drop.

Lines subject to condensation shall be insulated with an approved insulation, applied with an approved contact cement. The liquid line shall be insulated in all areas where required to provide additional mechanical or thermal protection. Insulation at all joints and fittings shall be mitered and sealed with an approved material. The insulation, adhesive, and sealant shall meet the Specification requirements for thermal, smoke emission, toxicity, and flammability performance.
All refrigerant piping and pipe subassemblies shall be deburred, cleaned, dried, and capped with tight fitting plastic caps, or approved equal on all openings after fabrication. Caps shall remain in place until immediately prior to incorporation into the final assembly.

Vibration eliminators shall be used in piping at any location where there is relative motion between sections. Tubing installations shall be designed to allow any single length of tubing to be replaced without dismantling or removing surrounding equipment, piping, wiring, or other appurtenances.

Condensate drain lines shall be seamless copper tubing, Type “K”, in either the O60 annealed or H58 tempered condition, as defined by ASTM B 88, or seamless stainless steel tubing.

17.11.5 Soldering of Piping and Fittings

All refrigerant and air system copper piping shall be joined using silver solder, Sil-Fos, or approved equal conforming to Federal Specification QQ-B-654, BAg-5 or BcuP-5. Refrigeration tubing shall be internally swept with a continuous flow of an inert gas such as dry nitrogen during brazing.

Condensate drain tubing and air piping shall be joined using 95-5 solder or silver solder as above. Solder fittings shall be wiped and have flux cleaned from tubing and fittings after soldering. After fabrication, the system shall be cleared of all dirt and foreign matter, evacuated, dried and charged according to an approved procedure. Refer to Section 7 for run-in testing and additional refrigeration system cleanliness requirements.

17.12 Air Filters

17.12.1 Low Pressure Air Filters

All filters shall meet the equipment manufacturer's recommendations. All filters shall be framed, throw away types and shall be freely accessible for maintenance.

Unless otherwise required by the equipment manufacturer, filters shall be resin-bound, spun-glass fiber materials having an uncompressed thickness not less than 3-1/2 in (90 mm). Filters shall be non-absorptive of fluids and gases, be processed in such a manner that material density increases progressively from air inlet to air exit side and shall be coated with not less than 24 g/ft² (258 g/m²) of a dust-retaining, viscous adhesive film. This film shall be stable at temperatures up to 150°F (65°C).

The filter pad shall be cut oversize to ensure adequate sealing between the edge of pad and its case.

17.12.2 High Pressure Air Filters

Air filter assemblies with replaceable filter elements shall be provided in the air line that connects each subsystem to the air supply system. The air filter filtering capability, flow rate capability, and overall size shall be appropriate for the application so that the filter replacement interval is greater than one year. It shall be possible to gain access to the filter element for replacement without requiring any pipe fittings to be disconnected or loosened.
17.13 Paints and Coatings

The portion of the carbody or any of its components, receiving paint shall be painted as required by the Specification and in accordance with the specified color scheme. Austenitic stainless steel portions of the carbody shall not be painted, unless otherwise specified by DART for cosmetic reasons. Where stainless steel is painted, procedures shall be as recommended by the paint manufacturer for the application, and surfaces shall be properly prepared to ensure adhesion.

All painting to be applied on the carbody or any component shall be performed in accordance with the paint manufacturer's recommendations. The Contractor and its paint Supplier shall supply a touch-up procedure and assure that a continuing supply of touch-up paints in colors used on the car, suitable for spot application by spray or brush, will continue to be available in the United States.

17.13.1 Materials and Preparation

Preparation of the substrate surface and application of painting materials shall be in accordance with the paint Supplier's recommendations. All paint materials shall be used at the consistency recommended by the paint Supplier. If thinners are necessary, they shall be approved by the paint manufacturer and shall be used only to the extent recommended. Painting shall be done by experienced labor, using proper equipment under competent supervision.

All painting materials for all surfaces shall be a high quality finishing system resistant to corrosion, chipping, and fading and shall retain the gloss level. The coating shall be a two-part, high solids, low VOC, two-part polyurethane paint system with a solids content between 50% to 70%. Alternate paint systems, such as waterborne coatings, base coat-clear coat systems, or direct-to-metal paint systems will be considered if the paint performance equals or exceeds two-part polyurethane. All paint and filler materials which are to be superimposed to form a finish system shall be mutually compatible and shall be warranted for use as a system by the manufacturer of the components.

Metal portions of the carbody not constructed of austenitic stainless steel shall, after fabricating, be prepared for painting by grit blasting and immediately painted with an approved epoxy primer, or washed with an alkaline solution, properly rinsed, phosphate coated or painted with a coat of wash (etch) primer, and then coated with an approved epoxy primer.

The Supplier shall submit color samples and corresponding tri-stimulus values for approval. The exterior finish shall have a minimum gloss level of 90 as measured with a 60 degree glossometer. (CDRL 17-13)

17.13.2 Underfloor Paint

After erection of the framing structure and body sheets, all undercar metal, except stainless steel, shall receive a black polyurethane finish as specified above.

17.13.3 Exterior Finish Painting

All exterior surfaces that are to be painted shall be prepared as specified and the paint shall be applied according to the paint manufacturer's recommendations. The paint shall be uniformly applied over all surfaces to be covered and shall be free from runs, sags, or other
application defects. Painting shall be done in a clean, dry atmosphere at an ambient temperature as recommended by the paint manufacturer.

Before painting any car surface that is exposed to view, all dents, gashes, nicks, roughness, or other surface imperfections or depressions shall be removed so far as possible by straightening and shall be properly prepared to receive the filler material. These surfaces shall be properly cleaned and wash primed following straightening. Any remaining dents or other surface imperfections shall then be filled with an approved filler and sanded smooth. The maximum allowable filler thickness shall be as recommended by the filler manufacturer for the environment and service to which it is to be exposed, but in no case shall it exceed 0.125 inch (3 mm). Maximum deviation from flatness after filler application shall be 0.063 in (1.6 mm), peak to valley, measured with a 3 ft (0.9 m) straight-edge placed anywhere on the car exterior.

The finished exterior shall present a high quality appearance free from sags, drips, scratches, variations in gloss, and other imperfections. The first car will be inspected by DART, and if approved, shall set the standard of quality for all remaining cars.

17.13.4 Apparatus and Equipment Enclosures

All underfloor- and roof-mounted apparatus and equipment enclosures (motors, control boxes, junction boxes, brake valves, and other equipment as specified) shall be primed and painted in accordance with the following requirements unless otherwise indicated.

The exterior surfaces of equipment enclosures and apparatus, other than propulsion control equipment, made from carbon steel shall be prepared, primed, and painted as specified in Sections 17.13.2 and 17.13.3. The interior and exterior surface of all propulsion control equipment enclosures shall be coated with an approved insulating, thermosetting, resin-based, powder coating or polyurethane paint system. The interior of the boxes, including insides of covers, shall be white and the exteriors shall match the surrounding paint scheme.

Parts of equipment enclosures made from plastic or fiberglass shall be painted in accordance with the above requirements for metal portions except that the paint system shall be compatible with the plastic used, and an insulating coating need not be applied.

An exterior finish of polyurethane in a color approved by DART shall be provided for roof mounted apparatus and equipment enclosures. Underfloor apparatus and equipment enclosures shall be painted to match the underfloor paint color.

17.13.5 Miscellaneous Painting and Finishing

Exterior stainless steel shall be cleaned with an approved alkaline cleaning solution, which shall not damage any previously painted surfaces. Other than framing structures, all hidden aluminum or ferrous materials, except stainless steel, shall be given one coat of a primer and one coat of an approved sealer.

17.13.6 Painting Restrictions

Any equipment or parts of equipment which would be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant.

The following undercar items shall not be painted:

- Flexible conduit and fittings
• Copper tubing, piping and fittings
• Wire and cable
• Power resistors
• Heat transfer surfaces
• Electrical insulators
• Elastomeric parts
• Grounding pads

The following truck-related items shall not be painted:

• Wheels
• Axles
• Elastomeric parts
• Grease fittings
• Linkages
• Threaded parts used for adjustments
• Electrical equipment
• Current pick-up devices
• Wearing surfaces
• Grounding pads
• Wire and cable

17.13.7 Interior Painting
All exposed interior surfaces, including molding and trim, shall be as specified in Section 15.

17.13.8 Corrosion Protection
Concealed surfaces capable of rusting or oxidation shall be properly cleaned, receive a wash primer, then primed with an epoxy paint, and painted with an approved finish coat of paint.

Where arc welding is performed on joints between stainless steel and other materials, the joint shall be de-scaled and cleaned, and then painted in accordance with this Section.

Structures that will be used to support bonded FRP panels shall be painted with a single layer of high bonding strength epoxy paint. The paint shall provide corrosion protection as further specified.

Closed-section tubular beams of the structure frame will be properly treated and coated for corrosion prevention by equally sufficient means.
17.13.9 Acoustic Insulation

Acoustic insulating materials shall be applied to properly cleaned and primed underframe, sides, ends, roof and floor members, as required in Section 3 and 15, in accordance with the Supplier’s recommendations. The materials shall be resistant to dilute acids, alcohols, grease, gasolines, aliphatic oils and vermin and shall meet the smoke and flammability requirements of Section 17.14.

The material shall be unaffected by sunlight and ozone and shall not become brittle with age. The material shall be Daubert Chemical Company's No. 368 sound deadening compound, Aquaplas No. DL-10, or approved equal.

17.13.10 Truck Painting

All truck components to be painted shall be given a full coat of primer prior to assembly. Following assembly, trucks shall be cleaned by blowing off with compressed air and solvent-wiped to remove all dirt and grease. All truck components shall then be sprayed with one coat of an approved black truck paint and air dried. Truck paint shall be selected such that structural cracks will not be hidden. Truck paint selection shall subject to DART review and approval. (CDRL 17-14)

17.13.11 Lettering and Numbering

Lettering and numbering shall be applied to the interior and exterior of the car by means of approved decals. Decals shall be applied and edge sealed in accordance with manufacturers' recommendations.

All decals shall be formulated and applied such that removal does not damage the underlying paint or surface.

17.13.12 Paint Process Documentation

The Contractor shall prepare a detailed paint coating and application document containing manufacturer's product data sheets, procedures for surface cleaning and preparation, priming, surfacing, dry and recoat times, and painting for the carbody and all equipment that is painted or powder coated, whether by itself or by its manufacturers and Suppliers. Touch-up and repair procedures shall also be provided. A detailed paint schedule showing the equipment painted, paint type and manufacturers, recommended thickness, and other pertinent information shall also be included. This information shall be made part of the maintenance manuals. This document shall be submitted for DART review and approval prior to painting of any surfaces or components. (CDRL 17-15)

17.14 Flammability and Smoke Emissions Requirements

17.14.1 General

All combustible material used in the construction of the car shall satisfy the flammability and smoke emission requirements cited in this Section.

DART approved, independent laboratory test results indicating successful compliance with these requirements will be required for all materials. (CDRL 17-16) Testing must be conducted within the Contract duration period, and preferably on a production batch of material. Each laboratory must have tested a standard test sample no more than 30 days prior to performing the tests which will be submitted to DART. The Contractor shall be
responsible for complete conformance with these standards for itself and its Subcontractors and Suppliers. DART may, at its discretion, accept prior test results up to 5 years prior to NTP or require that the current batch of material being provided for this contract be retested for conformance with these standards.

As a minimum, all materials used in the construction of the car, shall meet the requirements of Section 17.14.2 or NFPA 130, latest revision, subject to the following conditions:

Should a conflict exist between NFPA 130 and the detailed requirements in Section 17.14.2, the more restrictive requirements shall govern. Independent laboratory certification is required for all materials, including successful compliance with these requirements.

Should the Contractor feel that the quantity of a particular material is such that it would not contribute significantly to a fire, the Contractor may request a waiver from testing for this material. The waiver shall be submitted in writing and shall include the total weight of the material to be used, the location of the material and the distribution in the car, and any previous test reports available. Waivers shall be accompanied by proper justification and will be subject to DART review and approval on a case-by-case basis. (CDRL 17-17)

### 17.14.2 Flammability and Smoke Emission

Materials used in passenger vehicles shall be tested to demonstrate compliance with the requirements set forth in Section 17.14.1.

#### TEST REQUIREMENTS FOR PASSENGER VEHICLE MATERIAL

#### FIRE RISK ASSESSMENT

<table>
<thead>
<tr>
<th>Function of Material</th>
<th>Test Procedures</th>
<th>Performance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat Cushion</td>
<td>ASTM D 3675</td>
<td>Is &lt; 25</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>Ds (1.5) &lt; 100</td>
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<tr>
<td></td>
<td>ASTM E 662</td>
<td>Ds (4.0) &lt; 175</td>
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<tr>
<td>Seat Frame</td>
<td>ASTM E 162</td>
<td>Is &lt; 35</td>
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<td></td>
<td>ASTM E 662</td>
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<tr>
<td></td>
<td>ASTM E 662</td>
<td>Ds (4.0) &lt; 200</td>
</tr>
<tr>
<td>Seat Shroud/Arm Rests</td>
<td>ASTM E 162</td>
<td>Is &lt; 35</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
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<tr>
<td></td>
<td>ASTM E 662</td>
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<tr>
<td>Upholstery</td>
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<td>Flame Time &lt; 10 sec.</td>
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<td></td>
<td>Burn Length ≤ 6 in (152 mm)</td>
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<tr>
<td></td>
<td>ASTM E 662</td>
<td>Ds (4.0) &lt; 100</td>
</tr>
<tr>
<td>Wall Panel</td>
<td>ASTM E 162</td>
<td>Is &lt; 35</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>Ds (1.5) &lt; 100</td>
</tr>
<tr>
<td></td>
<td>ASTM E 662</td>
<td>Ds (4.0) &lt; 200</td>
</tr>
</tbody>
</table>
Ceiling Panel
ASTM E 162  Is ≤ 35
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

Partition Panel
ASTM E 162  Is ≤ 35
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

Windscreen Panel
ASTM E 162  Is ≤ 35
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

HVAC Ducting
ASTM E 162  Is ≤ 25
ASTM E 662  Ds (4.0) ≤ 100

Light Diffusers
ASTM E 162  Is ≤ 100
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

Floor Assembly
ASTM E 119  Pass
(with minimum 30 min endurance period at AW4 loading)

Roof Assembly
ASTM E 119  Pass
(with minimum 30 min endurance period at full equipment loading)

Flooring (Covering)
ASTM E 648  CRF > 0.5 W/cm²
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

Insulation (Thermal)
ASTM E 162  Is ≤ 25
ASTM E 662  Ds (4.0) ≤ 100

Insulation (Acoustic)
ASTM E 162  Is ≤ 25
ASTM E 662  Ds (4.0) ≤ 100

Elastomers
ASTM C 1166  Flame propagation < 100 mm
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

Exterior Shell including shrouding and equipment box covers
ASTM E 162  Is ≤ 35
ASTM E 662  Ds (1.5) ≤ 100
ASTM E 662  Ds (4.0) ≤ 200

Electric Wire Insulation
Flammability
See NFPA-130 8.6.7.1 and Section 17.21.2.1
Notes:

Materials tested for surface flammability shall not exhibit any flaming running or flaming dripping, except light diffusers.

ASTM E 662 test limits must comply with Specification limits in both the flaming and non-flaming modes.

The following information shall be supplied for all materials tested.

- Test Description
- Test Facility
- Test Result

17.14.3 Floor Assembly Testing Requirements

The Contractor shall test the floor assembly (structural) in accordance with ASTM E 119, as stated above, to demonstrate a 30 minute endurance rating. The section of the floor to be tested, test procedure, test facility, and test results shall be subject to DART review and approval, and approved prior to the Contractor's procurement of any flooring material necessary for vehicle production. (Procedure: CDRL 17-18 Report: CDRL 17-19)

The following test criteria shall be met:

- The test specimen shall be a full width vehicle section including side sills or that portion of the wall, which extends below the floor. The specimen shall have a minimum exposed area of 100 ft\(^2\) (9.3 m\(^2\)). If approved, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 11 ft (3.7 m). No fewer than one typical penetration of each type, spaced from each other at distance no greater than that which will exist in actual construction, shall be included in the test specimen. The specimen shall include typical floor splice configurations.
- The test specimen shall be loaded to simulate AW3 passenger loading conditions. Concentrated loads shall be applied to simulate underfloor equipment.
- The test specimen shall include at least three typical transverse supports.
- The test specimen shall represent the actual construction utilized in production. This includes the floor covering, floor boards, floor structure, thermal and acoustic insulation, and floor pans.

Conditions of acceptance for this test shall be:

- Transmission of heat through the assembly shall not raise the temperature of the unexposed surface more than 250°F (139°C) average and 325°F (181°C) single point.
- The assembly does not permit the passage of flame or gases hot enough to ignite waste cotton on the unexposed surface.
- The assembly supports the representative loading.
17.14.4 Roof Assembly Testing Requirements

The Contractor shall test the roof assembly in accordance with ASTM E 119, to demonstrate a 30 minute endurance rating. The test procedure, test facility, and test results shall be subject to DART review and approval, and approved prior to the Contractor's procurement of any roofing material necessary for vehicle production. (Procedure: CDRL 17-20, Report: CDRL 17-21)

The following criteria shall be incorporated within the test:

- The test specimen shall be a full width vehicle section including the roof rail or that portion of the wall which extends below the roof rail. The specimen shall have a minimum exposed area of 100 ft² (9.3 m²). If approved, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 11 ft (3.7 m). No fewer than one typical penetration of each type, spaced from each other at distance no greater than that which will exist in actual construction, shall be included in the test specimen. The specimen shall include typical panel joint configurations.
- The test specimen shall represent the actual construction utilized in production, including roof sheeting, thermal and acoustical insulation, air duct, HVAC transition duct, and interior ceiling panels.
- The test specimen's exposed surface shall be that surface on which equipment is mounted, i.e., the outside of the roof assembly.

Conditions of acceptance for this test shall be:

- Transmission of heat through the assembly shall not raise the temperature of the unexposed surface more than 280°F (139°C) average and 358°F (181°C) single point.
- The assembly does not permit the passage of flame or gases hot enough to ignite waste cotton on the unexposed surface.
- The assembly supports the representative loading.

17.14.5 Toxicity

Those materials and products generally recognized to have highly toxic products of combustion shall not be used.

All materials used in the car construction, except for materials used in small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall be tested for toxicity using Boeing Specification Support Standard BSS-7239. Materials shall meet the following maximum toxic gas release limits (ppm) as determined per BSS-7239.

- Carbon Monoxide (CO) 3500 ppm
- Hydrogen Fluoride (HF) 200 ppm
- Nitrogen Dioxide (NO₂) 100 ppm
- Hydrogen Chloride (HCL) 500 ppm
The tests shall be run in the flaming mode after 240 seconds using the NBS Smoke Density Chamber for sample combustion. The gas sampling may be conducted during the smoke density test. The test report shall indicate the maximum concentration (PPM) for each of the above gases at the specified sampling time. Results shall be subject to DART review and approval. (CDRL 17-22)

17.15 Wood and Panels

Surfaces exposed to passengers shall not deviate from the specified contour by more than 3/32 in (2.4 mm) in any 36 in (0.91 m) distance. The slope of any such deviation shall not exceed 3/32 in (2.4 mm) in 12 in (0.3 m).

17.15.1 Lumber

Lumber shall be thoroughly air seasoned or kiln dried before using and shall be dressed on all surfaces to full dimensions and treated to meet the testing requirements of Section 17.14. Lumber shall be straight grained, free from dry rot, knots checks, and other defects which may impair its strength and durability or mar its appearance.

The use of wood in the car, except where specified, shall be limited to specifically approved applications.

17.15.2 Plymetal

The term "plymetal" as used in this Specification covers metal-faced plywood and shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Test Conditions</th>
<th>Minimum Metal to Wood Average Shear Value (or 80% Wood Failure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry shear</td>
<td>250 lbf/in$^2$ (1.7 MPa)</td>
</tr>
<tr>
<td>Boil shear, 3 hour boil, tested wet at room temperature</td>
<td>150 lbf/in$^2$ (1 MPa)</td>
</tr>
<tr>
<td>Soak shear, 48 hour soak wet at room temperature</td>
<td>150 lbf/in$^2$ (1 MPa)</td>
</tr>
<tr>
<td>Creep or cold flow, under static load for 48 hour, at room temperature</td>
<td>250 lbf/in$^2$ (1.7 MPa)</td>
</tr>
</tbody>
</table>

Plymetal that is faced with melamine shall have the melamine bonded to the metal sheet in accordance with Section 17.15.5, and the melamine-faced metal sheet shall then be laminated to the plywood core in accordance with this Section.

17.15.3 Plywood

All plywood shall be manufactured to conform to the requirements of Grade - Structural I of the National Bureau of Standards Voluntary Product Standard (American Plywood Association) PS 1-83, and then stored under cover. All plywood panels shall be formed from...
one piece and shall be sealed with two coats of an epoxy paint on all edges and cutouts as soon as possible after fabrication. All exposed edges of panels, joints between panels, fastener heads, and openings of panels used in areas accessible to moisture shall be waterproofed and sealed in accordance with MIL-P-8053, paragraph 3.4, prior to installation in the car.

17.15.4 Honeycomb Panels

The term "honeycomb panels" as used in this Specification refers to an assembly of honeycomb material bonded to melamine-faced metal panels or to metal panels.

Aluminum honeycomb material shall be commercial-grade meeting the requirements of MIL-C-7438G. Bonding shall be sufficient to develop the full strength of the honeycomb material.

Stainless steel honeycomb panels shall be constructed in accordance with the requirements of MIL-A-9067. The adhesive bond strength of the honeycomb core to the stainless steel face shall not be less than 15 lb/in (2.7 kg/cm) climbing drum strength when tested in accordance with SAE-AMS-STD-401. The adhesive bond strength of the integral stainless frame to stainless steel face shall not be less than 30 lb/in (13.6 kg/2.5 cm) climbing drum strength when tested in accordance with SAE-AMS-STD-401. Stainless steel honeycomb panels shall be tested in accordance with SAE-AMS-STD-401 to demonstrate the following requirements:

- Core shear yield at 200°F (93°C) 250 lbf/in² (1.7 MPa)
- Flatwise tension at 200°F (93°C) 250 lbf/in² (1.7 MPa)
- Beam flexure at 200°F (93°C) 75,000 lbf/in² (517.13 MPa)
- Core shear fatigue at R.T. 150 lbf/in² (1.03 MPa) @ 10⁶ cycles
- Flatwise tension at R.T. 250 lbf/in² (1.7 MPa) @ 10⁶ cycles
- Beam flexure at R.T. 50,000 lbf/in² (344.75 MPa) @ 10⁶ cycles

Honeycomb panels meet the relevant flammability and smoke emission requirements in Section 17.14.

No other honeycomb materials will be permitted.

17.15.5 Melamine-Faced Aluminum

Melamine-faced aluminum panels shall be constructed by laminating melamine to aluminum sheets as follows: The melamine impregnated papers shall be directly molded to the aluminum sheets at temperatures of no less than 270°F (132°C) and pressure no less than 1000 psi (6.9 MPa). The surface characteristics, after manufacture, shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3-1980, or latest revision. The melamine and the required binder sheets shall be 0.020 ± 0.005 in (0.50 ± 0.15 mm) thick. The aluminum sheets shall not be less than 0.025 in (0.65 mm) in thickness when used as a facing on plywood. The aluminum sheets shall not be less than 0.081 in (2.1 mm) in thickness when not laminated to a substrate such as plywood.
Aluminum sheets shall be properly cleaned by etching, sanding or other approved process to insure full, permanent, acceptable adhesion.

The use of any adhesives to bond the melamine sheets to the aluminum backing will not be acceptable.

The bond between the melamine and aluminum sheets shall, as a minimum, meet the following requirements:

**ASTM D 952**  
Internal bond: 2,600 lbf/in² (17.9 MPa)

**ASTM D 790**  
Flexural strength - (S)  
with grain: 26,500 lbf/in² (183 MPa)  
crossgrain: 25,300 lbf/in² (174 MPa)

**ASTM D 790**  
Modulus of elasticity - (E)  
with grain: 2.8 x 10⁶ lbf/in² (19.3 GPa)  
crossgrain: 3.1 x 10⁶ lbf/in² (21.4 GPa)

**ASTM D 638**  
Tensile strength  
with grain: 22,300 lbf/in² (154 MPa)  
crossgrain: 20,300 lbf/in² (140 MPa)

Melamine-faced aluminum panels shall meet the relevant flammability and smoke emission requirements in Section 17.14.

### 17.15.6 Melamine Panels

Unbacked melamine panels may be used in the vehicle interior. The panels shall be a minimum of 3.2 ± 0.1 mm thick. The surface characteristics shall be no less than that required of type GP (General Purpose) in the NEMA Standards Publication No. LD-3-1980, or latest revision. Melamine panels meet the relevant flammability and smoke emission requirements in Section 17.14.

Sidewall panels shall be of unbalanced melamine. However, ceiling panels located under air ducts must be balanced melamine to prevent warpage from duct condensation.

### 17.15.7 Phenolic Composite Floor Panels

Phenolic composite floor panels shall be designed to withstand the following physical requirements with no visible or audible indications of delamination of the panel skin from the core and permanent deformation of the top surface shall be less than 0.010 in (0.25 mm) unless otherwise specified. There shall be no puncture or damage to fibers of the top surface. There shall be no separation of any internal core from the top or bottom skin. There shall be no fracture of the balsa core. All test results shall be submitted to DART for approval. (CDRL 17-23)
• Indentation Resistance – The floor panel shall withstand a concentrated load of 300 lbs (136 kg) applied to a test dowel that has an overall 0.375-sq in \(^2\) (242 sq mm\(^2\)) surface area, with a 0.0625-in (1.6 mm) radius on bottom edge of test dowel.

• Static Load Test - Average Loading – A representative sample section of the flooring (without rubber floor covering attached) shall be supported on beams spaced at the maximum spacing used on the car using production bonding and fastening techniques. A uniformly distributed load in accordance with AW3 loading requirements of Section 2.5.1 shall be applied to both sides of the joint (butt and/or shiplap). There shall be less than 0.088-in (2.2 mm) deflection.

• Static Load Test – Maximum Loading – Using the identical floor panel-mounting configuration as described above, a uniformly distributed load of 200 lb/ft\(^2\) (976 kg/m\(^2\)) shall be applied to both sides of the joint (butt or shiplap).

• Small Area Static Load Test – Using the identical floor panel mounting configuration as described above, a 300 lb (136 kg) load shall be applied to a 1.0 in (25.4 mm) by 3.0 in (76 mm) contact area directly over the midspan, 6 in (152 mm) from the outer carbody sidewall edge. The footprint shall be machined flat within 0.010 in (0.24 mm) and the edges shall have a radius of not more than 3 mm. There shall be less than 0.200 in (5 mm) deflection as a result of the load applied.

• Small Object Impact Test - Using the identical floor panel mounting configuration as described above, a 16 lb (7.25 kg) standard bowling ball shall be raised directly over the mid-span, 24 in (610 mm) from the edge of the panel and dropped from height of 60 inches (1500 mm). Permanent deformation of the top surface shall be less than 0.0625 in (1.5 mm).

• Large Object Impact Test - Using the identical floor panel mounting configuration as described above, a 150 lb (68 kg) load shall be dropped upon a 3.0 in (76 mm) by 8.0 in (200 mm) contact “footprint” pad located directly over the midspan, 24 in (610 mm) from the edge of the panel and dropped from a height of 12 in (305 mm). The “footprint” pad shall have a rubber pad on the downside surface with a Shore D 70 minimum, at a 1 inch (25 mm) thickness machined flat within 0.0625 in (1.5 mm) with edges having a radius of not more than 0.030 in (0.75 mm). Permanent deformation of the top surface shall be less than 0.030 in (0.75 mm). Some damage to the top phenolic composite skin will be allowed.

• Rolling Load Test - Using the identical floor panel mounting configuration as described above, a four-wheeled cart with a load of 200 lbs (91 kg) per wheel shall be rolled on the panels laterally, longitudinally and in a circular path 24 in (610 mm) radius. The wheels shall be 3 in (75 mm) in diameter, 1 in (25.4 mm) wide with a 0.125-in (3 mm) radius on each edge with a Shore A durometer of 80.

• Flammability and Smoke Emission Tests – Floor panels meet the relevant flammability and smoke emission requirements in Section 17.14.

17.16 Fiberglass Reinforced Plastic
Fiberglass Reinforced Plastic (FRP) shall be a polymeric-reinforced, laminated material, composed of a gel-coated surface, fiberglass reinforcement, and a polyester, vinyl ester or
other approved resin. FRP shall withstand, without any physical deformation, structural
damage, or reduction in life, the environmental conditions in Section 2.3.5, and shall be
resistant to acids, mild alkaline solutions and those cleaning solutions recommended by the
Contractor. The FRP shall meet the smoke and flammability requirements of Section 17.14.

FRP shall be manufactured by either open molding or matched die molding process. FRP
skin may be pultruded. Production techniques shall ensure that the glass fiber reinforcement
is uniformly distributed throughout the final product in such a manner as to avoid resin-rich
or resin-starved sections. An analysis shall be performed to confirm that the construction
method chosen is adequate for its intended purpose. Finished gel-coated surfaces shall
have a minimum gloss value of 85 when measured with a 60 degree glossometer and shall
exhibit no print through of the reinforcements or have any appreciable orange peel. FRP
skin surface shall be as reviewed and approved by DART.

Reinforced plastic parts shall have greater thickness at attachment points and edges. Exposed sharp edges will not be permitted on any parts.

Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke
inhibitors shall be added to the resin mixes to obtain finished products with the required
physical characteristics below and other requirements of this document.

Mineral filler shall not exceed 28 percent of finished weight for any preformed matched die
molding process.

17.17 Thermoplastic Sheet

Thermoplastic sheet shall withstand without physical deformation or structural damage, the
environmental conditions in Section 2.3.5 and shall be resistant to all recommended cleaning solutions. The thermoplastic sheet shall meet the relevant flammability and smoke
emission requirements in Section 17.14.

Thermoplastic Sheet shall be used "as is" or vacuum-formed.

The thermoplastic sheet shall be homogeneous and extruded from virgin stock which shall
not include any regrind of vacuum formed parts. No cap sheet will be permitted.

Only UV stabilized pigments shall be used to create the specified color of the thermoplastic
sheet. The color and surface finish of parts manufactured from this material shall be
approved before the manufacture of any parts.

17.17.1 Quality

Finished parts shall be free of waves and quilting on both sides. Degraded polymer in the
sheet shall not be allowed, and if present, shall be cause for rejection of the piece. Voids,
lumps, and contamination shall also be cause for rejection of parts if the defects are larger
than 0.010 in (0.25 mm), and the population of these defects is greater than one defect in 4
ft² (0.37 m²).
17.17.2 Strength Requirements

Independent laboratory test certificates shall be provided stating that the Thermoplastic Sheet complies with the requirements of the below listed standards. Extruded sheet in the surface finish specified shall be used for testing.

<table>
<thead>
<tr>
<th>Mechanical Properties</th>
<th>ASTM Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>D 792</td>
<td>1.20 to 1.45</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>D 638</td>
<td>5,500 lbf/in² (38 MPa) min</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>D 790</td>
<td>8,000 lbf/in² (55 MPa) min</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>D 790</td>
<td>$3.3 \times 10^5$ lbf/in² (2275 MPa)</td>
</tr>
<tr>
<td>Hardness Rockwell</td>
<td>D 785</td>
<td>90 to 110</td>
</tr>
</tbody>
</table>

"R" Scale

| Heat Shrinkage              | -----      | 10% maximum            |
| 15 minutes at 350°F (177°C) |

| Heat Deflection             | D 648      | 165°F (74°C) min       |
| (annealed) @ 264 lbf/in² (1.8 MPa) |

| Impact Strength             | D 5420     | 160 in-lb (18 J) min   |
| Fabricated Parts            |            |                        |
| Gardener Dart Drop          |            |                        |
| 0.5 in (13 mm) dia. ball @ 73°F (23°C) |

17.18 Seat Cushion Material

17.18.1 General

Seat cushion fill material shall be low-smoke flexible foam constructed of inherently fire-retardant materials. The thickness shall be approved during design review. The material shall have a polymerized or vulcanized homogeneous (free from foreign material), cellular structure with a porous surface and open cells. The cells shall be interconnecting and uniform in size. Cellular material may be molded in one piece or may be assembled by laminating to achieve the required thickness. Laminated cushions shall be bonded together. Cushion material shall be properly cured to prevent any objectionable odor.

17.18.2 Physical Properties

Flexible foam shall meet the following physical property criteria when tested without upholstery material:

- Tensile Strength - 5.0 lbf/in² (34.5 kPa) minimum tested to ASTM D 3574 Test E
- Elongation - 70% minimum when tested according to ASTM D 3574 Test E
• Compression Set at 50% - 15% maximum when tested according to ASTM D 1055
• Flex Fatigue - Thickness loss 5% maximum when tested according to ASTM D 1055
• Tear Strength - 2.0 lbf/in² (13.8 kPa) minimum tested according to ASTM D 3574

17.19 Seat Upholstery Material

17.19.1 General
Fabrics used for seat upholstery shall be made of woven, transportation grade fabrics of wool, wool/nylon blend (90/10, 85/15) or an approved flame-resistant polyester. The maximum fabric shrinkage shall be 2% in either the warp or fill direction.

17.19.2 Physical Properties
Seat upholstery material shall be subjected to the physical tests of textile products required by the latest revision of the following ASTM methods, and the results shall not be less than the following values.

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 3776</td>
<td>Fabric Weight</td>
<td>14.5oz/yd² (492 g/m²) without back coating</td>
</tr>
<tr>
<td>D 3775</td>
<td>Fabric Count</td>
<td>Warp - (ends) 88epi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - (picks) 40 to 72ppi</td>
</tr>
<tr>
<td>D 5034</td>
<td>Breaking Strength and Elongation</td>
<td>Warp - 200 lbs (896 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill – 200 lbs (896 N)</td>
</tr>
<tr>
<td>D 2261</td>
<td>Tear Strength (Tongue)</td>
<td>Warp - 20 lbs (89 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 20 lbs (89 N)</td>
</tr>
<tr>
<td>D 1683</td>
<td>Seam Strength</td>
<td>8 to 10 stitches/in (3-4 stitches/cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warp - 100 lb (444 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill – 100 lb (444 N)</td>
</tr>
<tr>
<td>D 4034</td>
<td>Yarn Slippage</td>
<td>Warp – 75 lb (336 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill – 65 lb (291 N)</td>
</tr>
<tr>
<td>D 597</td>
<td>Color Fastness</td>
<td>Water - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solvent - Class 4 min</td>
</tr>
<tr>
<td>Test No.</td>
<td>Description</td>
<td>Criteria</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Crocking - Class 4 min</td>
<td>Light - Class 4 min</td>
</tr>
<tr>
<td>D 4966</td>
<td>Martindale Abrasion Test</td>
<td>20,000 cycles - no breaks</td>
</tr>
</tbody>
</table>

Flame-resistant polyester seat upholstery material shall be subjected to the physical tests of textile products required by the latest revision of the following ASTM methods, and the results shall not be less than the following values:

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Description</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 3776</td>
<td>Fabric Weight</td>
<td>12 oz./sq. yd. (407 g/m²) without back coating</td>
</tr>
<tr>
<td>D 3775</td>
<td>Fabric Count</td>
<td>Warp - (ends) 88 epi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - (picks) 40 to 72 ppi</td>
</tr>
<tr>
<td>D 5034</td>
<td>Breaking Strength and Elongation</td>
<td>Warp - 270 lbs (1210 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 200 lbs (896 N)</td>
</tr>
<tr>
<td>D 2261</td>
<td>Tear Strength (Tongue)</td>
<td>Warp - 20 lbs (89 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 20 lbs (89 N)</td>
</tr>
<tr>
<td>D 4034</td>
<td>Yarn Slippage</td>
<td>Warp - 75 lbs (336 N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fill - 65 lbs (291 N)</td>
</tr>
<tr>
<td>D 3597</td>
<td>Color Fastness</td>
<td>Water - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solvent - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crocking - Class 4 min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light - Class 4 min</td>
</tr>
<tr>
<td>D-4966</td>
<td>Martindale Abrasion Test</td>
<td>20,000 cycles - no breaks</td>
</tr>
</tbody>
</table>

**17.20 Electrical Fire Safety**

Electrical equipment, wiring and apparatus shall conform to NFPA 130, Chapter 8.

**17.21 Wire and Cable**

All wire sizes and insulations shall be based on the current carrying capacity, voltage drop, mechanical strength, temperature and flexibility requirements in accordance with applicable AAR, ICEA, ASTM, NFPA (NEC), and MIL specifications as indicated in this Section or as approved by DART.
Within this document, the term "wire" refers to a single insulated conductor of any size while the term "cable" refers to a group of wires contained within an overall insulating covering. Cable may also be referred to as multi-conductor cable.

All requirements in this document referring to wire also apply to cable, except for requirements that explicitly apply to wire or cable only.

All car wiring shall be designed, rated, and selected to last the life of the car.

The Contractor shall submit a report that includes list all wire and cable types to be used on the vehicle along with technical specifications for each type of wire and cable for DART's approval. (CDRL 17-24)

Refer to Section 17.22.2 for wire size limitations.

17.21.1 Conductors

Maximum wire ampacities for each circuit shall conform to the lower of the following:

- The 110°C rating table in APTA RP-E-009-98 for the wire insulation with ratings 110°C or higher, or lower temperature rating table if the insulation rating is less than 110°C or the rated temperature of connected devices, as noted in the next bulleted item, approved by DART.
- The lowest temperature rating of all devices connected to the circuit, such as wire terminals, circuit breakers, etc.

Where more than three conductors are routed in a conduit or raceway, the ampacities of each conductor shall be derated in accordance with APTA RP-E-009-98.

All wire conductors shall be of stranded, soft annealed, tinned copper wires in accordance with ASTM B 33.

Stranding and conductor construction for all wires and cables of No. 18 AWG and larger shall be in accordance with AAR RP-585 (Standard S-501) and RP-586 (S-502), ICEA S-66-524 Table L-7, Class K, or Table L-8, Class M, as appropriate for the application.

Stranding and conductor construction for wires and cables AWG 20 and smaller diameters shall be in accordance with ICEA S-19-81 Table 2-8, Class M, or shall be 19-strand construction as appropriate for the wire size.

17.21.2 Insulation

17.21.2.1 General

All general carbody wire insulation shall be a flame retardant, flexible, cross-linked polyolefin material having a continuous temperature rating of 110°C.

Insulation shall be formulated for extra flexibility for wire sizes AWG 6 and larger.

Insulation shall be rated at 2000 Vdc for circuits of greater than 300 Vac or Vdc and rated at 600 Vdc for circuits of 300 V or less, ac or dc and shall be in accordance with the requirements of AAR Standard RP585.
17.21.2.2 Wire Insulation for High Temperature Applications

High temperature insulation shall be in accordance with the following requirements:

- For wire sizes AWG 16 and larger: abrasion resistant Teflon (Polytetrafluoroethylene (PTFE)) meeting MIL-W-22759/6B, or SAE-AS-22758/10 as appropriate for the voltage level used, or silicone rubber meeting AAR RP-587 (Standard S-503).

- For wire sizes AWG 18 and smaller: Abrasion resistant PTFE Teflon meeting MIL-W-22759/6B or 10B as appropriate for the voltage level used. When used for interconnecting pieces of apparatus, this type wire shall be in bundles with a protective covering.

High temperature insulated wire shall not be used in conduit or raceways without specific approval.

17.21.2.3 Wire Insulation within Equipment

Wiring within replacement modular units, electronic apparatus such as cards and card racks, and other equipment, as approved, shall be Tefzel (Ethylene tetrafluoroethylene (ETFE)) per ASTM D 3159 and insulation construction per SAE-AS-22759/16, except the wall thickness shall be 0.65 mm, cross-linked polyolefin per Section 17.21.2 above or Teflon (Polytetrafluoroethylene (PTFE)) type EE per NEMA HP3.

17.21.2.4 Wire Insulation in Crowded Locations

Wire for connections to the control console, or in other locations with similarly crowded low voltage control wiring, may be insulated with ETFE Tefzel per ASTM D 3159 and insulation construction per SAE-AS-22759/16 except the wall thickness shall be 0.65 mm.

When used for this application, these type wires shall be bundled with a protective covering of cross-linked modified polyolefin or similar high temperature rated, low smoke generating insulation.

17.21.3 Multi-Conductor Cables

Multi-conductor cables shall be constructed using wiring as described above. For high temperature applications, the cable shall conform to MIL-C-27072, with Type V connectors Style 4 sheaths, Class D jackets, if needed, and shields, if needed. All conductors in multi-conductor cables shall be color coded or otherwise permanently identified by approved means. Materials used in the construction of multi-conductor cables shall meet the requirements below.

In applications where current is not a factor in wire size selection, such as LED indicator lights or status displays, AWG 22 may be used between repeater devices and displays. For multi-conductor cables carrying low-voltage, high-speed, serial data, exceptions to the wiring requirements may be submitted for DART’s review and approval, based upon availability of wire to meet the application requirements.

17.22 Wiring Installation

17.22.1 General
Wire shall be applied as specified in APTA RP-E-002-98 "Recommended Practice for Wiring of Passenger Equipment", APTA RP-E-009-98 "Recommended Practice for Wire Used on Passenger Equipment", NFPA 130, and IEEE Standard 16 "IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles" as appropriate or as specified in this document.

All car wiring shall be in conformance with Chapter 3 of the National Fire Protection Association's Publication NFPA No. 70, National Electrical Code, except where otherwise specified, and except that all wire shall be as specified in this document.

All car wiring shall have circuit protection conforming to Chapter 2 of NEC, Article 240 or as specified in this document.

17.22.2 Wiring

Wiring shall be sized for the intended load, voltage drop, installation method, and applicable codes.

Regardless of the load, minimum wire sizes shall be as follows:

- Wire which is pulled through conduit – AWG 14.
- Wire within control compartments – AWG 18.
- Multi-conductor cables where current is not a factor in wire size selection – AWG 22.
- Wire on electronic units, cards, and card racks – AWG 22.
- Wiring which is laid in, rather than pulled through, wire ducts – AWG 18.

Wires sizes other than the above shall be as approved.

17.22.3 Wire Handling

All wiring shall be performed by qualified, experienced wiring personnel using appropriate tools for stripping insulation, cutting, tinning, soldering, harness making, attaching terminals, etc. All wiring tools and equipment shall be used as recommended by the tool and equipment manufacturer.

Wire shall be protected from damage during all phases of equipment manufacture. Wire shall not be walked on, dragged across sharp or abrasive objects, kinked or twisted, or otherwise mishandled. The ends of wire shall not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors.

When removing insulation, wire strands shall not be nicked or broken in excess of the requirements of FAA Specification No. AC 43.13-1A, Chapter 11, Section 449, "Stripping Insulation". Additionally, the following criteria shall apply:

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Nicked or Broken Strands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wires smaller than AWG 10</td>
<td>None</td>
</tr>
<tr>
<td>AWG 10 through 1/0</td>
<td>7.4 - 4.4%</td>
</tr>
<tr>
<td>Above 1/0 through 1600/24</td>
<td>4.4 - 2.0%</td>
</tr>
</tbody>
</table>
Definitions:

a) A cutoff strand shall count as two nicked strands.
b) A nick is defined as 25% or more of the strand area damaged, or cut more than 1/3 of its diameter.
c) Longitudinal scratches in a copper strand will not be considered cause for rejection.

17.22.4 Harnessing

Where it is practical, wiring shall be pre-fabricated into standardized harnesses, wrapped and tied with a high strength, waxed lacing cord or nylon wire ties. Separate harnesses shall be provided for major circuit groups or types, or as required for specified circuit separation (below).

Harnessed wires shall not be installed in conduit.

Each harness or collection of wires between equipment enclosures shall contain a minimum of 10% spares, but no fewer than two spares for each wire size smaller than AWG 10.

17.22.5 Circuit Separation

Circuits shall be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.

The following major circuit groups shall not be harnessed or bundled together, shall not run in the same conduit, and shall be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:

- High voltage circuits
- Ac circuits
- Communication circuits
- Battery voltage level circuits
- Semiconductor voltage level circuits

Wiring operating at potentials differing by 50 V or more shall not be harnessed or cabled together or be run in conduit together. Wiring of different potential in wire ducts, raceways, junction boxes, or other wire routing devices shall be separated by a rigid physical barrier.

Wiring of different potential within equipment enclosures shall be separated, routed, and secured such that contact between wiring is not possible. All wiring within an enclosure shall be insulated for the highest voltage in the enclosure, unless approved otherwise.

Separation and/or electromagnetic shielding shall be provided between the conductors of high current switching or transient generating equipment and the wiring of semiconductor, logic, or communication circuits such that interference does not occur between circuits.

17.22.6 Routing of Wiring

17.22.6.1 General
All wiring shall be secured and protected against movement, chafing, and any contact with conductive, sharp, or abrasive objects including the inside surfaces of wire runs.

No wiring shall be secured directly to the car structure, equipment enclosures, or any metallic surface. Wiring securing devices shall be either completely non-metallic or metallic with a resilient, insulating member between the wiring and the metallic portion of the device.

All wiring shall be located and secured such that normal equipment motions, maintenance access, heat sources, and DART environment do not damage or reduce the life of the wiring.

Within this document, the term "wire run" refers to all equipment used for routing of wiring except electrical enclosures or electrical apparatus and includes conduits, wire ducts, and associated hardware defined below.

All indicated wire run requirements apply to all wiring types and locations, including undercar wiring, wiring within the car, and truck wiring unless explicitly indicated otherwise.

17.22.6.2 Wiring Between Equipment or Enclosures

All wiring not fully contained within electrical enclosures or electrical apparatus shall be contained within wire runs, as defined below.

All wire runs shall be fully enclosed wire ducts, conduits, junction boxes, or similar hardware. Large wires and cables may be exempt from this requirement, see Section 17.22.6.3 below. For wiring within enclosures, see Section 17.22.6.4 below.

All undercar and roof wire runs shall be waterproof. All entrance and exit points of undercar and roof wire runs, equipment enclosures, or other wiring devices shall be waterproof. Except for conduit, all wire runs shall have removable covers sufficient to gain access to all wiring within the run. All wire run covers shall have reusable resilient waterproof seals.

All wiring to resiliently mounted or moving equipment shall be by flexible conduit or ducting.

All metallic wire runs shall be grounded to the car structure.

Except for within conduit, all wiring within wire runs shall be secured at least every 18 inches (0.5 m). Wiring shall be secured only to the top or sides of wire runs and no wiring shall be secured to, or rest on, the bottom of wire runs.

Wiring within conduit shall not be bundled or secured.

Junction boxes or equipment enclosures shall be used for all wire terminations or circuit branches. Wire splices of any type will not be permitted except as approved on a case-by-case basis during construction.

Wiring to electrical apparatus shall be carried within the wire run as close to the apparatus as possible. Wiring between the wire run and the apparatus shall be in rigid conduit, liquid-tight flexible conduit or other device. See Section 17.21.6.3 below for exceptions. In areas of likely impact, such as on trucks, flexible conduit shall be without an internal metallic liner and shall include an external abrasion shield.

All entrance and exit points from wire runs or enclosures shall have permanently-retained insulating liners. All wiring entering or exiting wire runs or enclosures shall be secured at or
within 6 inches (150 mm) of the transition point. The securing device and wiring slack shall insure that there is no strain on the wiring at the transition point.

All wiring shall be removable from wire runs and enclosures without removal of wire terminals or connectors.

Wiring shall not pass through or over the battery compartment, or over heat-generating equipment such as acceleration and braking resistors, even if the wiring is within wire runs.

All truck wiring shall be in rigid conduit to the greatest extent possible except for the connection to electrical apparatus (see above).

All wiring passing through the floor or roof shall be in wire runs.

All wiring shall be replaceable without disassembly of wire runs, except for access cover removal.

17.22.6.3 Exposed Wiring

Large sizes of wire, AWG 6 or larger, may be cleated in place with no protective wire run. Exposed wiring in areas of likely impact or abrasion shall have additional protection in the form of additional jacketing or armor. Multi-conductor cable shall not be exposed except for wiring to standard small devices, such as speed sensors, that cannot accept conduit fittings.

All exposed wiring and multi-conductor cabling shall be kept to a minimum and shall be subject to DART’s review and approval.

Cleating shall be by split-block cleats of fire retardant neoprene rubber with a durometer of 50 to 60. The neoprene blocks shall be clamped together with no fewer than two bolts with a rigid stiffener on each side of the cleat. The stiffeners shall insure that clamping pressure is evenly distributed over the full length of the cleat.

Each cleat opening shall be sized only for the intended wire size and shall firmly grip the wire without insulation damage or cold flow. Shimming of oversized openings will not be permitted. All cleat openings shall be molded into the material by an experienced manufacturer. Cutting, drilling, or modification of cleat openings during car construction will be prohibited.

Cleated wiring shall be routed and supported such that each individual run of wiring cannot contact other wiring or any other part of the car under any circumstances. Intervals between adjacent cleats shall not exceed 18 inches (0.5 m).

A drip loop shall be provided on all exposed wiring to prevent fluid runoff into connected equipment.

17.22.6.4 Wiring Within Enclosures

The requirements below apply to all electrical equipment enclosures, including junction boxes.

All wiring within enclosures shall be attached to wire supports rigidly fastened to the enclosure structure. Wiring shall be free from edges, bolt heads and similar areas, and shall not interfere with nor contact enclosure covers.
Wiring shall be located on the top or sides of the enclosure. All wiring shall be a minimum of 1 inch (25 mm) above the bottom of the box, including all wiring that must connect to the bottom of apparatus.

Wiring entering any removable enclosure shall be harnessed and secured to facilitate removal of the box. Wires from different wire runs shall not be harnessed together or with internal wiring.

All wiring shall be secured such that there is no strain on wire terminals, multi-pin connector pins, or other wire termination hardware.

Wire dress shall allow for sufficient slack at terminals to provide for shock and vibration induced movements, equipment shifting, alignment, cover removal and component replacement. Sufficient additional wire length shall be provided for retermination of wires without excess tension or splicing as follows:

- AWG 10 and smaller: Three reterminations
- AWG 8 and larger: Two reterminations

Wiring entry into enclosures shall be through the top or upper half of the sides for underfloor equipment and through the sides for roof mounted equipment. Wiring entry into the bottom of enclosures will be prohibited except for wiring entering into interior enclosures through the floor.

17.22.6.5 Primary Power Wiring

The primary power feed shall be installed without taps or splices from the roof-mounted HSCB directly to the primary power switch. This wire shall be run in a conduit containing no other wiring.

Primary power wiring installed within the carbody, including wiring between the roof and underfloor locations, shall be run in conduit or wireways as described in Sections 17.23 and 17.24, respectively. Conduits or ducts that penetrate the roof shall be terminated in a waterproof entrance box or with a waterproof fitting. Primary power wiring, except for heater wiring, shall not terminate within the carbody.

17.22.6.6 Articulation Connections

Flexible hoses, wiring and cabling routed across the articulation shall be run in ducting with non-conductive inserts. The routing shall minimize excess length and unnecessary flexing. All primary power wiring shall be run on the vehicle roof. Low voltage wiring may be run below or above the floor line, or on the roof.

Quick disconnects shall be provided for low voltage circuits and terminal connections shall be provided for high voltage circuits on one or both sides of the articulation. If provided on one side of the articulation, all wire and cable shall be readily removable from, and re-installed through, the articulation without damage to the wire, cable, or connectors.

Refer to Section 17.22.4 for connector requirements.

17.22.7 Insulation Resistance and High Potential Testing

All wiring shall be tested for insulation resistance and high potential breakdown as specified in Section 17.2.
17.22.8  Marking

The Contractor shall devise a wire and terminal designation system that will coordinate all electrical circuits in the car into a unified system. The system shall identify all wiring, including circuit return wiring, and terminals according to their respective circuit function(s), and shall accurately correlate with car schematics. Common designations for return circuits will not be permitted. Alternative designations may be used in small standard assemblies such as PA amplifiers. The wire and terminal designation system shall be subject to DART review and approval. (CDRL 17-25)

All wires and terminals shall be clearly identified with white or yellow permanent markers, with black printing or by continuous wire marking printed on the wire. Wire that is continuously marked shall have the durability of the printing verified in accordance with UL 1581 paragraphs 1690.3 and 1690.4, as appropriate for the application. Printing shall be done by machine with permanent ink that will not rub off. Wire markers shall meet the adherence and solvent resistance requirements as specified by MIL-M-81531 Sections 3.4.2 and 3.4.3, latest revision, and shall withstand all combinations of ambient and equipment temperatures. Hand printing will be prohibited. Color coded wires will be permitted as an alternative in small standard assemblies such as PA amplifiers.

Each wire shall be labeled with both its circuit designation, and if attached to a terminal, its terminal designation. All wires shall be marked within 3 inches (75 mm) of the end of the wire.

17.22.9  Pulling Compound

Pulling compound, if used, shall be non-conductive, non-hygrosopic, non-odorous and shall not attract vermin.

17.22.10  Tape

Electrical tape shall be polyvinyl chloride in accordance with AAR Standard S-540 of Section F of the AAR Manual Standards and Recommended Practices, or equivalent approved railway practice. Electrical tape shall meet or exceed the voltage rating of wire where the tape is applied.

17.22.11  Wire Ties and Clamps

Wire ties, clamps, and anchors shall be nylon formulated for resistance to ozone and ultraviolet light, rated for outdoor service, and shall last the life of the car. Wire ties shall be installed with tools with automatic tensioning devices, as supplied by the wire tie manufacturer, that will also cut ends flush with the locking mechanism. Wire ties shall be installed with sufficient tension to restrain the wiring without indenting the wire insulation.

If used, wire tie anchors shall be riveted or screwed to rigid structure. Adhesive-based wire tie anchors will not be permitted.

Wire tie width shall be selected for intended wiring load and minimum insulation indentation.

Wire clamps shall be either nylon or stainless steel covered with neoprene or silicone rubber similar to those manufactured by Adel. Wire clamps shall be sized for each harness such that no less than 90% of the harness circumference is securely clamped. Clamps shall be fastened with bolts and elastic stop nuts.
17.23 Wiring Connections

17.23.1 Terminal Boards

As used in this document, the term "terminal board" refers to all devices commonly called terminal blocks, terminal strips, terminal studs, or similar items to which wires are connected.

Terminal boards shall be either stud-type, compression-clamp, or push-on tab (FASTON type), with barriers and of a series service proven in rail transit. Terminal boards shall be subject to DART review and approval. (CDRL 17-26)

Each terminal board shall have a minimum of 10%, but no less than one, unused terminals. For terminal boards with more than 100 terminals, the minimum number of unused terminals shall be 10 plus 2 for every 50 additional terminals above 100. Jumpers between adjacent terminals shall be plated brass or copper.

The terminal board insulation shall be a strong, high temperature rated, tracking resistant material that is not brittle. The material shall be either a filled reinforced thermosetting material or a thermoplastic material. Use of general purpose phenolic will be prohibited.

Stud-type terminal boards shall be in accordance with MS-27212 and shall have plated brass or steel studs. Wiring shall be fastened with flat washers over the wire terminals, plated spring type lock washers and hex nuts of the same materials as the stud. Wiring connected to threaded studs shall have a minimum of 2-1/2 threads exposed beyond the nuts.

Adequate space shall be provided to permit connecting wire terminals with standard tools.

A maximum of four terminals shall be connected to any single terminal stud, provided that there is no interference between terminal barrels and sufficient threads protrude beyond the nut. On terminal boards, the wiring shall be arranged so that no more than two terminals are connected to a stud, from each side of the terminal board.

On compression clamp terminal boards, a maximum of two terminals shall be connected to any one binding terminal. All connected wires shall be terminated with mechanical crimp type terminals as specified in Section 17.23.2.

17.23.2 Wire Terminations

Wire terminals used throughout the car shall be mechanical crimp type terminals as made by AMP Incorporated or other approved manufacturer with a comprehensive line of terminals, connector pins and application tools available. The Contractor shall submit the proposed product line for approval. (CDRL 17-27) Terminal lugs shall be in accordance with Military Standard MS-25036. All terminals shall be plated copper.

Wire terminals shall be AMP PIDG ring-lug type terminals or approved equal. "FASTON" type terminals shall be of a type which permits at least 100 cycles of removal and re-attachment without loosing proper grip and shall be AMP PIDG terminals, S/N 640 903-1 for wire sizes 22-18, S/N 640 905-1 for wire sizes 16-14, or S/N 640 907-1 for wire sizes 12-10, or approved equal. Terminals used with compression clamp terminal blocks shall have insulating collars and shall be of a series approved by the terminal board manufacturer for use with the selected terminal boards. Spade and hook type terminals will not be permitted.
Terminals used on conductor sizes No. 10 AWG or smaller shall be insulated and shall have a metal strain relief device under the insulation that is crimped onto and grips the wire insulation simultaneously with the terminal. Other strain relief devices shall be submitted for approval. The insulation material shall be rated for the expected worst case temperature.

All wire terminals and connections shall be attached to the wiring with crimping tools and dies as recommended by the manufacturer and approved by DART. (include in CDRL 17-27) Crimping tools shall be ratcheting types that insure a complete compression. The Contractor shall maintain these tools in proper calibration and insure that all personnel using them are properly trained.

A maximum of one wire shall be crimped in any one terminal.

17.23.3 Power Wiring Terminations

Power wiring shall be terminated with bolted compression terminals as manufactured by AMP, Thomas & Betts, or approved equal and shall be applied using tools and procedures recommended by the terminal manufacturer. Crimping tools shall be ratcheting types that insure a complete compression.

Double bolted terminals shall be used at all locations where rotation of a single bolted terminal would result in contact or unacceptable clearance with other conductors or the enclosure.

Power wire terminals on the traction motors shall be waterproof cable connectors as described in Section 17.22.4.2 or a waterproof “clam shell” or similar multiple conductor assembly that routes all of the truck power cables through one connector.

17.23.4 Multi-pin Cable Connectors

17.23.4.1 General

All cable connectors shall be equipped with removable crimp contacts. Contacts shall be selected for the intended wire size and as recommended by the manufacturer.

The connector contact area shall be plated with a minimum of 0.000100 inch (2.5 μm) of silver for general purpose applications and plated with a minimum of 0.000030 inch (0.8 μm) of gold over a minimum of 0.000050 inch (1.3 μm) of low stress nickel for general purpose and low level dry circuit applications.

Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections.

Cables shall be clamped at the back of the connector by clamping over the cable jacket. Clamping on cable wires will be prohibited.

Extension bodies shall be used where necessary to insure that there is sufficient room to terminate cable wires while providing the seal and clamp on the cable jacket.

Ethernet connectors shall be M12. RJ45 connectors shall not be permitted.

The Contractor shall prepare a design submittal that lists and includes specifications for all connectors to be used on the vehicle. (CDRL 17-28)
17.23.4.2 Waterproof Cable Connectors

Waterproof cable connectors with the qualities described below shall be used for all undercar, roof, or exposed locations and may be used at all other locations. Cable connectors shall be equipped with sealing gaskets on the front mating surface and on the back at the cable entry. Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.

The cable connectors shall be metal-shelled, positive-locking, rectangular connectors as described below or circular one-quarter to one-third turn, with three bayonet couplings, quick disconnect, environmental watertight connectors. Connectors shall be rated for a minimum life of 2,000 couplings before failure. Connectors shall give audible, visual and tactile indications of full coupling. Circular connectors shall be type CIR connectors as made by Litton-Veam SPA, or approved equal.

Heavy-duty multi-pole rectangular connectors shall conform to DIN VDE 0627 and DIN 43652 as manufactured by Harting and ILME.

Speed sensor connectors only may be multi-turn, fine thread, metal shelled, waterproof connectors. These connectors shall be Cannon CA06RXA, or approved equal.

17.23.4.3 Non-waterproof Cable Connectors

In weatherproof interior locations, the use of non-waterproof connectors will be permitted. Connectors shall be Amp Circular Plastic Connectors, Amp Circular Metal Shell, or approved equal.

17.23.5 Ground Connections

Grounding connections to the carbody, truck frame, and other car structures shall be made through tinned or silver electro-plated copper pads silver soldered or brazed to both the carbody and the grounded item.

All grounding wires shall be sized to limit voltage rise to less than 50 V under worst case fault currents. The grounding connection method employed shall not produce a dc resistance in excess of 0.0025 ohms, or more than 0.025 ohms at 150 kilohertz for any applied ac voltage.

Grounding wires to resiliently mounted equipment, from the carbody to truck frame, or other locations with relative movement, shall be tinned braided copper ground cables fitted with flared terminal barrels designed for strain relief.

Grounding wires to fixed equipment may be standard car wiring. Fixed equipment which is held by screws, bolts or metallic clamps may be considered to be grounded by its mounting hardware.

All ground connections shall utilize bolted terminals. All ground pads shall be through-drilled and the ground wire fastened with a bolt, flat washer and locknut. The flat washer shall bear on the ground wire terminal.

17.23.6 Wire Splicing

Wire splicing will not be permitted.
17.24 Conduit

17.24.1 General
All conduit shall be rigid aluminum alloy or galvanized rigid steel as described below. Flexible conduit, as described in Section 17.23.4, may be used where necessary. Use of flexible conduit shall be limited to short lengths necessary to accommodate connections to equipment, subject to DART’s review and approval.

All conduit ends shall be deburred inside and out to remove sharp edges and all pieces shall be blown out with compressed air and cleaned before installation to remove filings and other foreign material.

Conduit shall be sized such that the sum of the cross-sectional areas of the conductors and their insulation does not exceed 40% of the cross-sectional area of the conduit for three or more conductors. For two conductors, a limit of 31% shall be used, while for a single conductor, a limit of 53% will be permitted. Where conduit nipples having a length not exceeding 24 inches (600 mm) without bends of more than 15 degrees are used between enclosures, a maximum fill of 60% will be permitted.

A run of conduit between junction boxes and/or pulling outlets shall not contain more than the equivalent of four quarter bends, 360 degrees total, including the outlet fittings. Bend radii at the inner edge of the bend shall be no less than eight times the nominal inside diameter of the conduit.

All conduit bends and offsets used shall be made by the use of special forms or tools and shall have the largest radius possible so that wires can be pulled without the use of tackle or power equipment.

Conduit shall be securely clamped with all runs electrically grounded to make a continuous ground. Electrical continuity of joints shall be provided by the use of conductive joint compound.

All conduit shall be arranged to prevent moisture traps and shall drain toward control boxes.

Conduit fittings which mate with wire ducts, enclosures or junction boxes shall be fitted with resilient seals.

17.24.2 Aluminum Conduit
Rigid aluminum conduit shall be seamless, rigid, aluminum alloy conforming to ANSI C-80.5 and to the requirements of Standard UL-6. The threads per inch and length shall conform to ANSI Standard B 2.1 (B1.20.0) on Pipe Threads. All threads shall be covered with an oxidation-inhibiting compound.

Aluminum fittings shall be used to assemble aluminum conduit. Elbows, nipples and couplings shall be made of the same grade of aluminum and alloy as that employed in the straight length of conduit. All fittings shall be treated, coated, and threaded according to the requirements for rigid aluminum alloy conduit and shall conform to Underwriters Laboratory Standard UL-6.

17.24.3 Steel Conduit
Steel conduit shall be mild steel in standard lengths with threaded ends and hot-dipped zinc-coated exterior and interior surfaces. It shall be free of burrs and projections, circular in cross-section, of uniform wall thickness and shall conform to the requirements of ANSI Standard C-80.1. The threads per inch and length shall conform to ANSI Standard B 2.1 (B1.20.0) on Pipe Threads.

Steel fittings shall be used to assemble steel conduit. Elbows, nipples and couplings shall be made of the same grade of steel as that employed in the straight length of conduit. All fittings shall be treated, coated, and threaded according to the requirements for zinc-coated, rigid steel conduit and shall conform to Underwriters Laboratory Standard UL-6.

17.24.4 Flexible Conduit

Flexible conduit shall have a waterproof, abrasion resistant covering over a plated flexible steel liner. The flexible covering shall not contain polyurethane or PVC. Liquid-tight flexible nonmetallic conduit may be used for special applications with DART approval, but not in locations subject to physical damage during operations. (CDRL 17-29)

Fittings for flexible conduit shall be as supplied or recommended by the flexible conduit manufacturer.

17.25 Wire Ducts

Wire ducts shall be fabricated from galvanized mild steel or stainless steel unless otherwise approved by DART.

Steel ducts and covers shall be galvanized after all welding, cutting and drilling operations. The inside steel shall be primed and painted with white paint. Exteriors and covers shall be painted according to the color scheme. Seals shall not be painted.

Wire ducts shall incorporate wire support hardware sufficient to support wiring every 18 in (0.5 m) or less, and if required, rigid barriers for circuit separation.

Undercar, roof, and other exterior wire ducts shall have waterproof covers with resilient seals. The seals shall retain their resilience and watertightness for no less than 10 years. The covers shall be stiffened such that the seals are compressed evenly over the seal length when fastened. Undercar duct covers shall be on the bottom of the duct.

Interior wire duct covers need not be sealed.

All wire ducts shall be located such that it will be possible to remove covers and reach the wiring within.

The sum of the cross-sectional areas of all conductors contained at any cross-section of a wire duct shall not exceed 50% of the interior cross-sectional area of the wire duct.

17.26 Junction Boxes

Junction boxes are defined as enclosures used only for the termination of wiring and do not contain electrical equipment.

All exterior and interior junction boxes shall be constructed to NEMA 250 Type 4 and Type 12 standards respectively and as described below. Where conflicts exist, this document shall prevail.
All junction boxes and covers shall be fabricated of HSLA or galvanized mild steel with a minimum wall thickness of 14 gauge. All cover hardware shall be stainless steel.

Junction box walls and covers of large boxes shall be stiffened with the stiffeners welded in place. Stiffening criteria shall conform to high quality commercial practice and shall be submitted for approval.

The interior of all junction boxes and covers shall be primed and painted with white paint. Exteriors shall be painted according to the color scheme. Seals and cover hardware shall not be painted.

Junction box cover openings shall have a NEMA-type formed lip which provides a bearing surface for the cover seal. The portion of the lip bearing on the seal shall be flat and no less than 0.125 inches (3 mm) wide.

The cover shall have folded edges that overlap the box opening lip by at least 0.375 inches (10 mm) with the cover fully secured. The folded edges shall be completely welded at the corners. The cover edge may also serve as the clamp bearing surface.

Seals shall be attached and retained in a channel near the perimeter of the cover. Seals shall be closed cell neoprene foam at least 10 mm thick and shall remain resilient and watertight for at least 10 years. The seal shall be compressed no more than 50% with the cover securely fastened. The sealing system shall pass the water test in Section 15.

Junction box covers shall be fastened by stainless steel NEMA-type clamps welded to the box structure. Clamp fasteners shall be hex or Phillips head captive screws. Clamp location and cover stiffness shall insure even compression of the seal. Clamp fasteners shall be sized to go solid when tightened and shall not rely on seal resilience for tightness. The edge of the cover shall not bear on the enclosure before the clamp goes solid.

Covers shall be fitted with retaining devices that prevent the cover from falling when unfastened and shall also permit the cover to swing fully open. On boxes larger than 12 inches (300 mm) in any dimension, the retaining devices shall permit the cover to be removed without tools. Chains or cables will not be permitted. Covers that open upward shall incorporate a holding device.

Junction boxes larger than 12 inches (300 mm) in any dimension shall have depressed bottoms such that water accumulates in the center. The central point shall have a 0.25 inch (6 mm) drainage hole fitted with a 0.125 inch (3 mm) cotter pin with the tangs facing into the box. Alternative drainage schemes may be proposed.

Terminal boards or other equipment shall not mount directly to the enclosure. All equipment shall mount to rails, brackets or standoffs fastened to the enclosure. No equipment shall be mounted to the enclosure bottom or within 1 inch (25 mm) of the bottom.

17.27 Electrical and Electronic Designs

17.27.1 Electronic Design Standards

All electronic control equipment shall comply with the requirements of IEC 60571 “Electronic Equipment Used on Rail Vehicles, Class TX”, IEC 61287-1 “Power Converters installed on board rolling stock”, or IEEE Standard 16 “IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles”, latest revision.
17.27.2 Vehicle Control Logic

The control logic units shall be microprocessor-based with associated peripherals and I/O, as required, to meet all of the specified functions and performance criteria. All I/O signals shall have galvanic isolation. The control units shall provide self-diagnostic routines, fault monitoring of internal and external devices, interfacing to the MDS system described in Section 9.8, and user programmable operating characteristics. Control programs shall be stored in field-programmable, non-volatile memory.

Electronic control equipment shall be both physically and electrically segregated from power equipment. Control circuitry and control voltage sources shall be isolated from power circuitry and high voltage sources by using opto-couplers, relays, or transformers.

All circuit boards shall be labeled with a part number and descriptive nomenclature. All components of circuit boards shall be labeled on the board.

All components shall be mounted on circuit boards in such a manner as to withstand repeated shock and vibration. Large components shall be supported in addition to the solder connections. Power resistors shall be mounted on stand-offs so that the resistor bodies do not contact the board.

Both sides of assembled printed circuit boards shall be coated with a clear insulating and protective coating material conforming to IPC-CC-830, Class 2 or better, except that all coatings shall include fluorescent indicators.

The control system shall be powered by dedicated, transformer isolated, power supplies powered from the vehicle battery circuit.

The control unit shall provide continuous monitoring of critical parameters, including motor currents, switching device currents, transmission conditions, cooling air flow and component temperatures. The control unit and all related software and devices shall be sufficiently responsive to detect and remedy all erroneous or potentially damaging conditions such that equipment damage is prevented or minimized.

17.27.3 Control System Documentation

The Contractor shall prepare the following documentation for each subsystem control logic. The documentation will be specific to the streetcar supplied under this Contract. All fixed parameters such as target levels, limits for variables, settings for protection devices shall be specified. All variables used within control routines or passed between routines shall be specified. The documentation shall provide for both a complete understanding of the system on an engineering level and a complete guide for finding and isolating problems experienced in the operation of the streetcars.

A System Functional Description (SFD) for each subsystem presenting an overview of the design, both software and hardware shall be prepared. The SFD shall include external interfaces, descriptions of the processors in the subsystem, the functions impacted by software control, and the internal interfaces within the subsystem. The SFD shall also include the interfaces with and operation of hardware within the system. External interfaces shall be identified with the type of signal and allowable range of input values including a translation to real engineering units such as lbf (N) if appropriate. All components identified in the SFD shall be classified as hardware or software and included in the hardware and software design descriptions below.
A hardware design description (HDD) shall be submitted for all hardware within the subsystem. The hardware shall include the platform on which any software is operating and other all electronic and electrical devices regardless of whether they are interfaced to software control. The HDD shall include control system circuit drawings and diagrams, component descriptions and manufacturer’s part numbers, protection requirements, and functional descriptions describing the application of each component.

A software design description (SDD) shall be submitted in accordance with ANSI/IEEE Standard 1016. The SDD shall include the purpose of each software module, a functional description of each software module, a listing of all software variables and fixed values utilized, interactions with other software modules, and an input/output table showing all interface details to system and vehicle hardware. The SDD shall include identification of all entities identified as user adjustable. Interface descriptions and definitions to the MDS system shall be included.

17.28 Electrical Devices and Hardware

All electrical devices shall be rail industry proven.

17.28.1 Contactors and Relays

All contactors and relays shall have a documented successful history of operation in rail transit control applications.

The coils of all devices shall be suppressed except where performance may be affected. Unsuppressed coils are permitted only with the explicit approval of DART.

Contact current ratings shall be based on continuous, inrush, or interrupting requirements, whichever is worse, and then derated by at least a factor of four. Contact materials shall be selected for the actual loads, and not solely on the device rating. Silver bifurcated contacts and gold alloy bifurcated cross bar contacts shall be used on low level and dry circuits, respectively.

Contacts connected in series shall not be operated in circuits where the voltages and currents exceed the single derated contact ratings. Contacts shall not be connected in parallel.

Contact ratings shall be for the worst condition of reduced surface contact which may result from tip misalignment during normal operation of the device.

All contactors shall be built with series fed arc blowout coils.

All time delay relays shall be of the R-C or solid state type. Mechanical or pneumatic time delay devices are not permitted.

All relays and contactors shall be identified with the appropriate circuit designation. The label shall not be obscured by wiring or other equipment and shall not be mounted on relay covers, arc chutes, or other removable items.

Plug-in relays shall be provided with a retainer that is captive to the relay socket. The retainer shall be arranged such that, when released, contact cannot be made with energized adjacent circuitry.
All contactors shall have a guaranteed mechanical service life of at least 5 million switching operations, except as approved where infrequent operation is expected.

All relays shall have a guaranteed mechanical service life of at least 10 million switching operations. Contact rated electrical life shall be no less that 500,000 operations, or 10 years, whichever is greater.

There shall be a maximum of two wire terminations on any relay or contactor terminal.

All relays and contactors shall be mounted and oriented as recommended by the supplier.

17.28.2 Switches

All switches shall be oiltight, industrial grade switches suitable for NEMA type 4 and type 13 applications for exterior and interior uses respectively.

Contacts shall not be operated at voltages or currents in excess of the manufacturer's recommendations. Contact current ratings shall be derated by at least a factor of four for all applications. Contacts connected in series shall not be operated in circuits where the voltages and currents exceed the single derated contact ratings. Contacts shall not be connected in parallel.

Switches shall not directly control highly inductive or high inrush loads. Switch contacts shall be silver, double break. All switch mechanisms shall provide a wiping motion when contacts make or break.

All switch bodies shall be keyed to prevent rotation. All mounting hardware, including the body portion extending through the panel, shall be metal.

There shall be a maximum of two wires connected to each switch terminal.

In addition to the above requirements, all switches and pushbuttons shall meet the following requirements:

- Contact resistance shall be less than 0.1 ohm at 3 Vdc and a 10 milliamp load
- Open circuit resistance shall be 50 megohms minimum
- Resistance to case shall be 1000 megohms minimum at 500 Vdc

17.28.3 Circuit Breakers

All circuit breakers of the same rating shall be of the same manufacture and model throughout the vehicle. Design and selection of all circuit breakers shall be subject to review and approval (CDRL 17–30).

The ON and OFF positions of all circuit breakers shall be permanently marked on the handle or the case of the circuit breaker. The circuit breaker, when tripped, shall assume a distinct position between the ON and OFF positions to permit determination of the fact that it has been tripped by either its overcurrent or shunt trip elements. All circuit breakers shall be mounted in the vertical direction with the ON position up.

Circuit breakers shall be individually replaceable without disconnecting or removing anything other than the mounting fasteners and electrical connections of the breaker to be replaced.
Electrical connections to circuit breakers shall either be threaded to accept machine screws or use a threaded stud. Wires to circuit breakers shall use ring terminals.

Circuit breaker terminals shall not be used as junction points.

Each and every input power circuit shall be protected by an individual circuit breaker. Separate circuit breakers shall be provided for major assemblies or functions. No circuit breaker shall protect more than one circuit, nor shall any one circuit be protected by more than one circuit breaker.

All circuit breakers shall be sized by current rating and tripping time to protect both the associated equipment and the smallest wire size used in the circuit. All circuit breakers shall be sized to interrupt the maximum circuit fault current and shall be guaranteed by the manufacturer to successfully interrupt those, and all lower, currents.

The continuous current rating of thermal-magnetic trip circuit breakers shall be selected in accordance with ANSI C37.16 for the load and type of service specified. Circuit breaker current rating shall be clearly and permanently marked.

All thermal-magnetic trip circuit breakers shall conform to the requirements of ANSI C37.13 and ANSI C37.14.

Circuit breaker current rating shall be clearly and permanently marked and shall be completely visible after installation.

17.28.4 High Speed Circuit Breaker
See Section 9 for high-speed circuit breaker requirements.

17.28.5 Fuses
Fuses are not permitted except where specified or approved.

17.28.6 Bus Bars
Bus bars shall be fabricated from OFE (Oxygen Free Electronic CDA C10100) or ETP (Electrolytic Tough Pitch CDA C11000) copper. The bus bar conductivity shall be 100% IACS. All bus bars shall be silver or tin plated.

Current densities, other than at joints, shall not exceed 1750 A/in² (2.71A/mm²), and in any case shall not exceed a value which would cause a bus bar temperature rise greater than 86°F (30°C). Current densities in joints shall not exceed 650 A/in² (1 A/mm²).

Bus bars shall be properly brazed together at joints unless bolted connections are found to be absolutely necessary for maintenance purposes and are approved. The overlap at bus bar joints shall be no less than 10 times the thickness of the bus material. Bus bar connection bolts shall be torqued to obtain a uniform bus bar connection pressure of 200 psi. Bolting hardware shall be plated steel with Belleville washers to maintain connection pressure.

17.28.7 Capacitors and Resistors
Hermetically sealed, dry tantalum capacitors in metal cases shall be used in place of aluminum electrolytic capacitors, except for very high values which are not commercially practical or available; in which case, long life grade aluminum electrolytic capacitors (for
circuits with nominal voltages 100 V), oil, or gas impregnated metalized polypropylene capacitors shall be used. Long life grade aluminum electrolytic capacitors may be used in the circuits with nominal voltage levels about 100 V only with Sound Transit approval.

Commutating capacitors shall be a paper or plastic film type and incorporate a non-toxic impregnant, and shall be chosen to give a service life of at least 30 years. Filter capacitors shall have high ripple current rating for long life.

Capacitors shall be derated 20% for voltage based on the nominal supply voltage and maximum case temperature. If filter capacitors are exposed to low ripple voltages, lesser values of derating may be accepted if it can be shown that reduced operating temperatures can be achieved due to lower dissipation; however, the sum of the dc and ac ripple voltages shall always be less than the capacitor's voltage rating at a maximum case temperature of 185°F (85°C).

Except for braking and motoring resistors, all resistors shall be derated 50% for power dissipation.

17.28.8 Transformers and Inductors
Transformers and inductors shall be derated 10% for current. Transformers shall:

- Have vacuum-pressure impregnated (VPI) windings
- Be rated to withstand at least twice the maximum peak-to-peak voltage that they shall be subjected to in operation
- Not emit audible noise in excess of 60 dB referenced to 20 micropascals at a distance of 2 ft (0.6 m) while operating at rated voltage and load. (This applies only to units located within the vehicle interior.)
- Be designed to minimize radiated and induced EMI
- The location, orientation, mounting, cable connections and cable routing shall be in accordance to the overall EMI/EMC control plan for the vehicle

17.28.9 Switch, Circuit Breaker, and Fuse Panels
Each switch, breaker, fuse, and indicating light shall be provided with a nameplate of raised or recessed lettering on the dead front, clearly identifying the circuit to which each applies, its circuit designation, operating voltage and instructions such as “Do Not Operate Under Load” as appropriate. The dead front panel shall conform to NFPA 70, Article 384. The dead fronts shall be made of moisture-proof, electrically insulating, laminated phenolic. Asbestos shall not be used.

Power distribution to circuit breakers and switches shall be from a bus bar or bus circuit. Distributing power by successive or daisy-chained connections between device terminals is not permitted.

17.29 Contract Deliverables
The following submittals are required:

17-1 Substitution for a cited standard (Section 17.1.2)
17-1 List of recommended cleaning agents (Section 17.1.4)
17-2 Commercial material specifications (Section 17.1.6)
17-3 Single-source material (Section 17.1.6)
17-4 Material safety data sheets (Section 17.1.6)
17-5 Safety-related fastener test data (Section 17.2.2.3)
17-6 Ferritic stainless steel test and inspection plan (Section 17.3.4)
17-7 Structural steel test and inspection plan (Section 17.4.2)
17-8 Structural casting qualification test reports (Section 17.5.2)
17-9 Structural castings test and inspection reports (Section 17.5.3)
17-10 Radiographic inspection sampling frequency (Section 17.5.3.2)
17-11 Aluminum used in structural applications test reports (Section 17.6)
17-12 Paint color samples and tri-stimulus values (Section 17.13.1)
17-13 Truck paint selection (Section 17.13.10)
17-14 Paint Process Documentation (Section 17.13.12)
17-15 Fire, smoke and toxicity test reports (Section 17.14.1)
17-16 Waiver for testing certain materials (Section 17.14.1)
17-17 Floor assembly fire test procedure (Section 17.14.3)
17-18 Floor assembly fire test report (Section 17.14.3)
17-19 Roof assembly fire test procedure (Section 17.4.4)
17-20 Roof assembly fire test report (Section 17.4.4)
17-21 Materials toxicity test reports (Section 17.14)
17-22 Phenolic composite floor panel test reports (Section 17.15.7)
17-23 Wire and cable report. (Section 17.21)
17-24 Vehicle wire marking system (Section 17.22.8)
17-25 Terminal boards design data (Section 17.23.1)
17-26 Wire terminal product line and tooling (Section 17.23.2)
17-27 Connector design report (Section 17.23.4.1)
17-28 Flexible conduit applications (Section 17.24.4)
17-29 Circuit breaker design report (Section 17.28.3)
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SYSTEM SUPPORT

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SECTION 18
SYSTEM SUPPORT

18.1 Manuals and Catalogs

18.1.1 Types and Quantities

The Contractor shall furnish manuals for use by vehicle operators and maintenance personnel in accordance with the requirements of this Specification. Printed manuals to be supplied as part of this Contract are as follows:

- Operator's Instruction and Troubleshooting Manual: 20 copies
- Maintenance, Servicing, and Heavy Repair Manuals: 5 copies
- Parts Catalogs: 3 copies
- Maintenance Training Manuals: 5 copies
- Operator Training Manuals: 5 copies
- Special Test Equipment Manuals: 2 copies

Delivery of two sets of first drafts and final copies of the manuals and catalogs shall occur in accordance with the following schedule:

<table>
<thead>
<tr>
<th>Manual Type</th>
<th>Delivery of First Draft no later than:</th>
<th>Delivery of Final no later than:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator's Instruction and Troubleshooting Manual</td>
<td>6 months after NTP</td>
<td>2 months before delivery of 1st car</td>
</tr>
<tr>
<td>Maintenance and Servicing Manuals</td>
<td>6 months after NTP</td>
<td>2 months before delivery of 1st car</td>
</tr>
<tr>
<td>Heavy Repair Manual</td>
<td>6 months after NTP</td>
<td>2 months before delivery of 1st car</td>
</tr>
<tr>
<td>Parts Catalog</td>
<td>6 months after NTP</td>
<td>2 months before delivery of 1st car</td>
</tr>
<tr>
<td>Training Manuals</td>
<td>2 months before start of training</td>
<td>1st Training Session</td>
</tr>
<tr>
<td>Special Test Equipment Manuals</td>
<td>6 months after NTP</td>
<td>2 months before delivery of 1st car</td>
</tr>
<tr>
<td>Integrated Schematic Diagrams</td>
<td>6 months after NTP</td>
<td>2 months before delivery of 1st car</td>
</tr>
</tbody>
</table>
18.1.2 Operator’s Instruction and Troubleshooting Manual

The Operator’s Instruction and Troubleshooting Manual shall contain all information needed for the optimum operation of the vehicle. (CDRL 18-1) It shall include general vehicle familiarization material, such as:

- Safety instructions
- Location, function and operation of controls, gauges, indicators and switches
- Discussion of the trucks, tow bars, lights, HVAC control, propulsion, brakes, and other features of the vehicle which the operator may not be in a position to control or adjust, but of which the operator should have some basic knowledge
- Monitoring and diagnostic system messages
- Emergency procedures
- Trouble symptoms and diagnosis methods
- Operator corrective action

The manual shall be logically organized with systems and elements considered in descending order of importance. Care shall be taken that all statements are clear, positive and accurate, with no possibility of incorrect implications or inferences.

18.1.3 Maintenance and Servicing Manual

The Maintenance and Servicing Manual shall enable the maintenance staff to have all information needed for preventive maintenance inspections, on-vehicle running maintenance and adjustment, and in-service trouble diagnosis of each system, including such data as troubleshooting guides, equipment specifications and schematics. (CDRL 18-2)

The information will include the intervals of preventive and required maintenance. The preventive and required maintenance will be listed on a chart that will define the intervals and type of maintenance for the first ten year period of the vehicle. The manual will include the forms required for each type of inspection or required maintenance to include tasks to be performed and required parts to be used in the inspection or task.

An integrated set of schematics for all electrical and hydraulic systems and interfaces on the vehicle shall be supplied as a separate section. (See Section 18.1.7) Schematics shall clearly show references to higher and lower levels of detail.

The Maintenance and Servicing Manual shall also contain a detailed analysis of each component of the vehicle so that the maintenance staff can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace, and overhaul same.

18.1.4 Parts Catalog

The Parts Catalog shall enumerate and describe every component with its related parts for the vehicles, including the supplier’s number and the commercial equivalents. (CDRL 18-3)

Drawings showing subassemblies and components shall be used to permit identification of all parts down to the Lowest Level Replaceable Unit (LLRU). The LLRU is defined as the lowest level of component assembly which consists of a separate individually fabricated part. Parts common to different components, such as, for example, bolts and nuts, shall bear the same Contractor’s number in all components with a reference to the other components in which they are found. Commercially available items such as common
fastenings, fuses, lamps, fittings, bearings, and relays shall be identified by standard hardware nomenclature adequate to be able to purchase these items through commercial channels, in addition to the Contractor's number.

An important aspect of the parts catalog shall be the complete itemization of all consumable parts and servicing materials (oils, paints, special compounds, greases, etc.) required on the cars and the component requiring their use. In addition to the normal cross referencing noted above, at least three supply sources shall be provided for all required consumables and servicing materials. Suppliers and materials shall be specified by trade name and type. Of the three required sources, at least two shall be located in the United States. Any consumable for which three suppliers are not listed shall be justified separately by the Contractor and subject to DART’s approval, and specifications suitable for the manufacture of the item shall be provided. The justification for use shall be submitted prior to the use of the material on the first vehicle.

DART shall have the right to secure bids and manufacture, for its exclusive internal use, any item which is not available from the original manufacturer or contractor within 120 days of request, or when new purchase price exceeds original procurement price by an amount exceeding normal inflationary cost for the corresponding type of product.

18.1.5 Training Manuals

Training Manuals shall contain sufficient material to aid the Contractor in performing the requirements of Section 18.3. (CDRL 18-4)

Training Manuals shall be separate and distinct from the operations and maintenance manuals described above. They shall contain a step-by-step introduction to each systems function and operation. Separate Training Manuals shall be provided for maintenance personnel and for operators.

18.1.6 Special Tools and Test Equipment Manuals

Operations and Maintenance Manuals for each special device identified in Section 18.2 shall include setup and testing procedures for each test device. It shall also include, in a separate section, all information needed for periodic inspection and servicing requirements of the test equipment, including lubrication, inspection and adjustment of all apparatus. (CDRL 18-5)

18.1.7 Integrated Schematic Diagrams for Troubleshooting

The Contractor shall prepare, and submit for approval, Integrated Schematic Diagrams detailing all electrical, electronic, pneumatic and/or hydraulic systems in schematic fashion, including all components, wiring, and piping on the cars. (CDRL 18-6)

The Integrated Schematics shall be comprehensive and thoroughly detailed.

At a minimum, the following information shall be on the schematics:

- Zone gradations around the perimeter of each sheet for location references.
- All components shall be shown with alpha-numeric designations for all components, including supporting hardware such as connectors and pins, terminals, and similar. The designations shall be logical and clearly distinguish between different components types, such as CBxxx for circuit breakers.
- Values for components such as resistor resistances and power ratings, capacitance, circuit breaker and fuse ratings, etc.
• All relays, contactors, connectors, etc., with multiple contacts or connections shall show all contacts or connections, even if unused.

• All circuit wiring shall have numerical designations, with logical groupings for power sources, return circuits, etc.

• A complete set of device tables for all components on the schematics, including the component designation, device description, relevant data and ratings, part number as it appears in the parts manual, etc.

• Wire sizes and circuit voltages, piping sizes and system pressures, etc. Wiring for circuits differing by more than 50 volts shall have unique color codes or drawing styles. Serial data circuits shall be identified according to type (10Mb Ethernet, for example).

• Piping, hydraulic, and pneumatics diagrams shall use industry standard device symbols and nomenclature, such as defined by ANSI or similar organizations.

The schematics shall be submitted in an electronic format that is readable on a PTU screen and is formatted to print on 11 inch x 17 inch paper. Pages shall be numbered numerically and consecutively.

Diagrams will reflect DART's vehicle as built, and include all circuits on the vehicle.

18.1.8 Format and Content

The organization of the manuals shall treat the vehicle as an integrated system and not as a grouping of disassociated parts. The manuals shall highlight the precautions to be taken by operating and service personnel to assure their safety while operating vehicles and performing maintenance and servicing operations.

Following the issue of each publication, the Contractor shall provide revised pages covering any changes, whether required by change of design or procedures or due to error, and these revisions shall be kept current (revised every 6 months or less) during the warranty period.

All publications shall be in a robust, hardened loose-leaf notebook with tear-resistant, reinforced pages. They shall be in five general categories and sized as follows:

• Operator's Instruction and Troubleshooting Manual: Pocket Sized
• Maintenance Manual: Standard Sized
• Parts Catalog: Standard Sized
• Training Manuals: Standard Sized
• Integrated Schematic Diagrams: 11" x 17"

(Note: "Pocket Sized" is 5" x 7"; "Standard Sized" is 8 1/2" x 11")

The Contractor shall supply master reproducible copies of all documents. The quality of the master shall be such that duplicates may be made of the same quality as the original, approved submittals.

All maintenance manuals, parts manuals, wiring schematics-diagrams, and component physical layouts shall be Dallas streetcar specific and accurately represent the completed as built vehicle.

All user education documents shall be in English.
18.1.9 Electronic Copies
All manuals and the parts catalog, including drawings, shall be delivered in editable electronic media versions on CD-ROM. (CDRL 18-7) Electronic media versions shall be PC compatible files, using a software format approved by DART. The Contractor must decide what format will be used and submit the choice for approval by DART within 20 months after NTP. (CDRL 18-8) The electronic media versions shall be revised in accordance with the hardcopy manual revisions.

18.2 Tools and Test Equipment

18.2.1 General
The Contractor shall provide all equipment specified in this Section for comprehensive in-service maintenance and testing of vehicles. All of the tools and test equipment shall be delivered at the same time as the final copies of manuals identified in Section 18.1.

If a system can be fully tested using a standard laptop computer, a separate portable test unit (PTU) for the specific system need not be provided.

Three hardened laptops for use as PTUs for on-board diagnostics shall be supplied loaded with all necessary software installed. The laptop software shall not be copy-protected, shall not require external validating devices such as “dongles”, and shall be freely copied by DART onto City-owned computers. Three sets of all necessary cables, connectors, and associated equipment to interface with each system must be included.

The following is a minimum list of PTUs required for the vehicle:

- Propulsion system
- Friction brake system
- Auxiliary power supply
- Low voltage power supply
- Battery charger
- HVAC system
- Door control system
- Communications system
- Automatic passenger counting system

18.2.2 Gauges and Special Tools
All special tools necessary to perform required maintenance, as defined in the Contractor's maintenance manuals, shall be supplied by the Contractor. Special tools include, but are not limited to, all jigs, fixtures, equipment, hand tools, power tools, or other tools and equipment necessary to maintain, repair, overhaul, assemble, and disassemble the vehicle or subsystems, that are not commonly available from commercial tool suppliers.

All gauges or special tools, other than the PTUs, that are required to maintain and overhaul the vehicle shall be supplied along with complete manuals explaining the use of the gauge or tool and its care and maintenance. Drawings showing all dimensions and materials and part lists must also be supplied.
All special tools and maintenance equipment shall be provided as two complete sets. The Contractor shall also provide part numbers and prices for all special tools and maintenance equipment to enable DART to purchase additional quantities.

18.2.3 Rerailing Equipment

The Contractor shall provide a set of Railquip or approved equal rerailing equipment to DART. (CDRL 18-9) It shall be suitable for lifting, shifting sideways, and rerailing a vehicle with any combination of wheels off the track. The equipment shall be suitable for use in both open and paved track, in open areas and in confined spaces such as against station platforms. The equipment shall include as a minimum:

- Aluminum alloy lifting jacks
- Lateral move equipment
- Gasoline powered hydraulic pump unit
- Hand pump
- Control desk
- Color coded hydraulic hose lines

The Contractor shall demonstrate the proper operation of the equipment by derailing each truck on a vehicle by lifting it off the track, and then by rerailing the vehicle.

18.2.4 Jack Socket Adapters

The Contractor shall supply two complete sets of Jack Socket Adapters (4 or 6 jack socket adapters per side, as required by the vehicle design) to DART. The jack socket adapters shall be coordinated with DART to interface to the portable jacks in DART’s maintenance facility. (CDRL 18-10)

18.3 User Education

18.3.1 General

The Contractor shall provide a draft training plan for proper operation and utilization of the systems and vehicles supplied. The final training plan will be required with the final training manuals. (CDRL 18-11)

User education shall consist of the two major categories listed below:

- Operator education (basic vehicle operation including how to detect and resolve in-service problems and emergencies)
- Maintenance education (including preventive, corrective, and overhaul of components and/or assemblies)

The program shall be conducted at DART’s facilities, and include classroom and hands-on instruction for a selected group of Instructors, Supervisors, Mechanics, Technicians, and Train Operators. The Contractor shall provide an adequate supply of high quality, professionally prepared material on paper, and such other training aids as required to impart the essential knowledge to the personnel involved, and provide them with accurate and up-to-date reference materials.
Manuals and other training materials to be used by the Contractor during training shall be delivered to DART two months before training is conducted. The manuals shall be complete, and of professional quality.

All training materials, such as training aids and lesson plans, shall become the property of DART at the completion of the training program.

All maintenance and operations courses shall include a combination of classroom and hands-on instruction. Written and practical tests shall be designed and given at suitable points in each course to determine the extent to which students have retained the course material and can apply the information.

DART reserves the right to video tape any or all training activities.

The Contractor shall work closely with DART’s staff as training materials are being developed to ensure DART’s standards are being met with respect to the course organization, content, and overall quality of training materials.

18.3.2 Operator Education

Within ten days of the delivery of the first vehicle, the Contractor shall train one group of 10 operators. This group shall come from the core team of operators for the vehicle test program. A vehicle shall be supplied by the Contractor for this purpose and shall have all applicable systems properly operating. Ultimately, the Contractor shall train an additional 15 operators.

The Contractor shall supply two sets of DVDs which address preparing a train for service, operating a train under normal conditions, and emergency procedures for moving a train under fault conditions. The DVDs shall be supplied at least 30 days prior to the delivery of the first car. (CDRL 18-12)

18.3.3 Maintenance Education

City employees shall be exposed to that depth of detail necessary for the performance of preventive, corrective, and overhaul maintenance operations for all systems and sub-systems supplied under this Specification. Students shall be afforded the opportunity to perform the more complex maintenance functions on the vehicle and in the shop, in addition to troubleshooting systems with faults artificially introduced in the equipment while using the appropriate subsystem test devices to locate and remedy these faults.

Classroom instruction for maintenance courses shall include not only the details and functioning of parts under discussion, but the essentials of their routine care, including lubrication schedules, materials, contractor’s recommendations for test frequency, tolerance limits, and methods for testing, including instruments required, as applicable. When methods of access, removal, dismantling, or application are not self-evident, the instruction shall cover these matters.

Training will utilize diagnostic tools specified by equipment manufacturer.

Field instruction for maintenance courses shall include both on-vehicle demonstrations and demonstrations of basic overhaul procedures using equipment in DART’s maintenance facility.

Prior to the delivery of the first vehicle, the Contractor shall have completed instruction for one group of up to 10 persons. Subsequent to the delivery of the first car, the Contractor shall supply maintenance training to an additional 15 technicians.
Instruction shall include, as a minimum, the following:

- Introduction to the equipment, including terminology, identification of major components and their location on the car
- Detailed theory of operation
- Routine care, including lubrication schedules, adjustments, limits, inspection criteria
- Problem symptoms, troubleshooting techniques, and repair procedures
- Removal and replacement of parts and components from the streetcar
- Disassembly and reassembly for the purpose of component familiarity and any special processes
- Instruction in the use of all special tools and processes

Maintenance training shall, at a minimum, include in-depth instruction addressing the following subjects:

- Air conditioning and heating systems, including their controls
- Auxiliary power supply system, including battery
- Braking system, including all controls
- Communications system
- Lighting controls
- Propulsion system, including traction motors and controls
- Trucks, including bearings, bearing surfaces, gear units, frame, suspensions, and shock absorbers
- Door operators and controls
- Removal, replacement, and adjustment of carbody materials and equipment, such as glazing, seats, doors, windshield wipers, heaters, circuit breakers and switches, light fixtures, underfloor equipment, and trucks

At least one complete set of all special tools and all test equipment (jigs, fixture, meters, gauges, vacuum pumps, temperature sensing devices, etc.) necessary to service, maintain, and overhaul each system shall have been delivered by the Contractor for use in the training program.

18.4 Replacement Parts

18.4.1 Recommended Spare Parts

In addition to the capital spare parts being purchased as part of the Contract, the Contractor shall furnish a list of recommended spare parts for use during the first two years of revenue service. (CDRL 18-13)

The Contractor shall supply the recommended spare parts list after design development is completed and within 18 months of NTP. The list of recommended spare parts shall be predicated on the Contractor and Subcontractor experience with the equipment in service on other properties and the maintenance requirements expected for DART. Consumption rate
data and data on lead time for procurement of replacement parts shall be made available to DART in support of these spare parts recommendations.

The recommended spare parts list shall include the parts description, part number, quantity recommended, the unit production prices, including Subcontractor markup for individual parts or carsets of equipment, and the extended price based on the recommended quantities.

A fixed unit price that is valid for one year after delivery of the recommended spare parts list to DART shall be provided for all parts. Beyond one year, part costs shall be escalated in accordance with Contractual Provision requirements.

18.4.2 Availability of Replacement Parts

The Contractor and its Subcontractors shall guarantee availability of parts or replacement parts with compatible functions for the vehicle and all systems for a period of 20 years from Contract award.

All consumable items, such as lamps, filters, lubricants, and similar shall be common components stocked in the U.S.

18.5 Technical Support Personnel

The Contractor shall furnish the services of at least one field service engineer at DART’s streetcar facilities, knowledgeable in each of the vehicle’s systems to the level of competent troubleshooting. The field service engineer shall be provided on a full time basis starting at least one month before arrival of the first car, and shall remain until two years after acceptance of the last car. All support personnel, including the field service engineer, shall be fluent in English.

Support personnel shall provide assistance during inspection, operation, testing and adjustment of the streetcar both before and after acceptance by DART. Support personnel shall provide assistance for additional training that may be required, both before and after acceptance by DART. Support personnel shall be available to work any of three 8-hour shifts, as may be required by DART.

The Contractor shall also insure that the expert services of equipment suppliers and designers are available, on short notice, during the same period to assist the on-site support personnel in the investigation and resolution of car and equipment malfunctions. If requested by DART, the Contractor shall provide specialized on-site technical assistance within 48 hours from receipt of request during the time period from delivery of the first car to final acceptance of the last car; and within 72 hours from receipt of a request for service during the warranty period.

18.6 CDRL

The following submittals are required:

18-1 Operator’s Instruction and Troubleshooting Manual (Section 18.1.2)
18-1 Maintenance and Servicing Manual (Section 18.1.3)
18-2 Parts Catalog (Section 18.1.4)
18-3 Training Manuals (Section 18.1.5)
18-4 Special Tools and Test Equipment Manuals (Section 18.1.6)
18-5 Integrated Schematic Diagrams for Troubleshooting (Section 18.1.7)
18-6 Electronic copies of manuals and catalogs (Section 18.1.9)
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<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-8</td>
<td>Rerailing equipment (Section 18.2.3)</td>
<td></td>
</tr>
<tr>
<td>18-9</td>
<td>Jack socket adapters (Section 18.2.4)</td>
<td></td>
</tr>
<tr>
<td>18-10</td>
<td>Training Plan (Section 18.3.1)</td>
<td></td>
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<tr>
<td>18-11</td>
<td>Operator training DVDs (Section 18.3.2)</td>
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</tr>
<tr>
<td>18-12</td>
<td>Recommended Spare Parts List (Section 18.4.1)</td>
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SECTION 19

PROGRAM CONTROL AND QUALITY ASSURANCE

19.1 General

The design and production of the streetcars shall be controlled by the Contractor to insure that a high-quality product suitable for long and trouble-free life is produced, and that the requirements of this specification are met.

DART may, at its option, monitor any or all Contractor activities and inspect or test any or all equipment. The Contractor shall not hinder or limit such activities.

All business is to be conducted in the English language, including all meetings, correspondence, and any other documents that are submitted to DART.

19.2 Management Plan

The Contractor shall confirm the project manager and vehicle integration engineer in its Proposal in a submittal within 10 days of NTP for DART's approval. The proposed project manager shall have an engineering degree and have at least 3 years of project management, construction and technical experience in the building of low floor rail vehicles. The proposed vehicle integration engineer shall have an engineering degree and at least 5 years of construction and technical experience in the building of low floor rail vehicles. (CDRL 19-1)

The Contractor shall submit a Management Plan within 30 days of NTP. (CDRL 19-2)

The plan shall include, but not be limited to:

- An organization chart for the Contractor's staff including primary personnel involved in this contract from senior executive positions to professional personnel such as system integration engineer, design engineers, manufacturing engineers, test engineers, and managers of material procurement, subcontractor administration, and quality assurance as a minimum. The organization chart shall also indicate management personnel responsibilities in relation to engineering, manufacturing, quality control, material procurement and other supporting functions.

- A management chart which clearly depicts the design, manufacturing, and testing responsibilities of the Contractor and each subcontractor or supplier for all systems and major components described in this Specification. The company name, affiliation, principal contact and position, and the location at which the work will be performed shall be included. This information shall be consistent with, and expand upon, the Contractor's Proposal and is considered a critical submittal in the initiation of the Contract. System integration responsibilities for all major interfaces shall be identified in the chart. This management chart, and any changes thereto, shall be as approved by DART during the course of the Contract.

- A progress schedule, with critical paths indicated, showing all major work tasks, including subcontractor contributions and all submittals, inspections, tests, and DART approvals as may be required by this Specification and the Contract
Deliverables Requirements List (see last bullet below). The progress schedule shall be updated at least every two months and resubmitted to DART. All updates shall retain the originally submitted schedule unless the schedule has been modified by change order. All schedules shall be current within two weeks of the time of receipt at DART.

- A Quality Assurance Plan which describes the methods, correspondence control, and communications to be employed to monitor, oversee, and control the progress schedule, technical performance, program changes, subcontracts, material procurement, in-service support, warranty, and tests (see Section 19.8.1).

- A Contract Deliverables Requirements List (CDRL) which shall contain a consolidated listing of all submittals and hardware required by this Specification such as data, test reports, material samples, and drawings. The CDRL shall be arranged as a vertical listing, and shall include an item number, submittal title, submittal description, and the section number of this Specification requiring the submittal, required submittal date, and the Contractor's projected submittal date. For each item it shall be indicated whether it must be reviewed and approved early in the program as a key conceptual design submittal, prior to the start of procurement, prior to the start of manufacturing, prior to first article inspection, prior to the start of vehicle testing, prior to the delivery of the first unit, may be deferred to some point after delivery of the first unit or as an as-built submittal, or for information only.

19.3 Interface with Subcontractors, Suppliers and Wayside Construction Contractors

19.3.1 Interface with Subcontractors, Designers, and Suppliers

The Contractor shall ensure that all designers, suppliers, and subcontractors are informed of all specified requirements and that appropriate engineering management tools are utilized to coordinate and provide communication between the designers of interrelated systems.

All applications of material, or equipment, by the Contractor shall be with the full concurrence of the suppliers that the application is suitable and within the recommended limits of operation of the material, or equipment.

The Contractor shall have all designers, subcontractors, and suppliers available when required for meetings, production problems, testing, resolution of design deficiencies, and all other similar situations. During all phases of this project, DART shall have access to all designers, subcontractors, and suppliers.

19.3.2 Interface with Wayside Construction Contractors

The Contractor shall coordinate and cooperate with the Dallas wayside construction contractors on administrative, civil, and systems interface issues. The Contractor shall provide the necessary documents and information to DART and the wayside construction contractors within the time limits specified elsewhere in this Specification. The Contractor shall provide the following vehicle information to DART and concurrently to the wayside construction contractors within 120 days of vehicle contract NTP:

- Actual dynamic and static envelope (preliminary) (CDRL 19-3)
- Jacking points and load distribution (CDRL 19-4)
• Accelerating and braking performance (CDRL 19-5)
• Pantograph mounting location, with wire tracking data and forces data (CDRL 19-6)
• Vehicle electrical load data for both propulsion and auxiliary systems, with vehicle at rest, accelerating, and at cruise speed (CDRL 19-7)

19.4 Meetings
Meetings shall be held between the Contractor and DART on a regular basis for the purpose of reviewing program progress and other program activities that cannot be readily resolved by correspondence. The Contractor shall insure that persons knowledgeable in the topics to be discussed, including subcontractors, are present at all meetings. Meetings shall be scheduled with a minimum of 10 working days advance notice. The meeting agenda and a data package covering all information to be addressed in the meeting shall be submitted at the time the meeting is scheduled. Meetings may be in person or by conference call, as determined by DART.

Meeting shall also include a Preliminary Design Review (PDR) and Final Design review (FDR) for each major system.

The Contractor shall prepare minutes of the meetings and submit to DART for review and approval by DART within ten days of the meeting. DART shall approve the minutes or request revisions within ten days of receipt of the minutes, otherwise the minutes shall be considered approved. (CDRL 19-8)

19.5 Monthly Progress Reports
The Contractor shall prepare a progress report each month for DART, starting with the first full month after award of contract. (CDRL 19-9) The report shall be submitted to DART no later than the 10th day of the following month (e.g., 10 July for the month of June) and shall be in a format, and with level of detail, as approved by DART. Monthly Progress Reports shall be based upon actual progress of the work and shall include as a minimum:

• A summary of work accomplished during the month, including actual completion dates, and start dates
• An updated CDRL Report
• An updated status of on-going or open engineering items
• Dates and locations of program review meetings
• An updated Change Order log
• Major work activities planned for the following month, including estimated remaining durations for activities in progress, and estimated start dates
• Status of correspondence
• An updated schedule, including changes in the expected durations of activities, and activities not previously included on the schedule

19.6 Design Approvals, Contractors Drawings, Documentation and Data Requirements

19.6.1 Review Procedures for Drawings, Documents and Data
The Contractor shall submit four copies of all documents, data, and assembly and installation drawings. Subassembly drawings shall also be submitted for information to facilitate the review of assembly and installation drawings. DART also reserves the right to request additional drawings to support the review of assembly and installation drawings.

When submitting drawings of structural parts or assemblies for the carbody structure, equipment supports, and trucks, the Contractor shall also submit stress analyses for these parts or assemblies in summary form.

Drawing submittals shall be coordinated with the CDRLs of specific sections of this Specification to enable a complete review of the system and its installation.

All drawings, documents, and data submitted by the Contractor shall be accompanied by a letter of transmittal listing drawing and document titles, numbers, and revisions. If more than one drawing or document is submitted at a time, the drawings and documents shall be listed in the transmittal in numerical sequence.

Drawings shall be submitted in an orderly and logical sequence to enable DART to readily determine and review the interface relationships between all major structural elements and their subassemblies and also between the structural elements and the attached apparatus, equipment, wiring, piping and hardware.

Except as provided below, DART will return submittals approved, conditionally approved, or disapproved within 30 calendar days after receipt by DART. DART will respond to the Contractor at an address designated by the Contractor. DART will not be obligated to review more than 50 drawings, or other mutually agreeable number, in a 30-day period. In the event that more than 50 drawings are submitted for review in a 30-day period, DART will review them in accordance with priorities as mutually agreed to between the Contractor and DART.

No extension of Contract time will be allowed for revision of Contractor's drawings or documents which have been either "disapproved" or "conditionally approved". Such drawings and documents shall be resubmitted and will be reviewed and returned to the Contractor within the same time intervals as would be allotted to the drawings and documents when initially submitted. Resubmitted drawings shall accrue toward the 50 drawings per month limit.

The Contractor shall maintain a record of Contractor and Subcontractor drawing and document status. This shall include drawing and document numbers, revision letter, drawing title, date submitted, transmittal document, disposition, and the document number identifying the disposition. This status report shall be updated and submitted to DART not less than monthly.

19.6.2 Requirements for Drawings, Documents and Data

All dimensions shall be expressed in the English system; all wording shall be in the English language. Where other dimensional systems are used, the equivalent English measurements shall be added, leaving the original intact and readable. All terminology used shall be conventional to the U.S. transit and railroad industries.

All drawings submitted by the Contractor shall be in a format approved by DART, and shall include a title block, drawing number, title, date, revision number, contract number, reference to next higher assembly, and signature of the Contractor's responsible engineer.

Contractor and Subcontractor drawings shall conform to the following standards:

34 x 44 in (size E) or 841 x 1189 mm (DIN A0)
A revision block shall be provided for all documents, drawings, and data. The revision block shall identify the revision letter, date of revision, the initials of the Contractor's responsible engineer authorizing the revision, a description of the change, and the reason for making the change.

The following ANSI standards for the preparation of drawings shall apply: Y1.1, Abbreviations for Use on Drawings; V32.2, Graphics Symbols for Electrical and Electronic Diagrams; and V32.14, Graphic Symbols for Logic Diagrams. The requirements for ANSI standard graphic symbols and abbreviations may be waived by DART provided a system of standard abbreviations and symbols for all drawings submitted is used, and the Contractor provides DART with five copies of a bound booklet showing all abbreviations and graphic symbols used on drawings.

19.6.3 Integrated Vehicle Schematics and Wire Lists

Totally integrated vehicle schematics relating to all electrical, hydraulic, and pneumatic systems shall include component identification, component values, waveforms, voltages, currents, resistance values, wire identification, connector identification, and connector pin numbers. All components on PC boards shall be individually shown in the schematics. Schematics shall be comprehensive in nature and thoroughly detailed to permit DART's shop personnel to troubleshoot and repair vehicle systems.

Schematic location (page number, for example) of the energization portion of each device (such as the coil in a relay) shall be noted adjacent to the operating portions (such as relay interlocks) of the device.

A set of device tables shall be located in a single section at the rear of the schematic book. This table shall be arranged in logical fashion by system device type. This table shall include data for all system and subsystem components including but not limited to:

- Electrical control and power components (groups, panels, PC cards, contactors, relays, circuit breakers, capacitors, inductors, resistors, specialized modules, rectifiers, thyristors, diodes, fuses, and other components, as appropriate)
- Electrical machinery (rotating equipment, reactors, transformers, pumps, fans, compressors, switchgear, and other machinery)
- Hydraulic control and power devices (valves, strainers, filters, and other components)
- Pneumatic control and power devices.

As a minimum, device listings shall include the following:

- Location in schematic and schematic designation
- Type, model, and part number
- Locations on vehicle
- Function
- Schematic symbol
- Appropriate ratings data
- Interface information, as appropriate

The integrated schematic drawings for this Contract shall be formatted by subsystem, using identical device symbols and wire and pipe designators for each subsystem. All interfaces, from page to page, and subsystem to subsystem, shall be clearly delineated. The integrated schematic and narrative shall be designed, drafted, assembled, and published by the Contractor, or by a single subcontractor placed under contract for that express purpose. It will not be acceptable to assemble a collection of subcontractor drawings, independently produced, into a single, vehicle integrated schematic. To ensure clarity, the Contractor shall select lettering and detail size to be legible for a schematic page reduced to a size of 8 1/2 in x 11 in; however, the schematic shall be submitted in an 11 in x 17 in page format.

Wiring diagrams shall be integrated connection diagrams and a wire list in book form based on the integrated schematic. The diagrams shall show all wiring, raceways, conduits, and connections.

The wire list shall include each individual wire segment in the vehicle, listed separately, whether the wire is used for the transfer of power or information.

As a minimum, the following information shall be provided for each wire segment:

- Wire code (schematic designation)
- Origin (from device and terminal)
- Destination (to device and terminal)
- Wire size
- Voltage rating
- Length
- Appropriate specifications
- Jacket color
- Harness designation

19.6.4 Drawings Requiring Approval

Drawings and documents to be furnished by the Contractor for approval by DART shall include, but not be limited to, those listed below in addition to those noted as CDRLs in Sections 2 through 18. DART reserves the right to request additional drawings or documents as required to clarify and amplify the intent of drawings furnished.

- General (coordinate with CDRL 2-1): (CDRL 19-10)
  - Exterior elevations of both sides of vehicle
  - Exterior elevations of both ends of vehicle
  - Floor plan
  - Reflected ceiling plan
  - Roof plan (with equipment layout)
  - Interior, longitudinal sections of both sides of vehicle
  - Interior elevations of both ends of vehicle
  - Reflected plan, under-car equipment layout
Reflected plan, conduit and cable layouts
Reflected plan, piping layout
Side elevation, undercar equipment layout
Side elevation, roof equipment layout

- Cab (coordinate with CDRL 5-1): (CDRL 19-11)
  Plan layout, cab equipment and operator’s seat
  Layout of cab console
  Interior elevations of cab layout, including console
  Master Controller Group plan and location
  Master Controller Group details, including deadman

- Clearance Drawings (coordinate with CDRLs 2-2 and 2-3): (CDRL 19-12)
  Actual dynamic envelope
  Relation of ends of two complete vehicles on curves, and showing vertical and horizontal drawbar swings, both static and dynamic
  Transverse section to show extreme movements of vehicle (including yaw) permitted by the vehicle suspension and running gear
  Transverse sections to show vertical and lateral undercar equipment clearances to rail and roadbed
  Transverse section to show vertical and lateral roof mounted equipment locations (including extended pantograph) relative to rail

- Framing and Miscellaneous Drawings (coordinate with CDRL 3-3): (CDRL 19-13)
  Underframe and bolster - plan, elevations, and sections
  Anticlimbers - plan, elevations, and sections
  Side frame(s) - plan, elevations, and sections
  Roof frame - plan, elevations, and sections
  End frame - plan, elevations, and sections
  Drawbar attachment to underframe - plan, elevations, and sections

- Trucks: (CDRL 19-14)
  Truck assembly (each type) – plan, elevations and equipment application
  Truck frame (each type) - details
  Bolster - details
  Suspension - details
  Wheels - details
  Axle - details
  Journal bearings - details
  Gear units - assembly
  Axle assembly - complete
  Brake equipment - details
  Traction motors - details
  Speed sensors - details
  Ground brushes - details

- HVAC (coordinate with CDRL 7-2): (CDRL 19-15)
  Plan, elevations
  Installation details
  Electrical and piping schematics
  Assembly details
- Carbody Articulation Unit: (CDRL 19-16)
  Plan, elevations, sections
  Graphic depiction of movements and limits

- Pantograph (coordinate with CDRL 9-2): (CDRL 19-17)
  Plan, elevations
  Ratings
  Application details
  MDS Interface Details

- Doors (coordinate with CDRL 6-2): (CDRL 19-18)
  Plan, elevations, sections
  Hardware and attaching details
  Circuit schematics

- Coupler and Drawbar (coordinate with CDRL 4-1): (CDRL 19-19)
  Plan, elevations
  Mechanical and details

- Ducting (HVAC, Traction, others): (CDRL 19-20)
  Plans, elevations, sections
  Joining details

- Propulsion Equipment (coordinate with CDRL 10-1 and CDRLs 17-29,-30, and -31): (CDRL 19-21)
  Inverters - details
  Controls - details
  Circuit schematics

- Equipment Boxes and Compartments: (CDRL 19-22)
  Plan, elevation, sections
  Hardware details

- Lighting Fixtures (coordinate with CDRL 8-1): (CDRL 19-23)
  Location
  Details

- Seating (coordinate with CDRL 15-1): (CDRL 19-24)
  Plan, elevations, sections
  Attaching details including stanchion attachments
  Wheelchair area plan, elevation, sections

- Electrical Equipment: (CDRL 19-25)
  Circuit breaker panels - details
  Knife switch - details
  High speed circuit breaker – details
  MDS interface details

- Auxiliary Inverter (coordinate with CDRL 9-5 and CDRLs 17-29,-30, and -31): (CDRL 19-26)
Auxiliary power supply - details
Circuit schematics

- Low Voltage Power Supply (coordinate with CDRL 9-6 and CDRLs 17-29,-30, and -31): (CDRL 19-27)
  - Low voltage power supply - details
  - Battery charger - details
  - Circuit schematics
  - MDS interface details

- Energy Storage System (coordinate with CDRL 9-7): (CDRL 19-28)
  - Storage device – details
  - Battery management system – details
  - Circuit schematics
  - MDS interface details
  - Software design description

- Battery (coordinate with CDRL 9-7): (CDRL 19-29)
  - Battery - details

- Friction Brake System (coordinate with CDRL 12-1 and CDRLs 17-29,-30, and -31): (CDRL 19-30)
  - Hydraulic pressure supply unit - details
  - Hydraulic control units - details
  - Electronic control units - details
  - Circuit schematics
  - Other brake hardware - details
  - Track brake – details
  - Sanding system and arrangement - details

- Vehicle Communications (coordinate with CDRL 13-1 thru 13-3 and CDRLs 17-29,-30, and -31): (CDRL 19-31)
  - Electronic control units and amplifiers - details
  - Circuit schematics
  - MDS interface details
  - Software design description

- Information and Destination Signs (coordinate with CDRL 13-4 and CDRLs 17-29,-30, and -31): (CDRL 19-32)
  - Electronic control units - details
  - Software design description
  - Sign mechanism - details

- Automatic Passenger Counting System (coordinate with CDRL 13-7): (CDRL 19-33)
  - Circuit schematics
  - MDS interface details
  - Installation and wiring routing

- Event Recorder: (CDRL 19-34)
  - Electronic unit - details
Circuit schematics
MDS interface details

- Stanchions and Handrails (coordinate with CDRL 15-3): (CDRL 19-35)
  Plan, elevations, details

- Interior Lining Panels and Bulkheads (coordinate with CDRL 15-1): (CDRL 19-36)
  Plan, elevations, sections
  Attaching details

- Sub-Floor and Finished Floor: (CDRL 19-37)
  Plan, elevations, sections
  Attaching details

- Electrical Drawings: (coordinate with CDRLs 17-29,-30, and -31): (CDRL 19-38)
  Schematic wiring diagram - nominal 750 Vdc equipment
  Schematic wiring diagram - nominal 28.5 and 12 Vdc equipment
  Schematic wiring diagrams - 120/460 Vac equipment
  Integrated wiring diagrams

- Hydraulic Diagram: (CDRL 19-39)
  Schematic piping diagram - hydraulic brake equipment

- Diagnostic Test Equipment: (coordinate with CDRLs 17-29,-30, and -31): (CDRL 19-40)
  Design details on each unit.
  Software design description for each unit.
  Catalog data for standard instruments that are included in each unit.

- Air System: (CDRL 19-41)
  Piping diagram.
  Compressor – details
  Other air system hardware – details.

19.6.5 Documents Requiring Approval

Documents to be furnished by the Contractor for approval by DART shall include, but not be limited to, those listed below in addition to those noted as CDRLs in Sections 2 through 18. DART reserves the right to request additional documents, as required, to clarify and amplify the intent of the vehicle design.

- Management plan
- System safety program plan
- Hazard listing
- System hazard analysis
- Carbody stress analysis
- Truck stress analysis
- Equipment support stress analysis
• Maintainability analysis
• HVAC design calculations
• All test procedures and reports
• Grounding scheme
• Test and inspection plan
• Welding and brazing procedures
• Flammability matrix
• Quality assurance plan
• Management plan
• Master test plan
• Maintenance and parts manuals

19.6.6 Approval of Contractor Documents, Drawings and Data
DART's approval or disapproval will be provided in one of the four following categories:

• Approved as submitted.
• Conditionally Approved: The Contractor may proceed in accordance with changes indicated and shall revise and resubmit the document, drawing, and/or data for DART approval.
• Disapproved: The Contractor shall revise and resubmit the document, drawing, and/or data for DART approval prior to commencing the affected portion of the work.
• Accepted for Information Only: The submittal was provided as information to assist in review of a required submittal or to satisfy a request. Specific approval and comment not required.

All drawings, technical data, test procedures, test schedules, test results, test reports, progress schedules and reports, drawing lists, samples, and other data submitted by the Contractor and requiring review and approval by DART will be dispositioned in accordance with the above provisions.

Incomplete submittal packages or submittals missing information required to understand the submittal details will be disapproved.

Approval does not relieve the Contractor of the obligation to meet all of the requirements of the Contract. Approval of a document, drawing, and data which contain deviations from, or violation of, the Specification does not constitute authority for that deviation or violation. Such deviations must be specifically requested and granted in writing.

Approval is intended to mean that DART is aware of the Contractor's intent and there are no objections to the apparent methods, procedures, designs, or calculations expressed in the submitted drawings or documents. It does not imply that all calculations, dimensions, materials, components or other details have been checked and verified.
19.6.7 Construction Photographs
DART reserves the right to photograph, at its expense, any or all phases of car or equipment construction, including subcontractor work, without restriction.

19.7 Reproducible Drawings to be Furnished by Contractor

19.7.1 List of Final Drawings
The Contractor shall provide DART with a complete list of Final Drawings to be supplied by the Contractor and each subcontractor. (CDRL 19-42)

19.7.2 Time and Scope of Submittals
Within 90 days following the acceptance of the first streetcar, the Contractor shall supply quality reproducibles for the following (CDRL 19-43):

- All Contractor's and suppliers' drawings, details, bills of material, and catalog cuts that are required by DART for future installation, maintenance, repair and overhaul purposes
- All assemblies, subassemblies, and arrangements of the vehicle as finally furnished, modified and accepted
- All electrical schematics, electronic circuits, and wiring diagrams
- All interface control drawings down to the lowest level replaceable unit (LLRU)
- All items which are special purpose or fabricated by the Contractor
- All materials furnished by the Contractor and by its suppliers, down to and including the module and circuit board level. In every case, outline drawings shall not be considered acceptable.

All Contractor reproducible drawings shall be supplied on CD-ROM which are fully compatible with AutoCAD, latest version. Subcontractor drawings on CD-ROM shall be supplied in AutoCAD, DXF, IGES, or other mutually agreeable format. (CDRL 19-44)

In the processing of the reproducibles of the Contractor's drawings, the drawing title, drawing number and other title block information shall be incorporated into the body of the drawing for identification purposes. The Bill of Material shall be retained on the reproducible.

19.8 Modification and Configuration Control
Throughout the Contract, the Contractor shall implement and maintain a configuration control system.

19.8.1 Design Changes
Changes to approved documents, drawings, and data shall be controlled by the processing of engineering change requests (ECR's). The Contractor shall submit a proposed standard ECR form for DART's approval within 60 days after award of contract. (CDRL 19-45) The Contractor shall maintain an Engineering Change Status Report which shall list all changes, their submittal/approval status, status of implementation, and completion dates. The Engineering Change Status Report shall be included with the monthly progress report (see Section 18.4). Implementation of a change shall require incorporation in all vehicles unless otherwise approved by DART. Any ECR resulting in a change to the contract price shall require an approved contract modification (change order) prior to implementing the change.
19.8.2 Component Identification and Serial Numbers

All streetcar components shall be permanently identified with a supplier's name, part number, and revision level.

In addition, the Contractor shall assign discrete serial numbers to certain equipment specified in this section. Serial numbers shall be in sequential, numerical order for the total quantity of each component, including spares.

Serial numbers of all components shall be presented to DART as each vehicle arrives on the property or when spare components are received. The Contractor shall track all serial number transfers and prepare a list of all serial numbered apparatus installed on each vehicle for inclusion in the car history book.

At a minimum, the following equipment shall have serial numbers applied:

- HVAC apparatus
- Converters
- Inverters
- Pantographs
- Master Controller
- Door operators and controls
- Motors within equipment
- All electronic cards and ECUs
- Principal communications equipment items (not including speakers)
- Principal items of traction and braking equipment
- Truck castings or weldments
- Primary and Secondary Suspension
- Axles
- Truck frames
- Truck gear units
- Journal bearings
- Wheels
- Brake disks

19.8.3 Car History Books

Each car shall have a car history book that reflects the configuration and testing status of the car. (CDRL 19-46) The car history book shall accompany the car through the production line and be presented to DART when each car is accepted. Each book shall contain the following minimum information:

- Description and completion dates of all car modifications, and list of modifications pending with expected completion dates
• List of car defects that were identified by Contractor QA or DART’s personnel during construction and the disposition of each as verified by inspection
• List of serial-numbered apparatus
• Shipping documents
• Results of each functional performance and acceptance test performed on the car or any part thereof
• Wheels, journal bearings, and gear mounting records, including pressing charts
• A record of any abnormalities that occur during the manufacture of the car or any of its subsystems, including their authorized, validated, repair procedures
• Open item status list

19.9 Quality Assurance (QA) and Quality Control (QC)

The Contractor shall plan, establish, and maintain a quality assurance (QA) and quality control (QC) program that complies with ANSI/ISO/ASQ Q9001-2000 or approved equal and the FTA QA/QC Guidelines document FTA-IT-90-5001-02. The Contractor's QA/QC program shall be imposed upon all entities within the Contractor's organization and on all subcontractors whenever contract work is performed. The Contractor may accept established QA/QC plans from its subcontractors and incorporate these plans as part of its overall QA/QC program.

19.9.1 Quality Assurance Plan

The Contractor shall submit a Quality Assurance Plan (QAP) for review and approval by DART within 60 days of NTP. (CDRL 19-47) The QAP shall be specific to this Contract and shall describe in detail the Contractor’s methods for planning, implementing, and maintaining quality in all aspects of both design and construction of the vehicles.

The QAP shall contain a company policy statement which clearly defines the authority and responsibilities of Quality Assurance personnel. At a minimum, the following QA and QC principles shall be included in the QAP and shall be implemented throughout the course of the Contract:

• The quality assurance organization shall have the authority and responsibility for establishment of the quality control system, inspection, production conformance testing, and acceptance/rejection of materials and manufactured articles in the production of the vehicle.
• The quality assurance organization shall exercise quality control over all phases of production from initiation of design through manufacture and preparation for delivery. The organization shall also control the quality of supplied articles.
• The quality assurance organization shall not report to the production manager and will function independently of the project organization.

19.9.1.1 QA Activities

The Contractor's Quality Assurance Plan shall provide requirements and assign the authority and means to implement procedures that control the activities listed below. The Contractor shall submit these written procedures for approval and assure effective implementation of quality assurance activities. As a minimum, procedures for the following activities shall be included as part of the Contractor's Quality Assurance Plan:
- Design and drawing control, including technical documentation and engineering changes
- Transmission of all quality assurance requirements to procurement sources
- Surveillance of subcontractors and suppliers
- Receiving, source, in-process, and final inspections
- Evaluation of procured articles against purchase order requirements
- Production and process control
- Equipment calibration and certification
- Skilled personnel qualifications and certifications
- Materials control
- Discrepancy control
- Functional testing
- Quality assurance records
- Shipping, handling, and storing

The Contractor shall verify that all applicable specification requirements are properly included or referenced in purchase orders of articles to be used on rail vehicles.

The Contractor shall ensure that all basic production operations, as well as all other processing and fabricating, are performed under controlled conditions. Establishment of these controlled conditions shall be based on documented work instructions, adequate production equipment, and special working environments.

The quality assurance organization shall monitor the Contractor’s system for controlling nonconforming materials. The system shall include procedures for identification, segregation, and disposition.

Statistical analysis, tests, and other quality control procedures may be used when appropriate in the quality assurance processes.

19.9.1.2 Subcontractor Quality Assurance

The Contractor shall require that each supplier maintains a quality assurance and quality control program for the services and supplies that it provides. The Contractor’s quality assurance organization shall inspect and test materials provided by suppliers for conformance to specification requirements. Materials that have been inspected, tested, and approved shall be identified as acceptable to the point of use in the manufacturing or assembly processes. Controls shall be established to prevent inadvertent use of nonconforming materials.

19.9.1.3 Personnel

An organization chart shall be included within the QAP to show the reporting relationships of all QA staff engaged in this Contract. Resumes of all the Contractor’s QA personnel engaged in this Contract shall be included in the QAP, and DART shall have the right to approve or disapprove all such personnel.
Contractor production personnel performing work, inspections, or tests shall be qualified for such activity by virtue of prior experience and training, certified where required, and verified by testing where applicable. The QAP shall list all certification requirements and describe the process for verification. Records of personnel certification and qualifications shall be maintained and available for DART’s review.

19.9.1.4 Records

The Contractor shall maintain drawings and other documentation that completely describe a qualified vehicle meeting all of the requirements of the approved design. The QAP shall describe how the quality assurance organization will maintain and use records and data essential to the effective operation of its program. These records and data shall be available for review by DART for a minimum of three years after the vehicle is placed in revenue service.

19.9.1.5 Calibration and Certification of Measuring Equipment and Tools

The Contractor shall provide and maintain the necessary gauges and other measuring and testing devices for use by the quality assurance organization to verify that the vehicles conform to the approved design. These devices shall be calibrated at established periods against certified measurement standards that have known valid relationships to national standards.

The Contractor’s gauges and other measuring and testing devices shall be made available for use by DART to verify that the vehicles conform to all specification requirements. If necessary, the Contractor’s personnel shall be made available to operate the devices and to verify their condition and accuracy.

When production jigs, fixtures, tooling masters, templates, patterns, and other devices are used to verify construction and construction tolerances, they shall be proved for accuracy at formally established intervals and adjusted, replaced, or repaired as required to maintain quality. The Contractor shall demonstrate an effective time-cycled or usage-cycled calibration and certification program. Validity of measurements and tests shall be ensured through the use of suitable inspection, measurement, and test equipment of the range and type necessary to determine conformance with Contract requirements. At intervals established to ensure continued validity, measuring devices shall be verified or calibrated against certified standards that have a known traceable relationship to the U.S. National Bureau of Standards, or approved equal. Tooling and fixtures used as media for inspection shall be included in this program.

Every device so verified shall bear an indication attesting to the current status and showing the date (or other basis) of last inspection or calibration and on which inspection or recalibration is next required. Devices yielding inconsistent measurements or clearly flawed data before the stated recalibration date shall be promptly recalibrated. Items on which inspections have been performed with devices proven to be out of calibration shall be promptly reinspected. All calibration certifications shall be recorded and become part of the QA records.

19.9.2 Quality Control and Inspection Plan (QCIP)

The Contractor’s quality assurance organization shall establish, maintain, and periodically audit a fully-documented quality control and inspection plan as outlined in the QAP. The Quality Control and Inspection Plan (QCIP) shall prescribe inspection of materials, work in progress and completed articles. The QCIP shall contain a list and a collection of all forms.
proposed to be used for the Contractor’s quality control and inspection activities. (CDRL 19-48)

Sufficient trained inspectors shall be used to ensure that all materials, components, and assemblies are inspected for conformance with the approved drawings, procedures, and these Technical Specifications.

19.9.2.1 Levels of Inspection

The Contractor shall specify 100 percent or sampling inspection for discrete items of work if not otherwise specified in these Technical Specifications. Sampling procedures shall be performed in accordance with MIL-STD-1916, ANSI/ASQC Z 1.9, or other approved approach. A list of parts and material to be inspected by sampling shall be included in the QCIP along with complete details of the manner of proposed sampling.

19.9.2.2 Inspection Status

The Contractor shall maintain a system to identify acceptance, rejection, or non-inspection status of materials and components. The method of identifying inspection status shall be submitted to DART for review and approval.

Articles rejected as unsuitable or scrap shall be plainly marked and controlled to prevent installation on the vehicle. Articles that become obsolete as a result of engineering changes or other actions shall be controlled to prevent unauthorized assembly or installation. Unusable articles shall be isolated and then scrapped.

Discrepancies noted by the Contractor or DART during assembly shall be entered by the inspection personnel on a record that accompanies the major component, subassembly, assembly, or vehicle from start of assembly through final inspection. Actions shall be taken to correct discrepancies or deficiencies in the manufacturing processes procedures, or other conditions that cause articles to be in nonconformity with the approved drawings. Inspection personnel shall verify all corrective actions and mark the discrepancy record. If discrepancies cannot be corrected by replacing the nonconforming materials, DART shall review and approve (or disapprove) the modification, repair, or method of correction to the extent that the contract specifications are affected.

19.9.2.3 First Article Inspections

A First Article Inspection (FAI) will be performed jointly by DART and the Contractor on all major components, subassemblies, and the fully assembled vehicle. The QCIP shall include a list of all those items proposed to receive an FAI and proposed inspection forms and data sheets for each FAI. FAIs may be waived at the discretion of DART if such items have been produced for other similar streetcar projects currently in operation, and there has been no change in the design or manufacturing location, process, and methods.

The Contractor shall provide an individual notice to DART for each FAI a minimum of 30 calendar days prior to the FAI. The Contractor shall not schedule more than two FAIs on the same date without prior approval by DART. First Article Inspection will not be conducted until the design drawings of the article have been conditionally approved or approved. If conditionally approved drawings are used, DART’s conditions for approval shall be satisfied at the FAI and represented by the inspection article. An FAI package shall be submitted to DART 30 days in advance of each FAI that provides all necessary logistics information, any Contractor inspection reports, and a complete set of approved or conditionally approved drawings and software documentation.
When appropriate, the inspection article shall be displayed on a stand or table in a well-lit work space with skilled labor and all necessary inspection tools and gauges available for any checking or disassembly work required by DART.

Equipment shall be shipped from the point of manufacture only after an FAI has been approved or waived by DART.

Should DART not accept the results of the FAI, the Contractor shall cause the provider to promptly take the necessary corrective action, after which a new FAI shall be held. Should the provider be unable to correct the deficiency, the Contractor may, with DART approval, substitute another provider. The project schedule will not be extended for any delays resulting from the disapproval of an FAI.

19.9.2.4 Receiving Inspection

Written procedures shall be implemented to assure items are inspected at source and upon receipt to verify conformance to acceptance criteria of specifications and drawings. All inspections will be performed to Purchase Order requirements, specifications, and drawing requirements. Material certifications and test reports shall be retained. Contractor shall specify 100 percent or sampling source inspection for all major subsystem equipment to be purchased.

19.9.2.5 Inspection of Work In-Process

The Contractor's quality assurance organization shall maintain and direct a force of inspectors to verify that work in its shops is performed in compliance with the approved design drawings and these Technical Specifications. The Contractor shall include in the QCIP sample forms or documents to record all in-process inspections.

Discrepancies in the work shall be recorded, and departments responsible for the work shall be notified of the need for corrections. Repairs and corrections shall be inspected for conformance to drawings and DART-approved rework instructions, as needed. Re-inspection acceptance status shall be indicated by the Contractor's inspectors by stamp or initials on the original of the discrepancy report. Responsible manufacturing supervision shall be notified of rework that is rejected.

19.9.2.6 Hold Point Inspections

The Contractor shall establish hold points in the manufacturing process to provide for critical inspections. Hold points shall be utilized to inspect completed operations or installations. Hold points shall also be used to inspect items that are about to be covered by succeeding assembly operations. The Contractor shall use inspection forms to record the list of discrepancies noted. Nonconforming products shall not be released from a hold point area until all discrepancies have been corrected. The inspection forms shall be posted at or near the point of inspection for each vehicle and included with the Car History Book when all discrepancies have been eliminated. The QCIP shall contain a list of hold point inspections which shall include as a minimum the following:

- Each underframe
- Each car roof section
- Each articulation unit after installation
- Each carshell body section before painting
- Each carshell body section after painting
• Each truck frame
• Each assembled truck, prior to installation under a car
• Each car roof after equipment installation
• Each car watertightness test prior to installation of insulation and interior finishings
• Each car final watertightness test
• Each car interior wiring before covered by panels
• Each car interior
• Each car exterior

The Contractor shall include in the QCIP the sample forms or documents to record these inspections.

19.9.2.7 Pre-Shipping Inspection
Subsequent to final inspection by DART and resolution of any outstanding items, the Contractor shall prepare each vehicle so as to preclude damage during shipment. The Contractor shall prepare inspection procedures and conduct inspections for vehicles scheduled for shipment to confirm that all shipping precautions and checks have been accomplished. The Contractor shall include in the QCIP the sample forms or documents to record this inspection.

19.9.2.8 Post-Shipping Inspection
Upon arrival of each vehicle on the tracks at DART's facilities, the Contractor shall inspect the vehicle for any damage or evidence of anomalous conditions during shipping. The Contractor shall include in the QCIP the sample forms or documents to record this inspection.

19.9.3 Audit and Inspection
DART may, at its discretion, perform its own QA/QC monitoring of work done under this Contract, including monitoring of the Contractor's or Subcontractor's QA and QC activities. DART may perform its own inspections at its discretion. Such activities shall not reduce or alter the Contractor's QA and QC responsibilities, nor reduce or alter the Contractor's obligation to meet the requirements of these Technical Specifications.

Following NTP, DART shall have the right of free access to facilities of the Contractor and subcontractors in order to inspect, examine, and test items during manufacture and shipment, and within a reasonable time after shipment. Specifically, but not by way of limitation, DART shall have the right to perform on-line inspections of vehicle assembly as required by 49 C.F.R. Part 663.

First Article Inspections shall be performed jointly by DART and the Contractor (see Section 18.9.2.3)

19.9.3.1 Contractor Provision of Facilities
The Contractor shall provide to DART personnel a heated, cooled and adequately lighted private office in the Contractor's manufacturing facility and DART personnel shall have ready access to modern toilet facilities. A private telephone line and Internet access shall
also be made available. In addition, copies of all drawings, diagrams, schedules, changes, deviations, and QA records shall be made available to DART’s representative upon request.

19.9.3.2 Final Inspection

After all work is completed, the Contractor shall perform its own final inspection to written procedures prior to DART’s inspection. Workmanship items covered by prior inspection reports shall be corrected before final inspection begins. The Contractor shall then schedule one day for DART’s final inspection of each car before shipment from the Contractor’s plant to DART’s facility.

The Contractor shall provide a qualified supervisor to accompany DART’s representative during the final inspection to assure that proper corrective action is taken. The Contractor shall provide labor and appropriate tools to remove or open and reapply covers and doors. During final inspection, all systems shall be operational with use of approved special equipment or power supplies.

19.10 CDRL

The following submittals are required:

19-1 Confirmation of Project Manager and Integration Engineer (Section 19.2)
19-2 Contractor’s management plan (Section 19.2)
19-3 Dynamic and static clearance envelope (Section 19.3.2)
19-4 Jacking points and load distribution (Section 19.3.2)
19-1 Accelerating and braking performance (Section 19.3.2)
19-2 Pantograph operating data (Section 19.3.2)
19-3 Electrical load data (Section 19.3.2)
19-4 Meeting minutes (Section 19.4)
19-5 Monthly progress report (Section 19.5)
19-6 General drawings (Section 19.6.4)
19-7 Cab drawings (Section 19.6.4)
19-8 Clearance drawings (Section 19.6.4)
19-9 Framing and miscellaneous drawings (Section 19.6.4)
19-10 Truck drawings (Section 19.6.4)
19-11 HVAC drawings (Section 19.6.4)
19-12 Articulation drawings (Section 19.6.4)
19-13 Pantograph drawings (Section 19.6.4)
19-14 Door and bridgeplate drawings (Section 19.6.4)
19-15 Draw bar drawings (Section 19.6.4)
19-16 Ducting drawings (Section 19.6.4)
19-17 Propulsion equipment drawings (Section 19.6.4)
19-18 Equipment boxes and lockers (Section 19.6.4)
19-19 Lighting drawings (Section 19.6.4)
19-20 Seating drawings (Section 19.6.4)
19-21 General electrical equipment drawings (Section 19.6.4)
19-22 Auxiliary inverter drawings (Section 19.6.4)
19-23 Low voltage power supply drawings (Section 19.6.4)
19-24 Energy storage system drawings (Section 19.6.4)
19-25 Battery drawings (Section 19.6.4)
19-26 Friction brake drawings (Section 19.6.4)
19-27 Communications drawings (Section 19.6.4)
19-28 Information and destination sign drawings (Section 19.6.4)
19-29  Automatic passenger counting drawings (Section 19.6.4)
19-30  Event recorder (Section 19.6.4)
19-31  Stanchion and handrail drawings (Section 19.6.4)
19-32  Interior lining drawings (Section 19.6.4)
19-33  Floor drawings (Section 19.6.4)
19-34  Electrical schematic drawings (Section 19.6.4)
19-35  Hydraulic diagram (Section 19.6.4)
19-36  Diagnostic test equipment drawings (Section 19.6.4)
19-37  Air system drawings (Section 19.6.4)
19-38  List of final drawings (Section 19.7.1)
19-39  Hard copy reproducibles (Section 19.7.2)
19-40  Electronic CAD reproducibles (Section 19.7.2)
19-41  ECR Form (Section 19.8.1)
19-42  Car History Books (Section 19.8.3)
19-43  Quality Assurance Plan (Section 19.9.1)
19-44  Quality Control and Inspection Plan (Section 19.9.2)

END OF SECTION
This questionnaire, the requested list of references, and the authorization to release financial information are used in part to assist in determining a potential contractor’s responsibility. Offerors shall submit the Exhibit L information within two (2) work days from the date of notification by the Authority, or with the offer, if so indicated in the Table of Contents page 2 of the Solicitation, Offer and Award Form, and in accordance with applicable provision(s) in Exhibit B, if any. All information must be current and traceable. Each venturer of a joint venture must submit a separate signed form.

DART reserves the right to make additional inquiries based on information submitted, or the lack thereof. Questions concerning this questionnaire or the authorization form should be directed to the contact person identified on the Solicitation, Offer and Award Form.

1. Name of Offeror (“Business”): ___________________________________________________

2. List name(s) and business address of officers and directors for corporations, partners for partnerships, and venturers for joint ventures (attach additional pages as necessary).
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

3. Number of years in business under present business name: __________

4. If applicable, list all other names under which the Business identified above operated in the last 5 years.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

5. Annual Gross Revenue (Past year): (M represents millions, K represents thousands)
   $\square$100K or less $\square$100K-$500K $\square$500K-$1M $\square$1M-$5M $\square$5M-$10M
   $\square$10M-$16M $\square$16M or Over

6. Number of current employees: __________

7. Has the Business, or any officer or partner thereof, failed to complete a contract? ☐Yes ☐No

8. Is any litigation pending against the Business? ☐Yes ☐No

9. Has the Business ever been declared "not responsible" for the purpose of any governmental agency contract award? ☐Yes ☐No

10. Has the Business been debarred, suspended, proposed for debarment, declared ineligible, voluntarily excluded, or otherwise disqualified from bidding, proposing, or contracting? ☐Yes ☐No

11. Are there any proceedings pending relating to the Business’ responsibility, debarment, suspension, voluntary exclusion, or qualification to receive a public contract? ☐Yes ☐No

12. Has the government or other public entity requested or required enforcement of any of its rights under a surety agreement on the basis of a default or in lieu of declaring the Business in default? ☐Yes ☐No
13. Is the Business in arrears on any contract or debt?  ☐ Yes  ☐ No

14. Has the Business been a defaulter, as a principal, surety, or otherwise?  ☐ Yes  ☐ No

15. Have liquidated damages or penalty provisions been assessed against the Business for failure to complete work on time or for any other reason?  ☐ Yes  ☐ No

16. If a "yes" response is given under questions 7 through 15, please provide a detailed explanation including dates, reference to contract information, contacts, etc. (attach additional pages as necessary).

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

I, individually and on behalf of the business named in this Business Questionnaire, do by my signature below, certify that the information provided in this questionnaire is true and correct. I understand that any false statements or misrepresentations regarding the Business named above may result in: 1) termination of any or all contracts which DART has or may have with the Business; 2) disqualification of the Business from consideration for contracts; 3) removal of the Business from DART’s bidders’ list; or/and 4) legal action(s) applicable under federal, state, or local law.

Name: ________________________________________    Title: ____________________________

Signature: _____________________________________  Date: ________________________

(Owner, CEO, President, Majority Stockholder or Designated Representative)
LIST OF REFERENCES FOR SIMILAR PROJECTS

Use additional pages as necessary.

1. Project:
   Date of Completion (if applicable):
   Contact Person:
   Company Name:
   Address:
   Telephone Number:
   Fax Number:
   E-mail Address:

2. Project:
   Date of Completion (if applicable):
   Contact Person:
   Company Name:
   Address:
   Telephone Number:
   Fax Number:
   E-mail Address:

3. Project:
   Date of Completion (if applicable):
   Contact Person:
   Company Name:
   Address:
   Telephone Number:
   Fax Number:
   E-mail Address:

4. Project:
   Date of Completion (if applicable):
   Contact Person:
   Company Name:
   Address:
   Telephone Number:
   Fax Number:
   E-mail Address:
This authorization will be used to obtain information to assist DART in determining a potential contractor's financial responsibility. Your signature authorizes the release of financial information to the DART Procurement Department for this purpose. All information must be current and traceable. Each venturer of a joint venture must submit a separate signed form.

This authorization form shall be submitted in accordance with the applicable provision(s) in Exhibit B, or as otherwise requested. DART reserves the right to make additional inquiries based on information submitted, or the lack thereof.

Name of Bank/Financial Institution ___________________________ Account Number ___________________________

Address ___________________________ Account Type: e.g., Savings, Checking, Other (Identify)

City, State, Zip Code ___________________________

Name of Bank Officer Familiar with the Account ___________________________

Telephone ___________________________ Fax ___________________________

Email Address ___________________________

Name of Business ___________________________ Address ___________________________

City ___________________________ State ___________________________ Zip Code ___________________________

I, individually and on behalf of the Business named above, do by my signature below, certify that the information provided is true and correct, and authorize the release of financial information for verification of financial responsibility. I understand that any false statements or misrepresentations regarding the Business named above may result in: 1) termination of any or all contracts which DART has or may have with the business; 2) disqualification of the Business from consideration for contracts; 3) removal of the Business from DART’s bidders list; or/and 4) legal action(s) applicable under federal, state or local law.

Name: ___________________________ Title: ___________________________

Signature: ___________________________ Date: ___________________________

(Owner, CEO, President, Majority Stockholder, or Designated Representative)
EXHIBIT O
SOLICITATION QUESTION SUBMISSION FORM

This form may be duplicated and used to submit questions and requests for clarification related to this solicitation and shall be submitted to the contract person identified on the Solicitation, Offer and Award form. (See the appropriate clause in Exhibit C for information regarding questions and their submission.)

1. Solicitation Reference: Exhibit/Other____________________, Page _____ of _____, Paragraph Number ________
Question/Clarification
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
Rationale
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________

2. Solicitation Reference: Exhibit/Other____________________, Page _____ of _____, Paragraph Number ________
Question/Clarification
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
Rationale
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________

3. Solicitation Reference: Exhibit/Other____________________, Page _____ of _____, Paragraph Number ________
Question/Clarification
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
Rationale
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________
_______________________________________________________________________________________________

Company Name

Represented By

Name: __________________________ Title: __________________________

Signature: __________________________ Date: __/__/___

Form 33.225(08/04)
MISCELLANEOUS EXPENSE POLICY

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1. Non-reimbursable Costs

Non-reimbursable costs include charges for entertainment, first-class or business class airfare, telegraph, alcoholic beverages, expenses for transportation for personal pursuits, gifts, flight insurance, traveler's checks and any other charges expressly disallowed under the terms of the Contract. See paragraph 5(a) for limitations on personal phone calls.

2. Pre-Approval for Seminars and Working Meals

The Authority's Project Manager, the Contracting Officer's Technical Representative, or the Contracting Officer must approve in writing, and in advance of expenditure, all working meals and seminars.

3. Supplies, Materials, and Equipment

Such items used directly in support of this Contract shall be reimbursed at actual cost without fee and be supported by original receipts or legibly signed copies. Prior approval of the Contracting Officer or a duly authorized representative is required to purchase items valued at $1,000 or more. Acquisition of electronic hardware and software requires prior approval of the Contracting Officer or his representative, regardless of dollar level. Contractors shall acquire all supplies, materials and equipment competitively and should obtain at least three bids whenever possible.

4. Travel and Living Expenses

The Contractor shall be reimbursed the necessary, actual and reasonable direct non-salary costs (expenses) applicable to the work included in this contract. All reimbursable expenses are defined below. The Authority's Project Manager, the Contracting Officer's Technical Representative, or the Contracting Officer must approve in writing, and in advance of expenditure, all trips and associated costs (including auto rentals). Recommend that companies issue credit cards to travelers. These would be available for paying airfare, hotel, automobile rental, airport parking, conference fees, cab rides and other miscellaneous travel expenses, as well as making reservations for hotel and auto rental.

(a) Per Diem: All travelers in overnight travel status and when such travel is in connection with the work requirements of the Contract will receive a per diem reimbursement based on the most current IRS Index for M&IE (Meals and Incidental Expenses) contained in IRS Publication 1542; plus $10 for personal phone calls, tips, and other personal expenses. For cities not listed in the index, the closest city listed by the IRS shall be used. Receipts will not be required. The traveler will be reimbursed the full daily per diem for each 24-hour period based on their scheduled departure and arrival times from their home airport. Per diem for partial days spent out-of-town shall be made based on the following distribution table:

<table>
<thead>
<tr>
<th>Distribution of Per Diem</th>
<th>Departure/Arrival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>one-third</td>
<td>9:59 A.M or earlier</td>
</tr>
<tr>
<td>one-third</td>
<td>10:00 A.M. to 3:00 P.M.</td>
</tr>
<tr>
<td>one-third</td>
<td>3:01 P.M. or later</td>
</tr>
</tbody>
</table>

Meal allowances (individual meal per diem) are not to be requested or reimbursed when another party pays for the meal. This includes any meals paid for by a DART employee, contractor, or vendor; meals provided in the cost of the conference registration; etc. Reimbursement for meals applies only to the Contractor and/or members of their staff working on this Contract. Consultant's staff members for whom meals were provided shall be identified. Except as
approved by the Contracting Officer, payment of meals for other than Contractor's employees are not reimbursable. However, this provision excludes those meal costs incurred while in relocation status. For relocation expenses, see paragraph 3 above.

(b) Hotel/Motel: Expenses will be reimbursed at the actual and reasonable rate (single occupancy rate only) for Contractor personnel when in travel status for this Contract. Expenses incurred by a dependent or other person accompanying the Contractor's staff on an official business trip are expressly disallowed except during relocation. For such costs, see paragraph 3 above. The Contractor shall attempt to obtain the government rate if one is given. An actual signed copy of the invoice will support this expense. Bills indicating a multiple occupancy rate will be disallowed unless disclosure is made indicating reason, names, dates and authorization. Travelers who will be in Dallas for more than one week should make hotel/motel arrangements in advance at long-term discounted rates that are satisfactory to the Contracting Officer.

(c) Air Travel: Airfares will be reimbursed at the actual rates and must be supported by a ticket. Only coach or economy rates will be allowed. Business class travel for overseas airline travel is no longer authorized. Official travel shall be by the most direct routing. Use of joint airfare savings shall be obtained whenever possible.

(d) Local Transportation: When the Contractor's employees are on business travel connected with performance of this Contract, the following transportation guidelines shall apply:

(1) Rental Automobiles: Automobile rental will be allowed if approved in advance by the Authority's Project Manager, the Contracting Officer's Technical Representative or the Contracting Officer. Rentals shall be limited to a compact-sized vehicle, unless three or more travelers are sharing the same vehicle. However, car size should be based on the needs and the number of passengers using the vehicle. An SUV may be appropriate in certain weather or location situations, and should be justified during the approval process. Parking expenses and toll fares will be reimbursed at the actual rate. Receipts will be required for these expenses.

(2) Taxi/shuttle/airport bus: These expenses are reimbursable at actual costs and receipts are required when costs exceed $25. Taxi usage should be kept to a minimum, using public transportation or shuttle/courtesy/shared transportation service, where feasible, especially to and from airports.

(3) Travel between work areas and airports where Contractor's personnel utilize personal automobiles shall be reimbursed at the most current IRS rate per mile. Tolls and parking while traveling to and from commercial carriers are reimbursable at cost. Parking at the airport will be reimbursed as follows:

(i) Trips lasting 24 hours or less – Terminal parking;

(ii) Trips lasting more than 24 hours – Remote or off-site parking; however,

(iii) Parking costs should be compared to taxi service to ensure the most cost effective mode is utilized.

(e) Telephone: Actual cost of business telephone charges incurred by the Contractor personnel while in travel status is allowed. Personal telephone charges are subject to the limitations in paragraph 5(a) above.

(f) Laundry/Dry Cleaning: A reasonable amount of laundry and dry cleaning is allowed if the Contractor personnel are required to be in travel status for longer than five (5) working days.
INSTRUCTIONS TO FORM 33.606B:

If the **OFFER PRICE EXCEEDS $100,000**, complete the certificate and submit it with your offer.

SECTION (1) Complete only for IRON, STEEL or MANUFACTURED PRODUCTS.

SECTION (2) Complete only for ROLLING STOCK and ASSOCIATED EQUIPMENT.

SECTION (3) SIGN and COMPLETE always.

CAUTION: Failure to return this form or to mark the appropriate □ in Section (1) OR Section (2) AND complete the information in Section (3), including a signature, may render your offer nonresponsive or unacceptable.

DEFINITIONS: (Pursuant to 49 CFR 661)

**ASSOCIATED EQUIPMENT:** All components or subcomponents of Rolling Stock, including, but not limited to, train control, communication and traction power equipment, and as otherwise defined in 49 CFR 661.11.

**IRON AND STEEL PRODUCTS:** All construction materials made primarily of iron or steel and meant for use in infrastructure projects, including, but not limited to, structural iron or steel, iron or steel beams and columns, running rail and contact rail. This certification does not apply to iron or steel used as components or subcomponents of other manufactured products or rolling stock, or to metallurgic processes involving refinement of steel additives.

**MANUFACTURED PRODUCT:** An item produced as a result of processes to alter the form or function of materials or of elements of the product in a manner adding value and transforming those materials or elements so that they represent a new end product functionally different from that which would result from the mere assembly of elements or materials.

**ROLLING STOCK:** Transit vehicles, such as buses, vans, cars, railcars, locomotives, trolley cars and buses, and ferry boats, as well as, vehicles used for support services.
 SECTION (1); Certify only for IRON, STEEL or MANUFACTURED PRODUCTS:  (Mark One)

☐ CERTIFICATE OF COMPLIANCE WITH SECTION 165(a). The offeror hereby certifies that it will comply with the requirements of Section 165(a) of the Surface Transportation Assistance Act of 1982, as amended, and the applicable regulations of 49 CFR Part 661;

--OR--

☐ CERTIFICATE FOR NON-COMPLIANCE WITH SECTION 165(a). The offeror hereby certifies that it cannot comply with the requirements of Section 165(a) of the Surface Transportation Assistance Act of 1982, as amended, but it may qualify for an exception to the requirement pursuant to Section 165(b)(2) or (b)(4) of the Surface Transportation Assistance Act, as amended, and regulations in 49 CFR Part 661.7.

 SECTION (2); Certify only for ROLLING STOCK and ASSOCIATED EQUIPMENT:  (Mark One)

☐ CERTIFICATE OF COMPLIANCE WITH SECTION 165(b)(3). The offeror hereby certifies that it will comply with the requirements of Section 165(b)(3) of the Surface Transportation Assistance Act of 1982, as amended, and the applicable regulations of 49 CFR Part 661.11;

--OR--

☐ CERTIFICATE FOR NON-COMPLIANCE WITH SECTION 165(b)(3). The offeror hereby certifies that it cannot comply with the requirements of Section 165(b)(3) of the Surface Transportation Assistance Act of 1982, as amended, but it may qualify for an exception to the requirement consistent with Section 165(b)(2) or (b)(4) of the Surface Transportation Assistance Act, as amended, and regulations in 49 CFR Part 661.7.

 SECTION (3); OFFEROR’S SIGNATURE:  (Sign, Date and Enter Your Title and the Name of Your Company)

____________________________  ______________________
SIGNATURE  DATE

____________________________
TITLE

____________________________
NAME OF COMPANY