



RFP Number 00002649

Goods + Services

October 21, 2025

**Request for Proposals (RFP) for**

# Streetcar Vehicles, Parts, and Tools

## Proposal Response Packet

[Section 7: Submission Instructions](#)

[Section 8: Required Proposal Components](#)

# RFP at a Glance

## Proposals Due:

January 30, 2026 at 4:00 p.m. Pacific Time

## Optional Pre-Proposal Meeting:

There will be a pre-proposal meeting and site visit scheduled for this Project on **November 13, 2025 at 8:00 am Pacific Time** virtually via Microsoft Teams.

**Attendance is not mandatory but is strongly encouraged**, Proposal submission will not be contingent upon attendance at this meeting.

Please RSVP to Kristina Kolata at [Kristina.kolata@portlandoregon.gov](mailto:Kristina.kolata@portlandoregon.gov) for the meeting link.

Please disable AI note taking apps before joining meeting as they will not be admitted.

Refer to the RFP Project Information Packet Section 1.9: Optional Pre-Proposal Meeting for details.

## Submit Your Proposal:

Submit one (1) Adobe PDF electronic copy clearly marked “Master” or “Original,” and if redactions are requested, one (1) additional electronic copy, in MS Word format with redactions made (the Redacted for Public Disclosure Copy) through the City’s Online Procurement Center:

<https://procure.portlandoregon.gov/bso/>

It is the proposer’s responsibility to ensure that proposals are received prior to the specified closing date and time, and in the manner required by the Proposal Response Packet, Section 7. Proposals received after the specified closing date, or time or in a manner other than specified in this RFP, shall not be considered and will be rejected.

Refer to Section 7: Submission Instructions for details.

## Have Questions or Need Help? Contact the Single Point of Contact:

It is the proposer’s responsibility to ask questions, request changes or clarifications, or otherwise advise the City of Portland if any language, specifications or requirements of this RFP appear to be ambiguous, contradictory, or appear to inadvertently restrict or limit competition to a single source.

Send questions, requests for clarification, or requests for assistance by 14 calendar days before December 5, 2025 at 4:00 p.m. Pacific Time. Any questions received after may not be answered. Only the Single Point of Contact can answer questions about this RFP.

**Kristina Kolata**

Senior Procurement Specialist

Procurement Services

(503) 509-0713

[kristina.kolata@portlandoregon.gov](mailto:kristina.kolata@portlandoregon.gov)

# Section 7: Submission Instructions

By submitting a proposal, you accept the general Terms and Conditions listed in Section 5 of the RFP Information Packet for this RFP and the insurance required in Attachment D – Sample Contract.

## **Proposals are Due January 30, 2026 at 4:00p.m. Pacific Time**

Late proposals are not accepted.

## **Proposal Page Limit is 100 Pages**

Proposals must be clear, succinct, and not exceed 100 pages. Not all parts of the proposal are included in the page limit. [The Proposal Checklist in Section 8](#) of this document lists which parts are included in the page limit.

The City will evaluate all proposals on the completeness and quality of the content. Proposers who submit more than the pages indicated may not have the additional pages of the proposal read or considered.

## **Proposal Contents and Organization**

You must provide all information requested in this RFP in your response. Responses must follow the format outlined in this RFP. We will not consider additional or unrequested materials.

Follow the order outlined in [Section 8: Proposal Checklist](#) for your submission.

## **Proposal Submission Instructions**

Submit one (1) Adobe PDF electronic copy clearly marked “Master” or “Original,” and if redactions are requested, one (1) additional electronic copy, in MS Word format with redactions made (the Redacted for Public Disclosure Copy) through the City’s Online Procurement Center (BuySpeed) at:

<https://procure.portlandoregon.gov/>

The entire proposal must be submitted before the due date. Allow extra time to upload proposal documents.

Instructions for submitting through BuySpeed are detailed in Attachment 1 – Buyspeed Submittal Instructions and are also available at:

<https://www.portland.gov/business-opportunities/documents/buyspeed-electronic-submittal-instructions/download>

<https://www.portland.gov/business-opportunities/documents/guia-de-envio-de-documentos-de-proveedores-para-buyspeed/download>

Proposers may request additional assistance from City staff with the submittal process prior to the proposal due date listed on the cover page of this RFP. Assistance is based on the availability of City staff and all requests for assistance shall be sent via email to the contact listed on the cover page of this RFP.

Requests for scheduled assistance shall be made at least one (1) week prior to the proposal due date. Requests for assistance after the scheduling deadline will be based on availability of staff to respond to requests. Assistance by City staff does not guarantee proposal submission will be completed accurately, on-time, or that proposals will be considered responsive. Compliance with all proposal submission requirements are still the responsibility of the Proposer even if assistance is provided.

To avoid potential issues with the submission of Proposal Documents, Proposers should avoid file names that utilize special characters (e.g. &\*-\_+#@). Proposers should limit file names to no more than sixty (60) characters in length. Proposers should attempt to reduce the size of files being submitted to reduce the chance of failure of uploading documents in Buyspeed.

Disclaimer: These instructions are advice only and the City does not warrant that following these instructions will guarantee that a proposer's proposal is submitted correctly. Proposers bear complete and total responsibility for ensuring their proposal is properly submitted and received on time.

The entire proposal must be properly submitted through the City's Online Procurement Center (BuySpeed) before the time and date specified on the cover page of this RFP. Proposers are advised to allow extra time to upload their proposal documents into BuySpeed.

## **Modifying or Withdrawing Your Submission**

You can modify or withdraw your submission through the City's Procurement Website, BuySpeed, any time before the proposal due date.

# Section 8: Required Proposal Components

Proposers must provide all information requested by the City in this RFP in their Response. Responses must follow the format outlined in this RFP. Additional or unrequested materials, and proposals submitted in other formats, may not be considered.

This Proposal will include three separate packages delineated in subsections 1, 2, and 3 below:

Package 1 – Pricing Schedules

Package 2 - Technical Proposal (a-j)

Package 3 – Corporate Responsibility (a-d)

## Proposal Checklist

Each complete proposal must contain the following, in the order indicated below:

Proposal Component	Required/Optional	Included in page limit?	<input checked="" type="checkbox"/>
<b>Package 1 – Pricing Schedules (Attachment F)</b>			
Pricing Schedules (Attachment F)	Required	N	<input type="checkbox"/>
<b>Package 2 – Technical Proposal (a-j)</b>			
<b>a. Cover Letter</b>	Required	N	<input type="checkbox"/>
<b>b. Proper Information Form (Attachment B)</b>	Required	N	<input type="checkbox"/>
<b>c. Documentation and Certifications (Attachments G, H, K, and L)</b>	Required	N	<input type="checkbox"/>
<b>d. Qualifications</b>	Required	Y	<input type="checkbox"/>
<b>e. Delivery and Production Schedule</b>	Required	Y	<input type="checkbox"/>
<b>f. Compliance to Technical Specification</b>	Required	Y	<input type="checkbox"/>
<b>g. Off Wire Capabilities</b>	Required	Y	<input type="checkbox"/>
<b>h. Detailed Information</b>	Required	Y	<input type="checkbox"/>
<b>i. Exceptions and Deviations to Contract (Attachment E)</b>	Optional	N	<input type="checkbox"/>

<b>j. Redaction Summary Form (Attachment C)</b>	Required if Redacted for Public Disclosure Copy is provided.	N	<input type="checkbox"/>
<b>k. Redacted for Public Disclosure Copy</b>	Optional	N	<input type="checkbox"/>
<b>Package 3 – Corporate Responsibility (a-d)</b>			
<b>a. Equal Employment Opportunity and Access in Subcontracting</b>	Required	Y	<input type="checkbox"/>
<b>b. Equal Opportunity Employer and Community Involvement</b>	Required	Y	<input type="checkbox"/>
<b>c. Sustainable Business Practices</b>	Required	Y	<input type="checkbox"/>
<b>d. Civil Rights Data Collection (Attachment J)</b>	Required	N	<input type="checkbox"/>

## Package 1 - Pricing Schedules

Proposers shall submit one (1) original signed Pricing Schedules, (Attachment F). Pricing must be submitted on Attachment F without taking into account any applicable tariffs that are currently and may potentially be put into place. The roadmap for including tariffs will be delineated in the resulting contract with the successful proposer.

## Package 2 – Technical Proposal

### a. Cover Letter.

The Proposal Cover Letter shall include a general statement of the purpose for submission and must be signed by a legal representative of the proposer who is authorized to bind the proposer in contractual matters. A proposer's submission of a proposal through BuySpeed constitutes an electronic signature of the proposal.

Additionally, the letter should discuss the proposed team organization (including all subcontractors); discuss proposed staffing and staffing commitments (including the Project Manager and key staff); affirm that all DBE requirements, if required, will be met; and be signed by an individual(s) authorized to bind the Proposer. The introductory letter should also include location of offices, appropriate telephone numbers, email addresses, individual to contact regarding this proposal, and any other information Proposers may deem pertinent and introductory in nature.

### b. Proposer Information Form

Proposers shall fully complete and submit the Proposer Information Form (Attachment B).

### c. Documentation and Certifications

The proposers shall submit the documents and certifications with their proposal documents:

1. Buy America Certification Form, (Attachment G)
2. Transit Vehicle Manufacturers (TVM) Certification Form, (Attachment H)
3. Debarment Certification Form (Attachment K)
4. Lobbying Certification Form (Attachment L)

### d. Qualifications

#### **1. Previous Experience and Proposed Streetcar**

The Proposer shall provide a description of its recent design and manufacturing experience in providing streetcars and light rail vehicles, including the streetcar proposed to the City, and fleets presently under design and/or construction and highlighting streetcars and low floor light rail vehicles.

Include the following for each vehicle order:

- Purchasing Agency



- Contact person (including name, title, phone number, and e-mail address) at the Purchasing Agency. the City may discuss any aspect of contract performance with each named individual. the City also reserves the right to discuss the Proposer's performance with other individuals at its discretion.
- Order size
- Schedule performance in delivery of the vehicles, i.e., original contract requirements v. actual delivery
- Differences between the vehicle supplied and the vehicle specified herein
- Revenue service miles accrued to date (if any)
- Describe past performance, including all contracts awarded with similar responsibility and scope within the last ten (10) years.
  - Identify how the Proposer met or did not meet a prior contract production schedule.
  - Explain if the Proposer has been late on prior contracts schedules and/or has the Proposer ever been assessed for liquidated damages (LDs) or have LDs been waived on previous contracts.

## **2. Manufacturing Capability**

The Proposer shall provide a comprehensive description of its manufacturing capability, including:

- Identification of current and expected workload, backlog, and capability to implement this order within the proposed schedule.
- Identification of the location where the vehicle shell will be and the experience level of this location in performing streetcar or light rail vehicle work.
- Identification of the location where the truck frames will be and the experience level of this location in performing truck frame fabrication work.
- Full description of the equipment, special machinery, and test facilities available at the vehicle shell manufacturing facility.
- Location of the following test facilities:
  - Carbody compression test facility
  - Truck static load and fatigue test facility
- Identification of all locations where major subassembly work will be performed
- Identification of the location of final assembly and the experience level of this location in performing this type of work.
- Identification of the location of truck assembly and the experience level of this location in performing this type of work.
- Prime Contractor's present and expected manufacturing backlog, and how this order will "mesh" with existing and expected orders.

## **3. Staffing Plan and Resumes**

Identify key personnel, including Project Manager, that would be assigned to this contract and provide a summary of their qualifications and percentage of their time dedicated to this contract.

Proposer shall demonstrate the adequacy of its staffing plan by providing the following:

- Project Organization Chart, including definitions of the functions shown thereupon, including as a minimum the place of the project management within the Proposer's overall organization and the organizations for the overall project, engineering,

manufacturing, and quality assurance. The chart shall indicate the authority and placement of all key Project personnel, including the Contractor's Project Manager. Key subcontractor personnel who will interface regularly with the Prime Contractor, and who will be given significant program authority, shall also be shown on this chart.

- Engineering design manpower loading requirements vs. projected availability.
- Quality Assurance manpower loading requirements vs. projected availability.
- Manufacturing manpower loading requirements vs. projected availability.

The Proposer shall provide resumes for all key personnel listed on the organization chart (including subcontractor personnel, as appropriate). Each resume shall contain the following, in the order given below:

- Corporate Title and affiliation
- Program Title
- Relevant Education
- Relevant Experience
- Brief description of the Project function they will fulfill, including decision-making responsibilities
- Percentage of time to be dedicated to this Project, by year

#### 4. Subcontractors

Provide a list of all proposed subcontractors for this project.

For each subcontractor proposed for each of the thirteen major vehicle systems, the Proposer shall provide a description of the subcontractor's relevant experience in the design and supply of that type system on streetcars or light rail vehicles. Include the following for each major system order:

- Prime Contractor
- Purchasing Agency
- Contact persons at the purchasing agency, for reference purposes
- Model number (or other identifier) of the system provided
- Number of units provided
- Significant differences between the system to be supplied and the system specified by the City
- Schedule performance in delivery of the system, including original promised delivery and actual delivery of systems

#### 5. Design, Planning Quality Assurance & Workflow.

Demonstrate an understanding of the work and provide a detailed description of how your firm will perform the tasks and assure all requirements will be met as described in the Sample Contract (Attachment D - Exhibit B – Statement of Work, and Exhibit C – Technical Specification).

Proposer shall demonstrate, through a single flow chart and narrative, how the vehicle design effort will be managed. Narrative should be keyed to flow chart. Factors that should be addressed in both the flow chart and narrative include:

- Where the design effort for each major vehicle system and/or component will be affected.
- How the Proposer as SCV Manufacturer will insure that the design (including subcontractor designs) incorporates all specification requirements.
- How the SCV Manufacturer will coordinate the design effort amongst the various subcontractors; that is, how the systems engineering and integration effort will be set up, managed, and carried out.
- How Quality Assurance of the design will be implemented.
- Description of checks and balances in place to insure a safe design.
- How City of Portland review comments will be fed back into the overall engineering design effort.
- How First Article and Design Qualification testing results will be fed back into the overall design effort.
- How will any language translation times be accounted for as part of the design, manufacturing, QA, and testing processes.

A second flow chart and narrative shall be provided to describe the Proposer's Quality Assurance organization. The narrative in each case should be keyed to the flow chart. Factors to be addressed include:

- Interface and controls between the SCV Manufacturer's design and manufacturing groups
- Interface and controls between SCV Manufacturer's and subcontractor's manufacturing groups
- Carbody assembly facility work flow and stationing
- Material control
- A complete description of the Proposer's Quality Assurance program. This description must include:
  - The structure of the Proposer's QA Department
  - The number of QA professionals expressed as a percentage of the total manufacturing workforce
  - How Quality Assurance maintains independence from manufacturing
  - How Quality Control inspectors maintain independence from manufacturing
  - How Quality Control problems are fed back into the manufacturing process and resolved
  - How Configuration Control is managed
- Proposer's documentation resources, including all specifications and standards identified in the Technical Specifications.

## **e. Delivery and Production Schedule**

Delivery and production schedules are of critical importance to City of Portland. Proposers shall submit a CPM schedule reflecting SCV delivery for the base SCVs as required in City of Portland's delivery schedule in as reflected in Sample Contract (Attachment D), Exhibit B – Statement of Work.

The maximum of 25 points reflected in this evaluation criterion will be allocated to a Proposer who submits a CPM Schedule that meets or exceeds the delivery schedule. Proposers must also submit documentation, its assumptions and rationale that support its CPM Schedule.

A CPM schedule and milestone dates that differ from the requirements of as reflected in Sample Contract (Attachment D), Exhibit B – Statement of Work will be evaluated under best value and given a prorated portion of the 25 points.

As a minimum, the events to be included in the Proposer's schedule are as follows (Proposer may include additional events as appropriate):

- Submittal of general arrangement drawings
- Each major subsystem contractor placed under contract
- Preliminary and final design reviews of each major subsystem
- First Article inspections of major subsystems and components
- Commence first SCV shell parts manufacture
- Commence first SCV shell major assembly
- Complete first bare SCV shell prior to painting
- Car shell static load test
- Complete first SCV set of truck frames
- Truck frame fatigue test
- Ship first SCV shell to final assembly site, if separate
- Commence first SCV final assembly
- Complete equipment installation on first SCV
- Final truck mounting on first SCV
- First Article inspection of first SCV
- Shipment of first SCV to City of Portland's Operations and Maintenance Center (OMC)
- Arrival of first SCV at the OMC
- Shipment/arrival of second SCV to OMC (2 SCVs required for Testing)
- Shipment/arrival of third SCV to the OMC
- Complete design qualification test series on first, second and third SCV
- Completion of each SCV shell in base order
- Shipment of each SCV to the OMC
- Arrival of each SCV at the OMC
- Contractual Delivery of each SCV (turnover to City of Portland)
- Reliability Demonstration Test

## **f. Compliance to Technical Specification**

Technical and Qualifications Information must include information in the categories listed below, arranged in separate sections corresponding to those categories. The Proposer shall demonstrate its ability to comply with the Technical Specifications within this Request for Proposals by response to the following items. The Proposal shall be formatted, numbered and lettered to exactly coincide with the outline below.

### 1. General Arrangement Drawings.

- Provide six (6) general arrangement drawings to scale with appropriate dimensions as follows
  - Vehicle Plan View (external)
  - Vehicle Side View (external)
  - Vehicle Front View (external)
  - Vehicle Roof Equipment Arrangement (external)
  - Vehicle Seating and Cab Arrangement (internal plan view)
  - Vehicle Underframe Equipment Arrangement
- Provide five (5) transverse sections at the following locations
  - Low floor section at truck
  - Low floor section end door
  - Low floor section between doors
  - Low floor section center door
  - Low floor center section
- Provide artist renderings of the interior and exterior of the vehicle
  - Exterior end view
  - Exterior side view
  - Exterior side view with doors open
  - Interior view of passenger end section
  - Interior view of passenger center section

### 2. Vehicle Weight Schedule.

Provide passenger numbers and a gross vehicle weight schedule as follows:

*(including train operator except for AW0, Passenger 70 kg each)*

	Passenger Criteria	Number of Passengers	Total Weight
AW0	Empty		
AW1	Fully seated load of passengers minimum, plus one Operator		
AW2	Seated + standees @ 4/m <sup>2</sup>		
AW3	Seated + standees @ 6/m <sup>2</sup>		
AW4	Seated + standees @ 6.6/m <sup>2</sup>		

### 3. Dynamic Performance.

Provide a dynamic performance simulation confirming the vehicle's capability to continually operate on the intended alignment (both the on-wire and off-wire segments). The simulation shall be performed over the alignment. Provide a graph of basic vehicle performance for the propulsion system proposed, as follows:

Present basic vehicle propulsion and braking performance in the form of a graph; the data shall be based on a vehicle loaded to AW2 with an overhead contact wire voltage of 750 Vdc. Acceleration shall be at the specified maximum values of 1.34 m/s<sup>2</sup> for both propulsion and braking. The empty weight of the vehicle and AW2 weight used in the calculations shall be stated.

The horizontal axis shall show vehicle speed from 0 to 57 km/h. Three vertical axes shall be provided, showing (1) tractive effort, (2) acceleration rate, and (3) catenary current. Tractive effort shall be shown as positive values for both propulsion and braking. Data shall be presented for the full indicated speed range.

Data presented shall be:

- Acceleration in braking and motoring
- Tractive effort for the propulsion equipment during motoring
- Tractive effort for the propulsion equipment during dynamic braking
- Tractive effort for the friction brake system
- Line current, including motoring and regeneration
- Bi-directional OESS current including tractive, regenerative and auxiliary loads
- Charge level of the OESS system as a percentage of full charge

In addition, the Proposer shall submit, for the candidate propulsion system and brake system, a computer simulation of streetcar performance of a round trip over each route including the Montgomery Park extension on the NS line. The simulations shall be based on the following parameters:

- 500, 600, 750, and 900 VDC nominal catenary voltages
- New wheels
- AW2 passenger load
- 1.34 m/s<sup>2</sup> acceleration and brake rate (acceleration may be voltage-limited as permitted in the Technical Specifications.)
- 30 seconds of dwell time at each intermediate station
- 2-minute layover at each terminus
- Maximum allowable speeds for alignment conditions, grades, curves, etc.

The computer model shall output the following which shall be provided in printed form:

- Station-to-station, and end-to-end round-trip times
- Average schedule speed, and average and peak speeds in each station-to-station segment
- Total energy consumption (assume no regenerated energy)
- Average and peak RMS line current for each station-to-station segment
- Motor temperature
- Braking resistor temperature (assume no regenerated energy)
- Braking disc temperature

The Proposer shall include an analysis of the results including a discussion of the simulation and the effect of changing operational parameters such as top speed or acceleration.

Recommendations for optimizing the operation of the proposed OESS are required. The

analysis shall also include the estimated total range of the streetcar operating on the onboard energy storage system across the entire terminus to terminus route.

#### **4. Vehicle Technical Specifications.**

Provide information, technical compliance, for each of the following items, as described in the Sample Contract, Attachment D, Exhibit C Technical Specification. The following general information shall be provided for the items:

- Basic system configuration
- System integration
- All appropriate system and key component ratings
- Identification of any differences between the proposed system and components and existing service-proven designs
- Service history of each proposed system, including:
  - Agency name and address
  - Agency contact person and phone number
  - Number of units provided
  - Revenue service history to date
  - Available reliability data

Sample Contract, Attachment D, Exhibit C Technical Specification Items:

- Section 4, Design and Performance Criteria
- Section 5, Operator's Cab
- Section 6, Interior and Exterior Appointments
- Section 7, Electronic Controls, Software, and MDS
- Section 8, Communication Systems
- Section 9, Passenger Doors
- Section 10, HVAC
- Section 11, Lighting
- Section 12, Electrical Equipment
- Section 13, Propulsion System
- Section 14, Carbody
- Section 15, Trucks
- Section 16, Brake Systems
- Section 17, Coupler
- Section 18, Vehicle and Systems Testing
- Section 19, Materials and Workmanship

#### **5. Vehicle System Support.**

Provide information for compliance with the Sample Contract, see Attachment D, Exhibit C, Technical Specification Section 3, System Support.

- Manuals and Catalogs
- Special Tools and Diagnostic Test Equipment
- Training
- Spare Parts

- Technical Support Personnel
- Firmware/Software updates

## **g. Off-Wire Capabilities**

### **1. General Description.**

Provide a general description of the proposed Onboard Energy Storage System (OESS). List any exceptions proposed to be taken to the TS OESS requirements, providing an explanation for each exception as to why it is being requested.

### **2. Warranty and Lifecycle Costs.**

Provide a comprehensive statement of warranty terms relating to the battery, including a description of any and all disclaimers, in the vehicle proposal package. Describe the battery replacement procedure. Describe the charge cycle and cycle life of the OESS, and provide a life cycle cost analysis of the proposed OESS.

## **h. Detailed Information**

### **1. System Suppliers.**

The Proposer may identify a maximum of two suppliers for each major subsystem; suppliers may be proposed subcontractors to the Proposer or the Proposer may list itself as a supplier of any of the items. The City will notify the Proposer, as a result of the review of the Proposals, of any suppliers who have been found not compliant with the specification, or who have insufficient experience, or who are not acceptable to the City due to poor performance on previous programs, or who are unacceptable for other reasons.

For each major subsystem, provide a description of the hardware, including the following:

- All appropriate system and component ratings
- Basic system configuration
- Model numbers of major components
- Service history of each proposed system, including:
  - Property references
  - Contact Person
  - Vehicle-miles and time in revenue service to date

The brief descriptions of the major systems shall be tabbed or denoted.

## **i. Exceptions and Deviations**

### **1. Sample Contract.**

The Sample Contract attached as (Attachment D) contains the terms and conditions that will govern the resulting Contract between the City and the Contractor.

As part of the Evaluation Phase 2 shortlisted proposers shall be required to submit exceptions and deviations to the City's Sample Contract. The proposer must identify the specific provision the proposer would like to negotiate, provide an explanation of why the proposer



believes the provision should be a negotiable provision, and provide the suggested revised language. This RFP contains a Sample Contract Exception and Deviation Form (Attachment E) for submission as part of Evaluation Phase 1. Exception and deviation requests that are not submitted in the format of Attachment E may not be considered. Requests that state the entire Contract be negotiated will not be considered.

### 1. Technical Specifications.

The Proposer must certify that the proposed vehicle meets all the requirements of the specification except as noted below.

In the first phase (prior to any BAFO), deviations or exceptions or substitutions or approved equals to the requirements in the RFP may be submitted with the technical proposal for the City of Portland's consideration. The exception spreadsheet must explain the reasons for each request for deviation, exception, substitution, or alternate requirement, identifying the appropriate Section(s) of the Technical Specifications, and providing revised language or deletions.

Any such deviations will be discussed with the Proposer if the Proposer is found to be within the competitive range during the first phase. As a result of such discussions, the City of Portland may issue addenda incorporating such deviations it considers to have merit when it issues the Request for BAFO. No deviations, substitutions, or alternate requirements will be allowed in the BAFO.

Proposers are advised that extensive deviations that change the basic characteristics or performance of the vehicle or the nature of the procurement may be grounds to render the Proposal non-responsive.

#### (a) Exceptions format

Exceptions and relevant information must be provided as detailed in the Table below. The exceptions shall be provided with proposals in a spreadsheet format, marked "Exceptions to RFP".

Solicitation Document	Paragraph/Page	Requirement	Rationale/ Revised Language	Impacts On
RFP, Specifications, Exhibits, Attachments, Amendment	Applicable Document, Page, Section, Paragraph, Sentence	Identify the requirement or portion to which the exception is taken	Proposers justification why the requirement will not be met and its alternative strategy or position	Delivery, Price, Performance, or Other

### j. Proposal Redactions for Public Records Purposes

Any portion of a proposal that the proposer claims as exempt from disclosure must meet the requirements of Oregon public records law. When preparing their proposal submission, if the proposer requests redactions to their proposal, the proposer shall provide one (1) "Redacted for Public Disclosure" copy of the proposal in unprotected

MS Word format with the requested redactions highlighted in yellow with their submission. The “Redacted for Public Disclosure” copy shall be a complete copy of the submitted proposal, in which all information that the proposer deems to be exempt from public disclosure has been identified. The proposer shall also include a completed “Redaction Summary Form” (Attachment C) detailing the location of all redacted information and reason for redaction.

When exempt information is mixed with nonexempt information on the same page, the exempt information must be redacted in such a way as to allow the disclosure of the non-exempt information. Should the proposer determine that no redactions are required, that should be indicated in the proposer Information Form. If a proposer fails to submit a “Redacted for Public Disclosure” copy of their proposal as required, the City may release the proposer’s original proposal without redaction.

## Package 3 – Corporate Responsibility

The City of Portland is committed to contracting with equitably aware and environmentally responsible businesses. The City values and supports diversity, advancing equity, and is dedicated to expanding economic opportunities by growing both the demand for and capacity of local contractors, including those owned by people of color and women.

### a. Equal Employment Opportunity and Access in Subcontracting

#### ***1. How are you providing equal opportunity and access in subcontracting for all businesses, including minority- and women-owned businesses?***

Your approach and description must, at a minimum, address the following:

- Describe your firm’s approach and methodology for identifying subconsultant opportunities (including suppliers, manufacturers and services) as an equal opportunity employer.
- How outreach will be conducted to inform subconsultant opportunities.
- Any mentoring and technical assistance to be made available to subconsultants.
- Any strategies, methods, initiatives, or examples of innovation to provide equal opportunity and access which may be utilized in the execution of the work.
- How do you balance establishing new relationships with firms vs. sustained engagement with trusted business partners?

**2. For three (3) projects worked during the past three (3) years, for either public agency or non-public agency projects, list:**

- Project Name
- All subconsultants utilized under those projects
- Total project value (including amendments, if any)
- Total project dollars
- Percentage of total project dollars paid to each subconsultant

**b. Equal Opportunity Employer and Community Involvement**

**1. List the top three actions/ongoing practices your firm has implemented to ensure you provide opportunities for, and remove barriers to, employment in your workforce for everyone, including women and people of color, at all levels of your firm (e.g., upper management, middle management and lower-level management).**

For each of the three actions, address the following:

- Describe the action or ongoing practice
- Describe when you started and any timelines for implementation
- Describe any performance metrics that characterize these achievements or third-party awards/recognition

**2. Describe your firm's approach to the following:**

- How do you approach internal on-the-job training, mentoring, technical training, and/or professional development and advancement opportunities for your workforce?
- Describe your firm's employee compensation structure, (e.g., living wages, healthcare coverage, employee leaves, dependent care, etc.)
- Describe your firm's commitment to community service (e.g., charitable programs, scholarships, economic development, etc.)

### c. Sustainable Business Practices

The City identifies Sustainable Procurement as a procurement that has the greatest positive environmental, social, and economic impacts possible over the entire life cycle. Sustainable procurement involves the sustainability aspects related to the goods, services, and suppliers along the supply chains. Sustainable procurement contributes to the achievement of organizational sustainability objectives and to overall sustainable development.

- 1. List the top three actions/ongoing practices your firm has implemented to ensure you provide opportunities for, and remove barriers to, employment in your workforce for everyone, including women and people of color, at all levels of your firm (e.g., upper management, middle management and lower-level management).***

For each of the three actions, address the following:

- Describe the action or ongoing practice
- Describe when you started and any timelines for implementation
- Describe any performance metrics that characterize these achievements or third-party awards/recognition

- 2. Does your firm hold any third-party certifications related to sustainable business operations? (e.g. B-Corp certification or similar)***

If so, provide the following:


- Name of the Certification
- Links to the certification requirements
- Name of organization who administers the certification

### d. Civil Rights Data Collection

The information provided in this section will be retained separately and will not be used for purposes of evaluating and scoring proposals. Please complete and return the Civil Rights Data Collection form, attached hereto as Attachment J.

# BuySpeed Electronic Submittal Instructions

These instructions are for uploading electronic attachments to a BuySpeed solicitation. The process is not intuitive, and the nomenclature of the system can sometimes be misleading. There are also a number of fields that are not necessary for City of Portland submittals, so these instructions will highlight only those fields that are necessary for City submittals. Please plan at least 30 minutes to submit your proposal, and when possible, submit your bid at least one business day before it is due.

**Step 1:** log in to the BuySpeed system. <https://procure.portlandoregon.gov>. Make sure you are in the “seller” not the “seller admin” role by clicking on this icon on the top right corner of the page:  and select “seller.”

Then navigate to the solicitation number. Click the solicitation number link to open the solicitation page containing a summary of the solicitation information. The resulting page should look similar to the image below.

Bid Solicitation: 00000694

---

### Header Information

<b>Bid Number:</b>	00000694	<b>Description:</b>	SUBMITTAL UPLOAD INSTRUCTIONS	<b>Bid Opening Date:</b>	09/20/2017 12:00:00 PM
<b>Purchaser:</b>	Jeff Blade	<b>Organization:</b>	City of Portland		
<b>Department:</b>	GOODSANDSERVICES - Goods & Services	<b>Location:</b>	GS - Goods & Services		
<b>Fiscal Year:</b>	17	<b>Type Code:</b>	04 - G&S RFP	<b>Allow Electronic Quote:</b>	Yes
<b>Alternate Id:</b>		<b>Required Date:</b>		<b>Available Date :</b>	09/19/2017 02:27:17 PM
<b>Info Contact:</b>	Contact Jeff Blade at (503)823-6858	<b>Bid Type:</b>	OPEN	<b>Informal Bid Flag:</b>	No
<b>Purchase Method:</b>	Open Market				

**Pre Bid Conference:** None.

**Bulletin Desc:** Electronic submittal upload instructions.

<b>Ship-to Address:</b>	Please See Solicitation Documents City of Portland Portland, OR 97204 US Email: test@periscopeholdings.com Phone: (123)456-7890	<b>Bill-to Address:</b>	Please See Solicitation Documents City of Portland Portland, OR 97204 US Email: test@periscopeholdings.com Phone: (123)456-7890	<b>Print Format:</b>	
-------------------------	--	-------------------------	--	----------------------	--

**File Attachments:** [Instruction.txt](#)

**Form Attachments:**

---

### Item Information

**Item # 1: ( 918 - 58 ) SUBMITTAL UPLOAD INSTRUCTIONS**

NIGP Code: 918-58  
Governmental Consulting

Qty	Unit Cost	UOM	Total Discount Amt.	Tax Rate	Tax Amount	Total Cost
1.0		EA - Each				

<b>Manufacturer:</b>	<b>Brand:</b>	<b>Model:</b>
<b>Make:</b>	<b>Packaging:</b>	

Print Page

Create Quote

Bid Q & A

Exit

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**Step 2:** Click the “Create Quote” button at the bottom of the page to start the quote wizard. “Quote” is a generic term in the BuySpeed environment for a solicitation submittal. City solicitation documents generally refer to submittals as “**Bid**”, “**Proposal**”, or “**Quote**”, depending on the type of solicitation.

**Item # 1: ( 918 - 58 ) SUBMITTAL UPLOAD INSTRUCTIONS**

NIGP Code: 918-58

Governmental Consulting

Qty	Unit Cost	UOM	Total Discount Amt.	Tax Rate
1.0		EA - Each		
Manufacturer:		Brand:		
Make:		Packaging:		

Print Page

Create Quote

Bid Q & A

Exit

**Step 3:** The screen will open to the “General” tab. If you would like to insert contact info or comments for your own reference, you can do that in the appropriate boxes, but additional information in this tab is not required. Click the “Save & Continue” button when ready to move to the next step.

## New Quote

[General](#) [Items](#) [Questions](#) [Subcontractors](#) [Notes](#) [Terms & Conditions](#) [Attachments](#) [Summary](#) [Back to Bid](#)

Quote #:		Bid #:	00000694
Organization:	City of Portland	Description*:	SUBMITTAL UPLOAD INSTRUCT ×
Status:	In progress	Discount Percent:	0.0 %
Delivery Days:	0	Alternate Bid:	<input type="checkbox"/>
Is "No Bid":	<input type="checkbox"/>	Freight Terms:	▼
Shipping Terms:	▼	Payment Terms:	▼
Ship Via Terms:	▼		
Promised Date: (MM/DD/YYYY)	<input type="text"/>		
Info Contact:	<input type="text"/>		
Comments:	<input type="text"/>		
Date Last Updated:	User Last Updated:		

Save & Continue

**Step 4:** You'll now see a warning at the top of the page stating that the terms and conditions are not acknowledged. Ignore that for now as the error will be addressed in Step 6.

Quote Validation Errors

Terms & Conditions is not acknowledged.

Quote Validation Warnings

Your quote has not been submitted.

Quote 00000939 - Magic Nose Goblins Inc

General

Items

Questions

Subcontractors

Notes

Terms & Conditions

Attachments

Summary

Back to Bid

Other Quotes for this bid by the same vendor: 00000938

Quote #:

00000939

Bid #:

00000694

Organization:

City of Portland

Status:

In progress

Description\*:

SUBMITTAL UPLOAD INSTRUCTIONS

Delivery Days:

0

Discount Percent:

0.0

%

Is "No Bid":

☐

Alternate Bid:

☐

Shipping Terms:

▼

Freight Terms:

▼

Ship Via Terms:

▼

Payment Terms:

▼

Promised Date:

(MM/DD/YYYY)

Info Contact:

Comments:

Date Last Updated:

09/20/2017 10:56:06 AM

User Last Updated:

Stimpson J Cat

Save & Continue

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**Step 4a:** Click the “Items” tab. This tab is important because there are fields here that must be completed in order to submit a quote.

Quote 00000939 - Magic Nose Goblins Inc

General **Items** Questions Subcontractors Notes Terms & Conditions Attachments Summary [Back to Bid](#)

**General** Notes

Sort by Column: Print Sequence ☐ Sort Descending

Item #	Print Sequence	Questions Exist	Description	Quantity	UOM	Unit Cost	Discount %	Tax Rate	Freight	Extended Amount	No Bid	No Charge	See Quote Attachment (s)
1	1.0	No	SUBMITTAL UPLOAD INSTRUCTIONS	1.0	EA	0.00	0.0		0.00	\$0.00	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
Alternate Description : <input type="text"/>													
											Quote Response Total \$0.00		

**Step 5b:** Enter the total amount from your bid, quote or proposal, in the “Unit Cost” field. If your submittal does not include a total amount, use \$10 as the value. After entering an amount, click the “Save & Continue” button.

Item #	Print Sequence	Questions Exist	Description	Quantity	UOM	Unit Cost	Discount %	Tax Rate	Freight	Extended Amount	No Bid	No Charge	See Quote Attachment (s)
1	1.0	No	SUBMITTAL UPLOAD INSTRUCTIONS	1.0	EA	750000.00	0.0		0.00	\$0.00	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
Alternate Description : <input type="text"/>													
											Quote Response Total \$0.00		

**!** Discount only quotes indicate discount amount off of list catalog price.



**Step 5c:** Both the “No Bid” and “No Charge” checkboxes should be cleared, and the “Quote Response Total” has been calculated. Uncheck each checkbox if still checked.

Description	Quantity	UOM	Unit Cost	Discount %	Tax Rate	Freight	Extended Amount	No Bid	No Charge
SUBMITTAL UPLOAD INSTRUCTIONS									
	1.0	EA	750000.00	0.0	▼	0.00	\$750000.00	<input type="checkbox"/>	<input type="checkbox"/>
							Quote Response Total	\$750000.00	

**Step 6a:** Click the “Terms & Conditions” tab.

Click the “Yes” radio button to accept the terms and conditions of the solicitation, and then click the “Save & Continue” button.

### Quote 00000939 - Magic Nose Goblins Inc

General Items Questions Subcontractors Notes **Terms & Conditions** Attachments Summary [Back to Bid](#)

The following list constitutes all the attachments for the bid which may include supplemental terms and conditions.

File Name	Description	File Size
<a href="#">Instruction.txt</a> <a href="#">(view details)</a>	This instruction is for uploading submittal documents electronically in BuySpeed.	81 bytes


Do you accept the terms & conditions of the bid?

☒ Yes ☐ Yes with exceptions ☐ No

If you do not fully accept the terms & conditions, please note the exceptions below:

[Save & Continue](#)

**Step 6b:** You'll see that the terms & conditions warning message is gone.

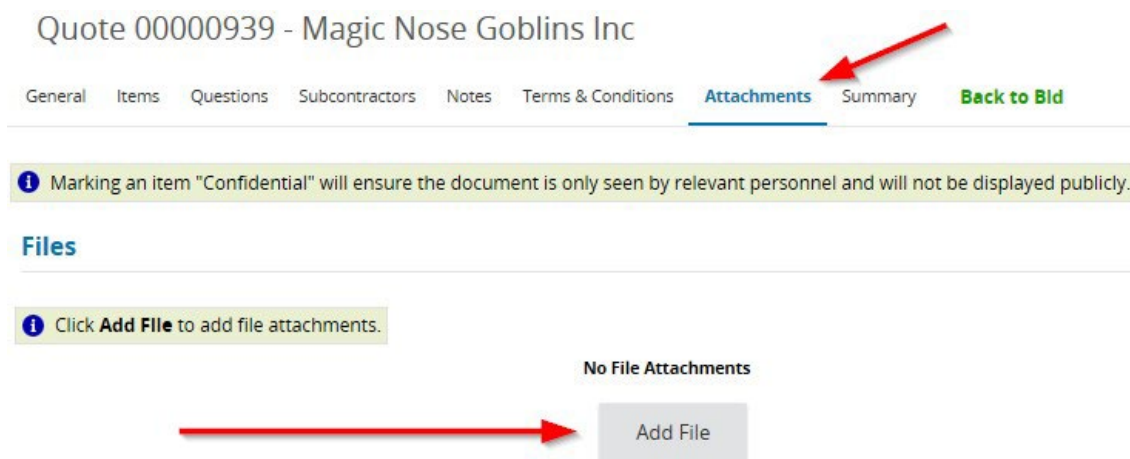


**Quote Validation Warnings**  
Your quote has not been submitted.

Quote 00000939 - Magic Nose Goblins Inc

General Items Questions Subcontractors Notes **Terms & Conditions** Attachments Summary

**Step 7a:** Click the "Attachments" tab. Then click the "Add File" button.



Quote 00000939 - Magic Nose Goblins Inc

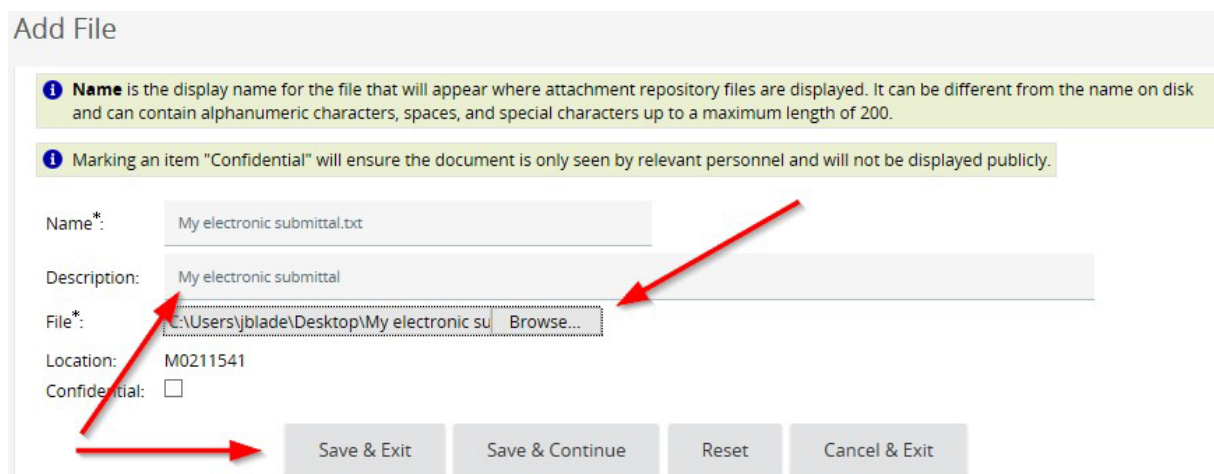
General Items Questions Subcontractors Notes Terms & Conditions **Attachments** Summary [Back to Bid](#)

**Files**

**No File Attachments**

**Add File**

**Step 7b:** Type a description for the file in the "Description" field. Then click the "Browse..." button and navigate to the file location. When the file is attached, click the "Save & Exit" button to upload it. Repeat this as necessary for any additional files.



**Add File**

**Name** is the display name for the file that will appear where attachment repository files are displayed. It can be different from the name on disk and can contain alphanumeric characters, spaces, and special characters up to a maximum length of 200.

Marking an item "Confidential" will ensure the document is only seen by relevant personnel and will not be displayed publicly.

Name\*: My electronic submittal.txt

Description: My electronic submittal

File\*: C:\Users\blade\Desktop\My electronic su **Browse...**

Location: M0211541

Confidential: ☐

**Save & Exit** **Save & Continue** **Reset** **Cancel & Exit**

**Step 7c:** After a document is uploaded, it will appear with its details under the “Attachments” tab.

The number in parentheses appended to the tab label denotes how many files have been uploaded.

You can also delete files by clicking the “Delete” checkbox next to the appropriate file and then clicking the “Save & Continue” button.

Quote 00000939 - Magic Nose Goblins Inc

General Items Questions Subcontractors Notes Terms & Conditions **Attachments(2)** Summary [Back to Bid](#)

**1** Marking an item "Confidential" will ensure the document is only seen by relevant personnel and will not be displayed publicly.

**Confirmation Messages**

Changes saved successfully.

**Files**

Name	Description	Confidential	Order	Attached By	Attached Date	Delete
<a href="#">My submittal.txt</a> <a href="#">(view details)</a>	First doc	<input type="checkbox"/>	1	Stimpson J Cat	09/20/2017	<input type="checkbox"/>
<a href="#">Attachment.txt</a> <a href="#">(view details)</a>	Second doc	<input type="checkbox"/>	2	Stimpson J Cat	09/20/2017	<input type="checkbox"/>

[Save & Continue](#) [Add File](#)

**Step 8:** Click the “Summary” tab, and then click the “Submit Quote” button to complete the quote process.

**Note:** If this last step is NOT completed, the quote will not have been submitted.

Quote 00000939 - Magic Nose Goblins Inc

General Items Questions Subcontractors Notes Terms & Conditions Attachments(2) **Summary** Back to Bid

---

**Header Information**

<b>Quote #:</b>	00000939	<b>Bid #:</b>	00000694	<b>Status:</b>	In progress
<b>Organization:</b>	City of Portland				
<b>Description:</b>	SUBMITTAL UPLOAD INSTRUCTIONS	<b>Delivery Days:</b>	0	<b>Discount Percent:</b>	0.0
<b>Bid Flag:</b>		<b>Alternate Bid:</b>	No	<b>Shipping Terms:</b>	
<b>Freight Terms:</b>		<b>Ship Via Terms:</b>		<b>Payment Term:</b>	
<b>Promised Date</b>		<b>Info Contact:</b>		<b>Quote Total</b>	\$750,000.00
<b>Comment:</b>	Second quote.	<b>User Last Updated:</b>	Stimpson J Cat		
<b>Date Last Updated:</b>	09/20/2017 11:26:04 AM				

**Vendor accepts the terms & conditions with no exceptions.**

**Bid Acknowledgements:**

Document	Amendment Note	Notifications	Acknowledged Date/Time
Amendment 1	Bid amendment 1. Header 1. Bid Opening Date changed from "09/20/2017 12:00:00 PM" to "09/20/2017 04:00:00 PM". Enrollment Date Changes:	Ready to send to : test@periscopeholdings.com at 09/20/2017 12:22:44 PM	

**Attachments**

**Agency Files:**

**Agency Forms:**

**Vendor Files:** My submittal.txt Attachment.txt

**Vendor Forms:**

**Item Information**

**Print Sequence # 1.0 : ( 918 - 58 ) SUBMITTAL UPLOAD INSTRUCTIONS**

Quantity	UOM	Unit Cost	Discount %	Tax Rate	Freight	Extended Amount	No Bid	No Charge	See Quote Attachment(s)
1.0	EA	\$750,000.00	0.0%	0.0%	\$0.00	\$750,000.00	No	No	No

Print Submit Quote Cancel Quote

Attachment B  
RFP 00002649 Streetcar Vehicles, Parts, and Tools

**Proposer Information Form**

This Attachment must be submitted with your Proposal.

<b>Proposal Date</b>	
<b>RFP Number</b>	
<b>Project Title</b>	
<b>Proposer's Full Legal Name</b>	
<b>Doing Business As (<i>if applicable</i>)</b>	
<b>Proposer's Address</b>	
<b>Authorized Representative Name</b>	
<b>Authorized Representative Title</b>	
<b>Authorized Representative Phone</b>	
<b>Authorized Representative Email</b>	
<b>Authorized Representative Mailing Address</b>	
<b>Authorized Representative Signature</b>	
<b>Local Contact (<i>if different</i>)</b>	
<b>Local Contact Phone</b>	
<b>Local Contact Email</b>	
<b>City of Portland Business License Tax Account # (if currently licensed)</b> <a href="https://www.portlandoregon.gov/revenue/29320">https://www.portlandoregon.gov/revenue/29320</a>	
<b>State of Oregon Registry Number</b> <a href="http://egov.sos.state.or.us/br/pkg_web_name_srch_inq.login">http://egov.sos.state.or.us/br/pkg_web_name_srch_inq.login</a>	
<b>City of Portland Buyspeed Vendor Number</b> <a href="https://procure.portlandoregon.gov/">https://procure.portlandoregon.gov/</a>	

Attachment B  
RFP 00002649 Streetcar Vehicles, Parts, and Tools

<b>Federal Taxpayer Identification Number (EIN)</b>	
<b>State of Incorporation</b>	
<b>Type of Organization</b>	<input type="checkbox"/> Sole proprietorship; <input type="checkbox"/> Partnership; <input type="checkbox"/> Corporate entity (not tax-exempt); <input type="checkbox"/> Corporate entity (tax-exempt); <input type="checkbox"/> Government entity (Federal, State, or local); <input type="checkbox"/> Other _____.
<b>Common Parent</b>	<input type="checkbox"/> Proposer is not owned or controlled by a common parent: <input type="checkbox"/> Name and EIN of common parent: Name: EIN:
<b>Redaction for Public Records</b>	<input type="checkbox"/> No redactions are required; OR <input type="checkbox"/> Proposer requires redactions and included with this proposal is a redacted copy and a summary of redactions.
<b>Open Data Requirements</b> <a href="https://efiles.portlandoregon.gov/Record/10879908/">https://efiles.portlandoregon.gov/Record/10879908/</a>	<input type="checkbox"/> Proposer acknowledges the goals of the City of Portland's Open Data Policy and will work with the City to meet the goals of the Policy, as is applicable to this project.
<b>Insurance Requirements</b>	<input type="checkbox"/> Proposer acknowledges the insurance requirements for the resulting Contract have been read, and proposer either currently has or will be able to obtain insurance at level required if awarded the Contract.

Attachment C  
RFP 00002649 Streetcar Vehicles, Parts, and Tools

Redaction Summary Form

If proposer provides a “Redacted for Public Disclosure” copy, proposer shall include a summary similar or identical to the template below, identifying information and location of information the proposer is deeming to be exempt from public disclosure, including the reason for redaction.

Proposal Page # and Section	Content to be redacted	Reason for redaction

## **EXHIBIT A: CONTRACTOR'S PRICE**

### **A.1 Pricing.**

#### **A.1.1 Most Favorable Prices and Terms: (\*)**

Contractor represents that all prices, terms, and benefits offered by Contractor under this Contract are equal to or better than the equivalent prices, terms and benefits being offered by Contractor to any other state or local government unit or commercial customer for the same or similar Goods or Services.

#### **A.1.2 Progress Payments for Streetcar Vehicles**

The City shall pay and the Contractor shall accept the amounts set forth in the price schedule as full compensation for all costs and expenses of completing the Work in accordance with the Contract, including but not limited to all labor, equipment and material required, overhead, expenses, storage and shipping, risks and obligations, taxes (as applicable), fees and profit, and any unforeseen costs.

The Contractor shall submit invoices to the City according to the milestone payment schedule set forth in A.2, Milestone Payment Schedule. The City will make payments as the Work proceeds on the invoices submitted, Contract Deliverable Requirements List (CDRL), and each invoice may include any number and combination of milestone payments that are payable during that period. Invoices need not be based on sequential milestones.

The Contractor shall certify on each invoice that the total costs invoiced do not exceed the total milestone payment allowed.

Each invoice shall be in a format approved by and in a quantity stipulated by the City, and shall include the following:

1. Contract number and Purchase Order number
2. Milestone(s) invoiced
3. Model and serial number of the vehicle invoiced
4. Unit and total prices by milestone number
5. Total invoice amount, including the funds to be retained by Sound Transit

#### **A.2 Milestone Payment Schedule**

Title to material included in any milestone payment request shall pass to the City upon payment by the City. Said title shall be free of all encumbrances. However, such transfer of title shall not relieve the Contractor of its responsibility for the furnishing, installation, fabrication, or inclusion of said materials as a deliverable element of vehicles procured in accordance with the requirements of the Contract.



### A.2.1 Schedule A, Contract Vehicles Price and Milestone Payment Schedule

Schedule A – Contract Vehicles Pricing				
Milestone	Quantity	Item	Unit Price	Extended Price
A-1	Up to 15	Portland Off-wire Streetcar		
Subtotal Schedule A				

Milestone Schedule A		
Milestones	Description	Percentage
A-1: A.1	Approval of CDRLs 2-1, 2-3, 2-5, 2-6, 2-8, 2-10, 2-14, 2-15, 2-20, 2-24	2.00%
A-1: A.2	Approval of CDRL 4-15 Items 1, 2.a and 2.b.	1.00%
A-1: A.3	Preliminary design, Approval of CDRLs: 4-4, 4-5, 4-6, 4-7, 4-8 item 1, 4-13, 5-2 item 3, 6-1, 6-8, 6-13 item 1, 6-15 item 1, 7-1, 7-4 item 1, 7-6, 9-1 item 1 and 2, 9-2, 9-5 item 3, 10-1, 13-3, 14-4, 14-6, 14-7 item 1.a, 14-9, 16-4	2.00%
A-1: A.4	Submittal of Supplier acknowledgment receipt of purchase orders for long lead time subcontracts for: Carshell, Truck Frame, Propulsion system, APS, LVPS, Door and Bridgeplate system, HVAC, Brake system, Communication system, and ATS.	9.00%
A-1: A.5	Receipt of long lead items per vehicle at the production facility.	Total: 18%
A-1: A.5.1	Communication system	1.00%
A-1: A.5.2	Brake system	1.75%
A-1: A.5.3	Traction motors	1.50%
A-1: A.5.4	Traction inverter/aps/lvps	5.75%
A-1: A.5.5	OESS	3.75%
A-1: A.5.6	Pantograph	0.25%
A-1: A.5.7	Door and Bridgeplate System	1.75%
A-1: A.5.8	HVAC	1.25%
A-1: A.5.9	ATS	1.00%

<b>Milestone Schedule A</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
A-1: A.6	Approval of long lead items First Article Inspections, including subsystem qualification test reports.	Total: 10%
A-1: A.6.1	Communication system	0.75%
A-1: A.6.2	Brake system	1.00%
A-1: A.6.3	Traction motors	0.75%
A-1: A.6.4	Traction inverter/aps/lvps	3.25%
A-1: A.6.5	OESS	1.75%
A-1: A.6.6	Pantograph	0.25%
A-1: A.6.7	Door and Bridgeplate System	1.00%
A-1: A.6.8	HVAC	0.50%
A-1: A.6.9	ATS	0.75%
A-1: A.7	Completion and Approval (close-out of all items) of each vehicle Hold Point Inspection per TS 2.7.2 listed below:	Total: 23%
A-1: A.7.1	Vehicle underframes, Hold Point b	1.00%
A-1: A.7.2	Vehicle roof sections, Hold Point c	1.00%
A-1: A.7.3	Vehicle shell body sections before painting, Hold Point e	2.00%
A-1: A.7.4	Vehicle shell body sections after painting, Hold Point f	2.00%
A-1: A.7.5	Truck Frames, Hold Point g	3.00%
A-1: A.7.6	Assembled trucks, Hold Point h	1.00%
A-1: A.7.7	Vehicle floor panel and coverings, Hold Point k	1.00%
A-1: A.7.8	Vehicle roof, Hold Point i	1.00%
A-1: A.7.9	Final watertightness, Hold Point m	1.00%
A-1: A.7.10	Vehicle electrical installation, Hold Point n	4.00%
A-1: A.7.11	Vehicle interior, Hold Point o	2.00%
A-1: A.7.12	Vehicle exterior, Hold Point p	2.00%
A-1: A.7.13	Final walk-through, Hold Point s	2.00%
A-1: A.8	Completion of each vehicle assembled and ready to start factory tests	5.00%
A-1: A.9	Vehicle Shipment	10.00%

<b>Milestone Schedule A</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
A-1: A.10	Vehicle Conditional Acceptance	15.00%
A-1: A.11	Vehicle Final Acceptance	5.00%

#### **A.2.2 Schedule B, Not Used**

<b>Schedule B – Not Used</b>			
<b>Milestone</b>	<b>Quantity</b>	<b>Item</b>	<b>Unit Price</b>
<b>Subtotal Schedule B</b>			

<b>Milestone Schedule B – Not used</b>			
<b>Milestones</b>	<b>Description</b>	<b>No.</b>	<b>Percentage</b>

#### **A.2.3 Schedule C, Contract System Support Price and Milestone Payment Schedule**

<b>Schedule C – Contract System Support Pricing</b>			
<b>Milestone</b>	<b>Quantity</b>	<b>Item</b>	<b>Extended Price</b>
C-1	n/a	Engineering	
C-2	n/a	Management	
C-3	n/a	Operations and Maintenance Training per Technical Specification Section 3.3	
C-4	n/a	Operations and Maintenance Manuals per Technical Specification Section 3.1	
C-5	n/a	Field Support per Technical Specification Section 3.5	
C-6	n/a	Performance Bond	
C-7	n/a	Warranty Bond	
<b>Subtotal Schedule C</b>			

<b>Milestone Schedule C</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
C-1: C.1	Conditional Approval of the following CDRLs:	Total: 75%
C-1: C.1.1	TS Section 2 CDRLs: 2-12, 2-13, 2-16, 2-21, 2-22, 2-23	3.00%
C-1: C.1.2	TS Section 3	1.00%
C-1: C.1.3	TS Section 4 all required CDRLs	3.00%
C-1: C.1.4	TS Section 5 all required CDRLs	3.00%
C-1: C.1.5	TS Section 6 all required CDRLs	6.00%
C-1: C.1.6	TS Section 7 all required CDRLs	4.00%
C-1: C.1.7	TS Section 8 all required CDRLs	4.00%
C-1: C.1.8	TS Section 9 all required CDRLs	5.00%
C-1: C.1.9	TS Section 10 all required CDRLs	4.00%
C-1: C.1.10	TS Section 11 all required CDRLs	2.00%
C-1: C.1.11	TS Section 12 all required CDRLs	4.00%
C-1: C.1.12	TS Section 13 all required CDRLs	6.00%
C-1: C.1.13	TS Section 14 all required CDRLs	10.00%
C-1: C.1.14	TS Section 15 all required CDRLs	4.00%
C-1: C.1.15	TS Section 16 all required CDRLs	3.00%
C-1: C.1.16	TS Section 17 all required CDRLs	1.00%
C-1: C.1.17	TS Section 18 CDRL 18-1 through 18-3, and test procedure required per 18-26 through 18-42, 18-47, 18-48 and 18-49	10.00%
C-1: C.1.18	TS Section 19 all required CDRLs	2.00%
C-1: C.2	Approval of the following CDRLs:	Total: 25%
C-1: C.2.1	TS Section 2 CDRLs: 2-12, 2-13, 2-16, 2-21, 2-22, 2-23	1.00%
C-1: C.2.2	TS Section 3	0.33%
C-1: C.2.3	TS Section 4 all required CDRLs	1.00%
C-1: C.2.4	TS Section 5 all required CDRLs	1.00%
C-1: C.2.5	TS Section 6 all required CDRLs	2.00%
C-1: C.2.6	TS Section 7 all required CDRLs	1.33%

<b>Milestone Schedule C</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
C-1: C.2.7	TS Section 8 all required CDRLs	1.33%
C-1: C.2.8	TS Section 9 all required CDRLs	1.67%
C-1: C.2.9	TS Section 10 all required CDRLs	1.33%
C-1: C.2.10	TS Section 11 all required CDRLs	0.67%
C-1: C.2.11	TS Section 12 all required CDRLs	1.33%
C-1: C.2.12	TS Section 13 all required CDRLs	2.00%
C-1: C.2.13	TS Section 14 all required CDRLs	3.33%
C-1: C.2.14	TS Section 15 all required CDRLs	1.33%
C-1: C.2.15	TS Section 16 all required CDRLs	1.00%
C-1: C.2.16	TS Section 17 all required CDRLs	0.33%
C-1: C.2.17	TS Section 18 CDRL 18-1 through 18-3, and test procedure required per 18-26 through 18-42, 18-47, 18-48 and 18-49	3.33%
C-1: C.2.18	TS Section 19 all required CDRLs	0.67%
C-2: C.3	Monthly submittal of CDRLs 2-2, 2-4, 2-6, 2-7.	Total: 90%
C-2: C.3.1	Milestone paid monthly month 1 through month 55. Percentage is based on the Schedule for Contractual Delivery of 12th Vehicle.	1.64%
C-2: C.4	Milestone paid at contract closeout	10.00%
C-3: C.5	Training	Total: 100%
C-3: C.5.1	Completion of Operator training	25.00%
C-3: C.5.2	Completion of Initial Maintenance training	50.00%
C-3: C.5.3	Completion of Refresher Maintenance Training	25.00%
C-4: C.6	Manuals	Total: 100%
C-4: C.6.1	Delivery of initial draft of all manuals	50.00%
C-4: C.6.2	Delivery of final draft of all manuals	25.00%
C-4: C.6.3	Contractual delivery of completed manuals	25.00%
C-5: C.7	Field Support, Milestones paid monthly based on Schedule for Vehicle Contractual Shipment and Delivery.	Total: 100%
C-5: C.7.1	Milestone paid 2 months before shipment of 1st vehicle.	4.50%

<b>Milestone Schedule C</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
C-5: C.7.2	Milestone paid monthly for 19 months starting Shipment of 1st vehicle, ending Delivery of 12th Vehicle.	2.50%
C-5: C.7.3	Milestone paid monthly for 24 months starting after the 12th vehicle enters revenue operations.	2.00%
C-6: C.8	Corporate Guarantee/Bond, paid after NTP and Proof of Bond delivered and verified.	100.00%
C-7: C.9	Warranty Bond, paid when 1st Vehicle enters revenue operations and Proof of bond delivered and verified.	100.00%

#### **A.2.4 Schedule D, Contract Qualification Testing Price and Milestone Payment Schedule**

<b>Schedule D – Contract Qualification Testing Pricing</b>		
<b>Milestone</b>	<b>Item</b>	<b>Extended Price</b>
D-1	CDRL 18-4 Paint Performance Type Test, TS 18.3.3	
D-2	CDRL 18-5 FRP Type Test Certificate, TS 18.3.4	
D-3	CDRL 18-6 EMI/EMC Component Type Tests, TS 18.3.5	
D-4	CDRL 18-7 Cab and Floor Heater Type Tests, TS 18.3.6	
D-5	CDRL 18-8 AC Traction Motor Type Test, TS 18.3.7	
D-6	CDRL 18-9 AC Auxiliary Motor Type Test, TS 18.3.8	
D-7	CDRL 18-10 Traction Gear Unit Type Test, TS 18.3.9	
D-8	CDRL 18-11 Auxiliary Power Supply (APS) Type Test, TS 18.3.10	
D-9	CDRL 18-12 Low-Voltage Power Supply and Battery Charger Type Test, TS 18.3.11	
D-10	CDRL 18-13 Truck Frame Type Test, TS 18.3.12	
D-11	CDRL 18-14 Traction Inverter Type Test, TS 18.3.13	
D-12	CDRL 18-15 OESS Type test, TS 18.3.14	
D-13	CDRL 18-16 Vehicle-Shell Structural Type Tests, TS 18.4	
D-14	CDRL 18-17 Floor Assembly Fire Performance Type Test, TS 18.5.2	
D-15	CDRL 18-18 Roof Assembly Fire Performance Type Test, TS 18.5.2	

D-16	CDRL 18-19 Propulsion Combined Type Test, TS 18.5.3	
D-17	CDRL 18-20 Friction Brake System Type Test, TS 18.5.4	
D-18	CDRL 18-21 Door System Type Test, TS 18.5.5	
D-19	CDRL 18-22 Bridgeplate System Type Test, TS 18.5.6	
D-20	CDRL 18-23 Unitized HVAC System Type Test, TS 18.5.7	
D-21	CDRL 18-24 Communication Systems Type Test, TS 18.5.8	
D-22	CDRL 18-25 Vehicle-Level Type Static Tests, TS 18.6	n/a
D-23	CDRL 18-25.a Horn and Bell, TS 18.6	
D-24	CDRL 18-25.b Jacking, TS 18.6	
D-25	CDRL 18-25.c Ducting watertightness, TS 18.6	
D-26	CDRL 18-25.b Air Leakage, TS 18.6	
D-27	CDRL 18-25.e Air Balance, TS 18.6	
D-28	CDRL 18-25.f HVAC system, TS 18.6	
D-29	CDRL 18-25.g Door operation, TS 18.6	
D-30	CDRL 18-25.h Bridgeplate operation, TS 18.6	
D-31	CDRL 18-25.i Lighting intensity, TS 18.6	
D-32	CDRL 18-25.j Communication equipment, TS 18.6	
D-33	CDRL 18-25.k Vehicle data networks, TS 18.6	
D-34	CDRL 18-43 Vehicle-Level Type Dynamic Tests, TS 18.9.1, 18.9.2, 18.9.3 and 18.9.4	
D-35	CDRL 18-44 Ride Quality Type Test, TS 18.9.1, 18.9.2, and 18.9.5	
D-36	CDRL 18-45 Noise and Vibration Type Test, TS 18.9.1, 18.9.2, and 18.9.6	
D-37	CDRL 18-46 EMI/EMC Type Test, TS 18.9.1, 18.9.2, and 18.9.7	
<b>Subtotal Schedule D</b>		

<b>Milestone Schedule D</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
D-1: D.1	CDRL 18-4 Paint Performance Type Test: TS 18.3.3	Total: 100%

<b>Milestone Schedule D</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
D-1: D.1.1	CDRL 18-4, Approval of Test Procedure	25.00%
D-1: D.1.2	CDRL 18-4, Approval of Test Report	75.00%
D-2: D.2	CDRL 18-5 FRP Type Test Certificate: TS 18.3.4	Total: 100%
D-2: D.2.1	CDRL 18-5, Approval of Test Procedure	25.00%
D-2: D.2.2	CDRL 18-5, Approval of Test Report	75.00%
D-3: D.3	CDRL 18-6 EMI/EMC Component Type Tests: TS 18.3.5	Total: 100%
D-3: D.3.1	CDRL 18-6, Approval of Test Procedure	25.00%
D-3: D.3.2	CDRL 18-6, Approval of Test Report	75.00%
D-4: D.4	CDRL 18-7 Cab and Floor Heater Type Tests: TS 18.3.6	Total: 100%
D-4: D.4.1	CDRL 18-7, Approval of Test Procedure	25.00%
D-4: D.4.2	CDRL 18-7, Approval of Test Report	75.00%
D-5: D.5	CDRL 18-8 AC Traction Motor Type Test: TS 18.3.7	Total: 100%
D-5: D.5.1	CDRL 18-8, Approval of Test Procedure	25.00%
D-5: D.5.2	CDRL 18-8, Approval of Test Report	75.00%
D-6: D.6	CDRL 18-9 AC Auxiliary Motor Type Test: TS 18.3.8	Total: 100%
D-6: D.6.1	CDRL 18-9, Approval of Test Procedure	25.00%
D-6: D.6.2	CDRL 18-9, Approval of Test Report	75.00%
D-7: D.7	CDRL 18-10 Traction Gear Unit Type Test: TS 18.3.9	Total: 100%
D-7: D.7.1	CDRL 18-10, Approval of Test Procedure	25.00%
D-7: D.7.2	CDRL 18-10, Approval of Test Report	75.00%
D-8: D.8	CDRL 18-11 Auxiliary Power Supply (APS) Type Test: TS 18.3.10	Total: 100%
D-8: D.8.1	CDRL 18-11, Approval of Test Procedure	25.00%
D-8: D.8.2	CDRL 18-11, Approval of Test Report	75.00%
D-9: D.9	CDRL 18-12 Low-Voltage Power Supply and Battery Charger Type Test: TS 18.3.11	Total: 100%
D-9: D.9.1	CDRL 18-12, Approval of Test Procedure	25.00%
D-9: D.9.2	CDRL 18-12, Approval of Test Report	75.00%
D-10: D.10	CDRL 18-13 Truck Frame Type Test: TS 18.3.12	Total: 100%
D-10: D.10.1	CDRL 18-13, Approval of Test Procedure	25.00%



<b>Milestone Schedule D</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
D-10: D.10.2	CDRL 18-13, Approval of Test Report	75.00%
D-11: D.11	CDRL 18-14 Traction Inverter Type Test: TS 18.3.13	Total: 100%
D-11: D.11.1	CDRL 18-14, Approval of Test Procedure	25.00%
D-11: D.11.2	CDRL 18-14, Approval of Test Report	75.00%
D-12: D.12	CDRL 18-15 OESS Type test: TS 18.3.14	Total: 100%
D-12: D.12.1	CDRL 18-15, Approval of Test Procedure	25.00%
D-12: D.12.2	CDRL 18-15, Approval of Test Report	75.00%
D-13: D.13	CDRL 18-16 Vehicle-Shell Structural Type Tests: TS 18.4	Total: 100%
D-13: D.13.1	CDRL 18-16, Approval of Test Procedure	25.00%
D-13: D.13.2	CDRL 18-16, Approval of Test Report	75.00%
D-14: D.14	CDRL 18-17 Floor Assembly Fire Performance Type Test: TS 18.5.2	Total: 100%
D-14: D.14.1	CDRL 18-17, Approval of Test Procedure	25.00%
D-14: D.14.2	CDRL 18-17, Approval of Test Report	75.00%
D-15: D.15	CDRL 18-18 Roof Assembly Fire Performance Type Test: TS 18.5.2	Total: 100%
D-15: D.15.1	CDRL 18-18, Approval of Test Procedure	25.00%
D-15: D.15.2	CDRL 18-18, Approval of Test Report	75.00%
D-16: D.16	CDRL 18-19 Propulsion Combined Type Test: TS 18.5.3	Total: 100%
D-16: D.16.1	CDRL 18-19, Approval of Test Procedure	25.00%
D-16: D.16.2	CDRL 18-19, Approval of Test Report	75.00%
D-17: D.17	CDRL 18-20 Friction Brake System Type Test: TS 18.5.4	Total: 100%
D-17: D.17.1	CDRL 18-20, Approval of Test Procedure	25.00%
D-17: D.17.2	CDRL 18-20, Approval of Test Report	75.00%
D-18: D.18	CDRL 18-21 Door System Type Test: TS 18.5.5	Total: 100%
D-18: D.18.1	CDRL 18-21, Approval of Test Procedure	25.00%
D-18: D.18.2	CDRL 18-21, Approval of Test Report	75.00%
D-19: D.19	CDRL 18-22 Bridgeplate System Type Test: TS 18.5.6	Total: 100%
D-19: D.19.1	CDRL 18-22, Approval of Test Procedure	25.00%
D-19: D.19.2	CDRL 18-22, Approval of Test Report	75.00%

<b>Milestone Schedule D</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
D-20: D.20	CDRL 18-23 Unitized HVAC System Type Test: TS 18.5.7	Total: 100%
D-21: D.20.1	CDRL 18-23, Approval of Test Procedure	25.00%
D-20: D.20.2	CDRL 18-23, Approval of Test Report	75.00%
D-21: D.21	CDRL 18-24 Communication Systems Type Test: TS 18.5.8	Total: 100%
D-21: D.21.1	CDRL 18-24, Approval of Test Procedure	25.00%
D-21: D.21.2	CDRL 18-24, Approval of Test Report	75.00%
D-22: D.22	CDRL 18-25 Vehicle-Level Type Static Tests: TS 18.6	Total: 100%
D-22: D.22.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-22: D.22.2	CDRL 18-25, Approval of Test Report	75.00%
D-23: D.23	CDRL 18-25.a Horn and Bell	Total: 100%
D-23: D.23.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-23: D.23.2	CDRL 18-25, Approval of Test Report	75.00%
D-24: D.24	CDRL 18-25.b Jacking	Total: 100%
D-24: D.24.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-24: D.24.2	CDRL 18-25, Approval of Test Report	75.00%
D-25: D.25	CDRL 18-25.c Ducting watertightness	Total: 100%
D-25: D.25.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-25: D.25.2	CDRL 18-25, Approval of Test Report	75.00%
D-26: D.26	CDRL 18-25.b Air Leakage	Total: 100%
D-26: D.26.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-26: D.26.2	CDRL 18-25, Approval of Test Report	75.00%
D-27: D.27	CDRL 18-25.e Air Balance	Total: 100%
D-27: D.27.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-27: D.27.2	CDRL 18-25, Approval of Test Report	75.00%
D-28: D.28	CDRL 18-25.f HVAC system	Total: 100%
D-28: D.28.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-28: D.28.2	CDRL 18-25, Approval of Test Report	75.00%
D-29: D.29	CDRL 18-25.g Door operation	Total: 100%
D-29: D.29.1	CDRL 18-25, Approval of Test Procedure	25.00%

<b>Milestone Schedule D</b>		
<b>Milestones</b>	<b>Description</b>	<b>Percentage</b>
D-29: D.29.2	CDRL 18-25, Approval of Test Report	75.00%
D-30: D.30	CDRL 18-25.h Bridgeplate operation	Total: 100%
D-30: D.30.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-30: D.30.2	CDRL 18-25, Approval of Test Report	75.00%
D-31: D.31	CDRL 18-25.i Lighting intensity	Total: 100%
D-31: D.31.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-31: D.31.2	CDRL 18-25, Approval of Test Report	75.00%
D-32: D.32	CDRL 18-25.j Communication equipment	Total: 100%
D-32: D.32.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-32: D.32.2	CDRL 18-25, Approval of Test Report	75.00%
D-33: D.33	CDRL 18-25.k Vehicle data networks	Total: 100%
D-33: D.33.1	CDRL 18-25, Approval of Test Procedure	25.00%
D-33: D.33.2	CDRL 18-25, Approval of Test Report	75.00%
D-34: D.34	CDRL 18-43 Vehicle-Level Type Dynamic Tests: TS 18.9.1, 18.9.2, 18.9.3 and 18.9.4	Total: 100%
D-34: D.34.1	CDRL 18-43, Approval of Test Procedure	25.00%
D-34: D.34.2	CDRL 18-43, Approval of Test Report	75.00%
D-35: D.35	CDRL 18-44 Ride Quality Type Test: TS 18.9.1, 18.9.2, and 18.9.5	Total: 100%
D-35: D.35.1	CDRL 18-44, Approval of Test Procedure	25.00%
D-35: D.35.2	CDRL 18-44, Approval of Test Report	75.00%
D-36: D.36	CDRL 18-45 Noise and Vibration Type Test: TS 18.9.1, 18.9.2, and 18.9.6	Total: 100%
D-36: D.36.1	CDRL 18-45, Approval of Test Procedure	25.00%
D-36: D.36.2	CDRL 18-45, Approval of Test Report	75.00%
D-37: D.37	CDRL 18-46 EMI/EMC Type Test: TS 18.9.1, 18.9.2, and 18.9.7	Total: 100%
D-37: D.37.1	CDRL 18-46, Approval of Test Procedure	25.00%
D-37: D.37.2	CDRL 18-46, Approval of Test Report	75.00%

### **A.3 Pricing for Spare Parts, Special Tools, and Test Equipment**

In accordance with the Technical Specification, the Contractor shall provide a list of recommended spare parts, special tools, and test equipment, with estimated quantities. The City and Contractor shall negotiate and agree upon the list of spare parts, Special Tools and Test equipment and estimated quantities and any pricing that was not submitted with the proposal.

The two schedules found in A.3.1 Schedule E –Pricing for Spare Parts and A.3.2 Schedule F – Pricing for Special Tools and Test Equipment are included in the Contract not to exceed amount. Pricing shall be in accordance with Attachment F – Pricing Schedules, Schedule G Spare Parts and Schedule H Special Tools, submitted as part of the solicitation. If there are any spare parts or special tools which were not listed in Attachment F – Pricing Schedules submitted with the proposal, Contractor shall identify those parts and tools in section A.3.1 and A.3.2.

The City shall order spare parts by written notice to the Contractor within 360 days after NTP. The notice shall specify the quantity of spare parts being ordered. The City may place one or more such orders for spare parts. Any budgeted amount included in the not to exceed amount, but not used in the course of the Work, shall be returned to the City by way of an Amendment.

#### **A.3.1 Schedule E, Pricing for Spare Parts and Special Tools**

<b>Schedule E – Budget for Spare Parts</b>			
<b>Milestone</b>	<b>Quantity</b>	<b>Item</b>	<b>Extended Price</b>
E.1	TBD	TBD	
<b>Subtotal Schedule E</b>			

<b>Milestone Schedule E</b>		
<b>Milestone</b>	<b>Description</b>	<b>Percentage</b>
E-1: E.1	Long lead Spare Parts	Total 100%
E-1: E.1.1	Submittal of Supplier acknowledgment receipt of purchase orders for long lead time subcontracts for: Carshell, Truck, Propulsion system, APS, LVPS, Door and Bridgeplate system, HVAC, Brake system, Communication system, and ATS. Invoiced per unit.	10.00%
E-1: E.1.2	Receipt of long lead items per part at Maintenance Facility. Invoiced per unit.	90.00%
E-1: E.2	Receipt of non-long lead spare parts	100.00%
E-1: E.2.1	Receipt of part at Maintenance Facility, Invoiced per unit.	100.00%

### A.3.2 Schedule F, Pricing for Special Tools and Test Equipment

Schedule F – Budget for Special Tools and test Equipment			
Milestone	Quantity	Item	Extended Price
F-1	TBD	TBD	
Subtotal Schedule F			

Milestone F		
Milestone	Description	Percentage
F-1: F.1	Long lead Spare Parts and Test Equipment	Total 100%
F-1: F.1.1	Submittal of Supplier acknowledgment receipt of purchase orders for long lead time subcontracts for: Rerailing equipment, Portable jacks, Flush cart, etc. Invoiced per unit.	10.00%
F-1: F.1.2	Receipt of long lead items per piece at Maintenance Facility. Invoiced per unit.	90.00%
F-1: F.2	Receipt of non-long lead special tools.	100.00%
F-1: F.2.1	Receipt of part at Maintenance Facility, Invoiced per unit.	100.00%

### A.4 Prompt Payments

#### A.4.1 Subcontractor Prompt Payment

Contractor, after receiving payment from the City, must make prompt payment to its subcontractors, for work completed in accordance with this Contract. This provision applies to all tiers of subcontracts.

Contractor's invoices must include payments for subcontractors whose work was performed in accordance with this Contract. The Contractor may not request payment for subcontractor work until the Contractor has determined that the subcontractor is entitled to the payment for the work completed.

Within five (5) working days of receipt of payment from the City, the Contractor must pay such subcontractors.

The requirements of this provision must be included in subcontracts of all tiers and must include a provision requiring payment be made to the lower tiered subcontractors within five (5) working days after receipt of payment by the higher tiered subcontractor.

In the event of any claim or demand made against any Indemnified Party hereunder, the City may reserve, retain or apply any monies due to the Contractor for resolving such claims; provided, however, that the City may release such funds if the Contractor provides adequate assurance of the protection of the Indemnified Parties' interests.

#### **A.5 Withholding of Payments by the City.**

The City may withhold all or part of a payment to the extent deemed necessary to protect City from loss because of:

1. Defective work not remedied
2. Third party claims filed, or evidence reasonably indicating that a third-party claim will be filed.
3. Failure of Contractor to make payments properly to subcontractors, or for labor, materials, or equipment.
4. Reasonable evidence that the work cannot be completed for the unpaid balance of the Contract sum.
5. Damage to City or another Contractor.
6. Contractor's failure to carry out the Work in accordance with the Contract.
7. Contractor's failure to comply with any material provision or requirement of the Contract.
8. Contractor's failure to pay the deductible portion of any insured claim filed by third parties against the Contractor.
9. Contractor's failure to provide the required progress schedules in accordance with the Contract.
10. Any sums expended by City in performing any of the Contractor's Work under the Contract which the Contractor has failed to perform.
11. Liquidated damages
12. Retainage, as provided herein
13. Any other sums that the City is entitled to recover from the Contractor under the terms of this Contract.

#### **A.6 Invoice Considerations.**

Invoices shall take into consideration any executed Change Orders affecting the equipment invoiced, all allowable escalation, and all other adjustments (liquidated damages, etc.) as provided for in the Contract.

If the City determines that security interests must be reserved in materials, work in progress, inventory or equipment being used or provided under the Contract, the Contractor shall fully cooperate with the City in documenting and perfecting such security interests.

Invoices shall be supported by evidence and such other documentation as the City may require. The Contractor shall certify that the equipment and other deliverables for which payment is requested comply with all requirements for payment.

Work performed under Change Orders will be subject to audit review of the Contractor's records supporting the payment for the Change Orders. Audits will not interfere with timely processing of pay applications. If an audit indicates the Contractor has been overpaid under a

previous payment application, that overpayment will be credited against current progress payment applications.

#### **A.7 Units of Currency/Currency Adjustment**

All Contractor invoices for payment shall be accounted in U.S. dollars, and all Agency payments to the Contractor shall be in U.S. dollars. There shall be no adjustments to Contract price for currency fluctuations through the term of the Contract.

#### **A.8 Payment of Taxes**

The Contractor must include any other applicable taxes, such as retail sales tax on consumables and business and occupation tax, in its Total Proposal Price and be responsible for making payment of such taxes as required by law. Except as provided herein, no increase will be made to the amount to be paid by Portland Streetcar under this Contract with respect to any such taxes, whether because of any misunderstanding by or lack of knowledge of the Contractor as to liability for, or the amount of, any taxes for which the Contractor is liable or responsible by law or under this Contract.

The City is exempt from Federal Excise Taxes.

#### **A.9 Final Completion**

The Contractor shall complete and shall deliver to the City all designated portions of the Work and all parts and requirements within the number of days set forth in the Contract. When all the Work has been performed and delivered in the quantities designated, the Work will be inspected by the City's designated representative. If the City's representative finds that the Work has been completed in all aspects and all documents have been submitted and all training has been completed, in accordance with the Contract, then the City will issue a Notice of Completion and make payment in accordance with the payment provisions.

#### **A.10 Final Payment and Claims**

Before applying for final payment, the Contractor shall complete all Work and shall correct any deficiencies in the Work and any Work rejected by the City.

Within thirty (30) days after the date of Notice of Completion issued by the City, the Contractor shall prepare and present to the City's Representative a Proposed Final Invoice in writing. The Proposed Final Invoice shall show the proposed total amount of compensation under the Contract, including therein an itemization of said amount segregated as to Contract item quantities, and other bases for payment. It shall also show all deductions made or to be made for prior payments and amounts to be kept or retained under the provisions of the Contract, together with any and all potential claims that have not yet been resolved or a statement that no claims will be filed. All prior invoices and payments shall be subject to correction in the Proposed Final Invoice. No claim for which a Notice of Potential Claim is required will be considered unless the Contractor has strictly complied with the notice provisions in GC 9.9.1, Notice of Intent to Claim.



**CITY OF PORTLAND**  
**CONTRACT FOR**  
**STREETCAR VEHICLES, PARTS & TOOLS**

**Contract Number: TBD**

As authorized by \_\_\_\_\_, this Contract is made effective on \_\_\_\_\_ ("Effective Date") by and between the City of Portland ("City" or "Agency"), a municipal corporation of the State of Oregon, and \_\_\_\_\_ ("Contractor"), a(n) \_\_\_\_\_ corporation, by and through their duly authorized representatives. This Contract may refer to the City and Contractor individually as a "Party" or jointly as the "Parties."

The initial Term of this Contract shall be from the Effective Date through \_\_\_\_\_, with the City's option to renew annually. The total not-to-exceed amount under this Contract for the initial Term shall be \$ \_\_\_\_\_. (04/20)

Party contacts and Contractor's and City's Project Manager for this Contract are:

For City of Portland:	For Contractor:
Name:	Name:
Title:	Title:
Address:	Address:
City, State:	City, State:
e-mail:	e-mail:
Copy to: <b>(BUYER)</b>	Copy to:
Procurement Services	
1120 SW 5 <sup>th</sup> Ave.	
Portland OR 97204	



## Scope and Consideration (9/19)

- a) Contractor shall perform the Services and provide the Goods and Deliverables set forth in the Statement of Work by the due dates specified in the Contract.
- b) City agrees to pay Contractor a sum not to exceed \$\_\_\_\_\_ for accomplishment of the Project.
- c) Payments shall be made to Contractor according to the schedule identified in Exhibit A, the Contractor's Price.

### Recitals:

WHEREAS, the City desires to contract for up to fifteen (15) new streetcar vehicles to further its government operations for the Portland Streetcar;

WHEREAS, the City desires to contract for the spare parts, special tools, trainings and manuals to support the ongoing operations; and

WHEREAS, the City issued Request for Proposal (RFP) # \_\_\_\_\_ for \_\_\_\_\_

WHEREAS, Contractor, in its Proposal dated \_\_\_\_\_ and submitted in response to the City's RFP represented that it has the knowledge, experience, and expertise in \_\_\_\_\_ for \_\_\_\_\_; and

WHEREAS, the City selected Contractor based on its Proposal;

THE PARTIES HEREBY AGREE AS FOLLOWS:

### **SECTION 1 DEFINITIONS (11/18)**

General Definitions. (11/18) These definitions apply to the entire Contract, subsequent Amendments, and any Change Orders or Task Orders, unless modified in an Amendment. If any definition contains a substantive provision conferring rights and/or obligations upon a Party, then effect shall be given to the substantive provision.

"Acceptance" (11/18\*) means the Deliverable demonstrates to the City's satisfaction that the Deliverable conforms to and operates according to any applicable Acceptance Criteria, and if required, has successfully completed Acceptance Testing, and for Deliverables not requiring Acceptance Testing that the Deliverable conforms to the Acceptance Criteria or the City's Specifications.

"Acceptance Certificate" (11/18) means a written instrument by which the City notifies Contractor that a Deliverable has been Accepted or Accepted with exceptions, and Acceptance Criteria have been met or waived, in whole or in part.

“Acceptance Criteria” (11/18) means functionality and performance requirements determined by the City, based upon the Specifications, which must be satisfied prior to City’s Acceptance of a Deliverable.

“Acceptance Date” (11/18) means the date on which the City issues an Acceptance Certificate for the Deliverable(s).

“Acceptance Test” (11/18) means the evaluation and testing method, procedures, or both, that are used to determine whether or not a Deliverable requiring Acceptance Testing performs in accordance with the Acceptance Criteria.

“Affiliates” (11/18) means, for Contractor, any individual, association, partnership, corporation, or other entity controlling, controlled by, or under common control. The term “control” means the power to direct or cause the direction of the management and policies of an individual or entity, whether through the ownership of voting securities, by contract, agreement or otherwise.

“Approved Equal or Equivalent” (\*) An item, material or method offered as a substitute for that specified in the Contract, for which approval in writing has been obtained from the City. The burden of proof that a substitute is in fact equal to or better than the item, material, or method specified in the Contract shall rest with the Contractor.

“Amendment” (12/18) means a written document required to be signed by both Parties when in any way altering the Master Terms and Conditions of the Contract, Contract amount, or substantially altering a Statement of Work.

“Business Day” (11/18) means a twenty-four hour day, excluding weekends and City holidays, beginning at midnight and ending at midnight twenty-four hours later.

“Calendar Day” (11/18) means a twenty-four hour day, including weekdays, weekends and holidays, beginning at midnight and ending at midnight twenty-four hours later.

“Change Order” (12/18) means a document, agreed and signed by both Parties, that changes an existing Statement of Work. Change Orders cannot change Contract amount or Master Terms and Conditions.

“City Representative” (\*) means a consultant, engineer, or inspector, under contract with the City to act as a representative of the City’s Project Manager.

“Conditional Acceptance of SCV” (\*) The status granted to a completely assembled SCV, located at the vehicle acceptance facility, that has successfully completed tests outlined in accordance with Exhibit C, Technical Specification, Section 18, Vehicle and System Testing, and is ready to run in revenue service except for minor Defects that require corrective action but that will not materially affect revenue service operations. Conditional Acceptance of a SCV requires that all documentation for the Portland SCV, including the Car History Book, per

Exhibit C, Technical Specification, Section 2, Program Control, Deliverables and Quality Assurance, has been delivered to and provisionally approved by the City.

“Confidential Information” (07/21) means any information that is disclosed in written, graphic or machine-recognizable form and is marked or labeled at the time of disclosure as being Confidential or its equivalent, or, if the information is in verbal or visual form, it is identified as Confidential or proprietary at the time of disclosure, or a reasonable time thereafter. Information shall always be considered Confidential Information, whether or not it is marked or identified as such, if it is described by one or more of the following categories:

- a) non-public financial, statistical, personnel, human resources data or Personally Identifiable Information as described in the Oregon Consumer Information Protection Act;
- b) business plans, negotiations, or strategies;
- c) unannounced pending or future products, services, designs, projects or internal public relations information;
- d) trade secrets, as such term is defined by Oregon Public Records Laws and the Uniform Trade Secrets Act;
- e) information which is exempt from disclosure per Oregon Public Records Law;
- f) attorney/client privileged communications;
- g) information which is exempt per federal laws (including but not limited to copyright, HIPPA); and
- h) information relating to or embodied by designs, plans, configurations, specifications, programs, or systems including without limitation, data and information systems, any software code and related materials and processes, Customizations, Configurations, Updates, Upgrades; and any Documentation.

Confidential Information does not include any information that:

- a) is or becomes publicly known through no wrongful or negligent act of the receiving Party;
- b) is already lawfully known to the receiving Party without restriction when it is disclosed;
- c) is, or subsequently becomes, rightfully and without breach of this Contract or any other agreement between the Parties or of any applicable protective or similar order, in the receiving Party's possession without any obligation restricting disclosure;
- d) is independently developed by the receiving Party, as shown by reasonable written documentation, without breach of this Contract;
- e) or is explicitly approved for release by written authorization of the disclosing Party.

“Contract” or “Contract Documents” (11/18) means the Master Terms and Conditions including all exhibits, attachments and schedules and their constituent parts listed in the Order of Precedence or incorporated by reference.

“Contract Deliverables Requirements List (CDRL)” (\*) List of select documents and other deliverable items that the Contractor is required to deliver to the City. CDRL is also used to refer to a specific item on the list, which include drawings, documents, analyses, technical data, test procedures and results, manuals, schedules, and similar.

“Contract Price” (11/18) means the not-to-exceed price agreed upon by the Parties for all Goods and Services.

“Cure Notice” (\*) Written notice from the City to the Contractor to cure a default or deficiency or to correct Work performed not in conformance with the Contract.

“Deliverable(s)” (11/18) means the Goods, Services, Documentation or documents or tangible work products described in the Statement of Work to be provided to the City by Contractor under this Contract.

“Documentation” (11/18) means user manuals and other written materials in any form that describe the features or functions of the Goods and Services, including but not limited to published specifications, online instructions and help, marketing materials, technical manuals, and operating instructions provided by Contractor to the City, or readily available to the public, or as required to be produced by Contractor subject to the terms of this Contract.

“Equipment” (11/18) means any hardware, machinery, device, tool, including add-ons, or peripherals of tangible form together with the necessary supplies for upkeep and maintenance, and other apparatus necessary for the proper implementation and operation of the Goods or Services to be provided to the City by Contractor under this Contract.

“Defect” (11/18) means any error, problem, condition, bug, or other partial or complete inability of a Service, Good or component thereof, to operate in accordance with the applicable Specifications.

“Final Acceptance of a SCV” (\*) The declaration that the Portland SCV has been completed in full accordance with the Specifications, including all testing, approved engineering submittals, and Change Orders; all corrective actions identified at Conditional Acceptance, including systematic failures and Fleet Defects have been completed, and all required documentation for the SCV has been received and approved by the City.

“First Article Inspection (FAI)” (\*) The comprehensive inspection and testing of the first production model of any component, system, subsystem, major assembly, subassembly, product, part, apparatus, article, and other Material before it is assembled into a SCV.

“Fleet” (\*) The collection of Conditionally Accepted SCVs provided to the City by the Contractor as a result of this Contract.

“Fleet Defect” (\*) A Fleet Defect is defined as the failure of any LLRU, in 20 percent of those units in the Fleet covered by this Contract. Fleet Defect percentage is calculated using the following formula  $(100 \times (\text{number of affected LLRUs} / \text{number of LLRUs in fleet}))$ .

“Force Majeure Event” (4/2020) means an exceptional, unforeseeable, and unavoidable occurrence beyond the reasonable control of the affected Party, such as, riots, epidemics, war, government regulations, fire, natural phenomena, or other causes beyond such Party’s reasonable control.

“Furnished Equipment” (\*) Material furnished by the City to the Contractor for use under the Contract.

“Good(s)” (11/18) means the items provided by Contractor to the City under this Contract, as outlined in the Statement of Work.

“Intellectual Property Rights (IPR)” (11/18) means any patent rights, copyrights, trade secrets, trade names, service marks, trademarks, trade dress, moral rights, know-how and any other similar rights or intangible assets to which rights of ownership accrue, and all registrations, applications, disclosures, renewals, extensions, continuations, or reissues of the foregoing now or hereafter in force.

“Key Personnel” (11/18) means the specific individuals identified in Section 3.11.2, Key Positions and Personnel. to fill Key Positions.

“Key Position” (11/18) means a job position critical to the success of the Project as identified in Section 3.11.2, Key Positions and Personnel, of this Contract.

“Lowest Level Replaceable Unit” (LLRU) (\*) is defined as the minimum unit which must be removed from a SCV to affect a repair.

“Maintenance” (11/18) means Services provided by Contractor to the City to keep the Goods or Services conforming to the Specifications and to respond to requests by the City.

“Maintenance Fee” (11/18) means the fee paid by the City for Maintenance.

“Maintenance Period” (11/18) means the time period when Contractor provides Maintenance to the City.

“Maintenance Request” (11/18) means a request from the City to Contractor for Maintenance or technical support.

“Manufacturer’s Warranty” (11/18) means a written statement to the City from Contractor or passed through Contractor from a third party, that one or more Goods manufactured by the third party and provided by Contractor will operate at the required Specifications, functionality, and performance level.

“Manufacturer’s Warranty Period” (11/18) means the time period during which a Manufacturer’s Warranty is valid and enforceable by the City.

“Master Terms and Conditions” (11/18) means the body of text from the preamble through the signature page of this Contract.

“Material Breach” (11/18) means any breach of this Contract that causes, caused, or may cause substantial harm to the non-breaching Party or substantially deprives the non-breaching Party of the benefit it reasonably expected under this Contract.

“Milestone”(\*) means a specified milestone date in the Contract by which the Contractor is required to complete a designated portion or segment of the Work. “Milestone” includes but is not limited to dates established for substantial completion of all or a designated portion or segment of the Work.

“Notice” (\*) Communication in writing, unless otherwise specified, to provide or issue any information, warning, announcement, instruction, consent, approval, certificate, or determination by any party to the Contract.

“Notice of Intent to Claim” (\*) A written notice of a potential claim submitted by the Contractor to the City within the time limits and under the circumstances specified in the Contract Documents.

“Notice to Proceed (NTP)” (\*) Written authorization from the City to the Contractor that establishes the date that the Contractor is to start work and the Period of Performance begins.

“Notice of Termination” (\*) A written notice delivered by the City to the Contractor terminating the Contract, either for convenience or for cause.

“Open Items Report” (\*) A description of all defects, shipping damage, missing parts, and open items from start of fabrication through Final Acceptance of a SCV.

“Personally Identifiable Information (PII)” (07/21) means information that can be used on its own or with other information to identify, contact, or locate a single person, or to identify an individual in context, as described in the Oregon Consumer Information Protection Act.

“Project” (6/19) means the overall delivery of the Goods all related Services including, without limitation, design, development, integration, implementation, testing, support and Maintenance, and any Deliverables any of which Contractor may be providing in whole or in part.

“Proposal” (11/18) means Contractor’s response to the City’s RFP referenced on page one of this Contract.

“Public Transit Agency Safety Plan (PTASP)” (\*) Portland Streetcar (Streetcar) is subject to the Federal Transit Administration (FTA) State Safety Oversight (SSO) Program. Streetcar was required to develop and adopt a comprehensive Public Transportation Agency Safety Plan (PTASP). PTASP establishes technical and managerial safety strategies for the identification, assessment, prevention, and control of hazards to passengers, workers, contractors, and

others that come in contact with the system. One of the major activities required under the City of Portland's PTASP is the implementation of the SSC for all new capital projects.

"Repair(s)" (11/18) means to fix, patch, reprogram, or replace the System, or a component thereof, to eliminate Defects to the City's satisfaction.

"Resolution Time" (11/18) means the time elapsed between the response to a Maintenance Request and the time the Maintenance Request is resolved to the satisfaction of the City.

"Response Time" (11/18) means the time elapsed between the time of notification to Contractor of a Maintenance Request, and the time Contractor acknowledges receipt of the City's request.

"Streetcar Vehicle" (SCV) means a complete streetcar assembled as described in Exhibit C, Technical Specification, ready to operate in revenue service.

"Services" (11/18) means both ordinary and professional services performed by Contractor under this Contract.

"Specifications" (11/18) means the most current cumulative statement of capabilities, functionality, and performance requirements for the System and its components as set out in the Technical Specifications, Acceptance Criteria, Change Orders, the Statement of Work, Documentation, Contractor's representations, Contractor's Proposal and Proposal Clarifications, and the City's Request for Proposals.

"State Safety Oversight (SSO)" (\*) the State Safety Oversight maintains a program which is obligated to oversee safety of transit agencies operating rail-fixed guideway systems, such as light rail, streetcars and trolleys. The Streetcar System is regulated through the Federal Transit Administration's State Safety Oversight Program under 49 CFR 673 and 49 CFR Part 674.

"Statement of Work" (SOW) (11/18) means the written detailed specifications of the Product(s) and Services(s) to be delivered to the City by Contractor, including any Change Orders or Task Orders subject to the terms and conditions of this Contract. See Exhibit B, Statement of Work.

"Subcontractor" (11/18) means any person or entity under the control of Contractor, other than an employee of Contractor, utilized by Contractor to perform all or part of this Contract.

"System" (11/18) means the operational combination of all Goods and Services to be provided by Contractor to City under this Contract.

"System Safety Certification Program" (\*) (SSC) means a program for safety certification for system modification and extension to ensure that Streetcar System continues to be safe for passengers, employees, contractors, and the general public. The purpose of the SSC is to ensure that Streetcar system expansions/modifications are systematically reviewed for compliance with essential safety requirements prior to the commencement of revenue service.

It provides traceable verification that all safety-critical systems, subsystems, procedures, and training programs have been reviewed.

**“Task Order”** (11/18) means any written request or document issued by the City and signed by both Parties for additional Product(s) or Service(s) to be provided under this Contract. Task Orders shall document the description of Goods and/or Services, price, payment schedule, Project and performance schedule, due dates, milestones, and Deliverables.

**“Technical Specifications”** (\*) means the requirements for the Deliverables delineated in Exhibit C, Technical Specification.

**“Term”** (11/18) means the period of time that this Contract is in effect as stated on page one.

**“Warranty Period”** (08/19) means a period not less than two (2) years from Acceptance of the Goods or Services or Contractor’s standard warranty term, whichever is longer, or the period of free Maintenance provided by Contractor for the Goods or Services.

**“Work”** (\*) All designs, Deliverables, engineering, manufacturing, operations, materials, equipment, parts and labor, and any other Goods and Services required to timely provide the completed SCVs and all other items indicated or referenced in the Contract.

## **SECTION 2 ORDER OF PRECEDENCE**

### **2.1 Order of Precedence.** (09/17)

In the event there is a conflict or ambiguity between the terms and conditions of one portion of this Contract with another portion of this Contract, the conflict or ambiguity will be resolved in accordance with the order of precedence below. This order of precedence designates which portion of the Contract takes precedence over the other for purposes of interpretation. Contractor’s hyperlinks contained herein will not supersede or alter the Master Terms and Conditions. For the avoidance of doubt, no other terms and conditions will override the Parties’ obligations in the Confidentiality, Indemnification, or Choice of Law provisions in these Master Terms and Conditions. In this Contract the order of precedence shall be:

1. Amendments
2. Exhibit E, Federal Requirements
3. Master Terms and Conditions
4. Exhibit A, Contractor’s Price
5. Change Orders
6. Exhibit B, Statement of Work
7. Exhibit C, Technical Specification
8. Exhibit D, City RFP/Bid # \_\_\_\_\_
9. Exhibit F, Contractor’s Proposal
10. Exhibit G - Sample Documents:
  - a. G-2 Certificate of Acceptance
  - b. G-3 Change Order



## **SECTION 3 GENERAL AND ADMINISTRATIVE PROVISIONS**

### **3.1 Term. (09/17)**

This Contract shall begin on the Effective Date and end upon the expiration date set forth on page one of this Contract unless terminated or extended under the applicable Contract provisions.

### **3.2 Point of Contact. (09/17)**

Contractor shall be the sole point of contact for the City with regard to this Contract and the System.

#### **3.2.1 Written Notifications. (10/18)**

All notices to, and other written communication between the Parties shall be deemed received five (5) Business Days after being sent by first class mail, or upon receipt when sent by courier services, or by e-mail. All notices and written communications shall be sent to the Parties set forth on page 1 of the Contract, or to such other places as they may designate by like notice from time to time. Each Party shall provide written notice of any changes to the Party's contacts within thirty (30) Calendar Days.

### **3.3 Changes to Contract.**

#### **3.3.1 Amendment of the Contract. (06/19)**

Any changes to the provisions of this Contract shall be in the form of an Amendment. No provision of this Contract may be amended unless such Amendment is approved as to form by the City Attorney and executed in writing by authorized representatives of the Parties. If the requirements for Amendment of this Contract as described in this section are not satisfied in full, then such Amendments automatically will be deemed null, void, invalid, non-binding, and of no legal force or effect. The City reserves the right to make administrative changes to the Contract unilaterally, such as extending years and increasing compensation. An administrative change means a written Contract change that does not affect the substantive rights of the Parties.

#### **3.3.2 Change Orders to a Statement of Work. (12/18)**

The City and Contractor can agree to make changes, at any time to a Statement of Work in the form of a Change Order. Contractor agrees to timely alter the delivery of Products or Services accordingly. If such changes materially increase or decrease Contractor's obligations, the Parties shall execute an Amendment to the Contract, and if the amount of such adjustment is not calculable as a function of hours or tasks, the Parties shall negotiate in good faith a modified amount. Oral Change Orders are not permitted.

Contractor must submit their Change Order requests to the City with detailed description and reason for their requested changes as specified in Exhibit G-3, Change Order.

Contractor's Change Order request may be rejected, accepted, or modified by the City. If the City determines that the Change Order request is not justified, such request will be denied. The City's findings of fact for either determination will be delivered to Contractor in writing.

If agreed upon, a Change Order or Amendment shall be executed in writing by both Parties.

From time to time, situations may arise in which services are necessary to be performed and the execution of a Change Order is not immediately practical prior to the commencement of the Contractor's performance of the requested services. In such a case, the Contractor shall perform such services upon receipt of a written request to perform additional work, pending execution of a Change Order.

### 3.4 Delivery. (\*)

Contractor shall ship Products freight and insurance prepaid; F.O.B. the City's designated location at the time indicated herein. Shipments will be complete and partial shipments will be avoided unless the City agrees in writing to the partial shipment in advance of such a shipment. The risk of loss or damage in transit shall be upon Contractor until a Product is received by the City at the delivery site. Delivery of Products shall not be deemed to be complete and title to Products shall not pass to the City until an Acceptance Certificate has been issued by the City.

#### 3.4.1 Transfer of Title and Risk of Loss.

Title to each SCV shall pass to the City upon issuance of Conditional Acceptance of SCV, and the Contractor shall furnish and execute all necessary documentation of title at that time. Passage of title shall not constitute Final Acceptance of SCV nor relieve the Contractor of any of its obligations under the Contract, nor does it preclude any revocation of Conditional Acceptance of a SCV by the City. Following City issuance of Conditional Acceptance of SCV, the City shall bear the risk of any loss or damage to the SCV, unless such the Equipment for the Good(s), Service(s), or Deliverable(s) is found to be Defective.

Notwithstanding the above, the Contractor shall bear the risk of loss for any SCV which has had its Conditional Acceptance of a SCV revoked pursuant to Section 8.4.7, Conditional Acceptance of a SCV, Final Acceptance of a SCV and Non-Acceptance.

Contractor shall be solely responsible for materials delivered and work performed prior to Delivery to the City, including any damage incurred during transportation to the City's designated point of delivery. Contractor shall promptly rebuild, repair, replace or restore such work, equipment or materials that have been damaged or destroyed.

If any loss or damage occurs to the equipment for which the Contractor is responsible hereunder, the Contractor shall immediately repair or replace and make good any such loss or damage, and in the event of the Contractor refusing or neglecting to do so, the City may itself or by the employment of some other person repair or replace and make good any such loss or damage, and the cost and expense of so doing shall be charged to Contractor. Contractor shall reimburse the City such costs within thirty (30) days of written demand from the City. If Contractor refuses or fails to pay these costs within thirty (30) days, the City may withhold said costs from any payments then due or to become due, to Contractor.

Contractor's responsibility for protecting and preserving equipment or for material shall be the same for any City Furnished Equipment or material, in the Contractor's possession, under this Contract as for Contractor furnished material.

#### 3.4.2 Delivery Schedule. (09/17)

Contractor shall use best efforts to deliver Product(s) and/or Services(s) on time, in accordance with the scheduled delivery date as set forth in this Contract or, Statement of Work or Change Order.

#### 3.4.3 Time is of the Essence. (06/19)

The Parties agree that time is of the essence as to the delivery of Deliverables and performance of Services under this Contract. By executing this Contract and accepting the Statement of Work, Contractor agrees that the time limits specified in the Statement of Work are reasonable. By accepting late or otherwise inadequate performance of Contractor's obligations, the City will not waive its rights to require timely performance of Contractor's obligations thereafter.

#### 3.4.4 Delays

If the Contractor is delayed at any time during the progress of the Work by the neglect or failure of the City or by a cause as described below, then the time for completion and/or affected delivery date(s) shall be extended by the City subject to the following cumulative conditions:

1. The cause of the delay arises after the Notice to Proceed and neither was nor could have been anticipated by the Contractor by reasonable investigation before such notice. Such cause may also include force majeure events such as any event or circumstance beyond the reasonable control of the Contractor, including but not limited to acts of God; earthquake, flood and any other natural disaster; civil disturbance; fires and explosions; war and other hostilities; embargo; or failure of third parties, including Suppliers or Subcontractors, to perform their obligations to the Contractor due to a force Majeure event described above;
2. The Contractor demonstrates that the completion of the Work and/or any affected deliveries will be actually and necessarily delayed;
3. The Contractor has taken measures to avoid and/or mitigate the delay by the exercise of all reasonable precautions, efforts and measures, whether before or after the occurrence of the cause of delay; and
4. The Contractor makes written request and provides other information to the City as described below. None of the above shall relieve the Contractor of any liability for the payment of any liquidated damages owing from a failure to complete the Work by the time for completion that the Contractor is required to pay pursuant to Liquidated Damages for Late Delivery, for delays occurring prior to, or subsequent to the occurrence of an excusable delay.

The City reserves the right to rescind or shorten any extension previously granted, if subsequently the Agency determines that any information provided by Contractor in support of a request for an extension of time was erroneous; provided, however, that such information or facts, if known, would have resulted in a denial of the request for an excusable delay. Notwithstanding the above, the City will not rescind or shorten any extension previously granted if the Contractor acted in reliance upon the granting of such extension and such extension was based on information which, although later found to have been erroneous, was submitted in good faith by the Contractor.

No extension or adjustment of time shall be granted unless: (1) written notice of the delay is filed with the City within 14 calendar days after the commencement of the delay, and (2) a written application therefore, stating in reasonable detail the causes, the effect to date and the probable future effect on the performance of the Contractor under the Contract, and the portion or portions of the Work affected, is filed by the Contractor with the City within thirty (30) calendar days after the commencement of the delay. No such extension or adjustment shall be deemed a waiver of the rights of either party under the Contract. The City shall make its determination within thirty (30) calendar days after receipt of the application.

#### 3.4.5 Late Delivery. (06/19)

In the event that any specified delivery date is not met, Contractor shall be liable for any loss, expense, or damage resulting from delay in delivery or failure to deliver Goods or provide Services which is due to any cause except as set forth in Force Majeure. In the event of delay due to any such cause, the City may obtain substitute Goods or Services from another source and bill all additional costs directly to Contractor who shall remain financially liable for all additional acquisition costs.

#### 3.4.6 Best Efforts. (06/19)

Contractor shall use best efforts to minimize any delay in the provision of Goods, Deliverables, or performance of Services. If Contractor anticipates any delay that may prevent timely performance of Contractor's obligations under this Contract, Contractor shall promptly notify the City, including the anticipated length of the delay, the cause of the delay, measures proposed or taken to prevent or minimize the delay, and the timetable for implementation of such measures.

#### 3.4.7 Cancellation and Reschedule. (08/19)

Unless otherwise set forth in Exhibit A, Contractor's Price or Exhibit B, the Statement of Work, the City reserves the right to cancel or reschedule any order without penalty or charge, by giving written notice to Contractor at any time in advance of scheduled ship date.

#### 3.4.8 Lead Time. (08/19)

Lead time for Goods shall be no longer than the lead time set forth in the Statement of Work.

#### 3.5 City Reporting Requirements. (12/18)

The City is required to track certain types of contract data for reporting purposes.

### 3.6 Payment. (09/17)

Payment(s) shall be in accordance with the payment schedule set forth in Exhibit A: Contractor's Price.

Payment shall be issued by the City net thirty (30) Calendar Days from receipt of a complete and acceptable invoice from Contractor. Contractor invoices must contain Contractor's name and address; invoice number; date of invoice; Contract number and date; description of Products and/or Services; quantity, unit price, (where appropriate), and total amount; City-required reporting, if any, and the title and phone number of the person to whom payment is to be sent. The City may stipulate how line items are entered on an invoice to ensure compatibility with the City's accounting and financial systems and to facilitate payment to Contractor.

The City makes payments via electronic fund transfers through the Automated Clearing House (ACH) network. To initiate payment of invoices, Contractor shall execute the City's standard ACH Vendor Payment Authorization Agreement. Upon verification of the data provided, the ACH Vendor Payment Authorization Agreement will authorize the City to deposit payment directly into specified Contractor accounts with specified financial institutions. All payments shall be made in United States currency.

### 3.7 Payment of Taxes/Contractor Shall Withhold. (09/17)

Contractor shall, at its own expense, timely (a) pay all salaries, wages, and other compensation to its employees; (b) withhold, collect, and pay all applicable federal, state, and local income taxes (domestic or foreign), FICA, Medicare, unemployment insurance and any other taxes or charges in connection with its employees; and (c) provide and pay for workers compensation insurance and any statutory or fringe benefits to employees. Contractor shall be solely responsible for all such obligations for its employees. Contractor shall also ensure that any Subcontractor shall comply with the foregoing obligations for its employees. The City shall have no duty to pay or withhold such obligations.

### 3.8 Records, Audits and Inspection (06/19)

#### 3.8.1 Records Retention. (06/19)

Contractor shall maintain current financial records in accordance with Generally Accepted Accounting Principles (GAAP). Contractor agrees to maintain and retain all financial records, supporting documents, statistical records and all other records pertinent to this Contract during the term of this Contract and for a minimum of six (6) years after the expiration or termination date of this Contract or until the resolution of all audit questions or claims, whichever is longer.

#### 3.8.2 City Audits. (06/19)

The City, either directly or through a designated representative, may conduct financial and performance audits of the billings and Products or Services at any time in the course of the Contract and during the records retention period listed above. Audits shall be conducted in accordance with generally accepted auditing standards as promulgated in Government

Auditing Standards by the Comptroller General of the United States Government Accountability Office.

### 3.8.3 Buys American Audits. (\*)

See Exhibit E, Federal Requirements, Section 18, Buy America Requirements.

### 3.8.4 Access to Records. (06/19)

The City may examine, audit, and copy Contractor's books, documents, papers, and records relating to this Contract at any time during the records retention period listed above upon reasonable notice. Copies of applicable records shall be made available upon request. See Exhibit E, Federal Requirements, Section 5, Access to Third Party Contract Records.

### 3.8.5 Access to Facilities.

Contractor shall at all times give the City and to any person designated by the City, access to all facilities, whether necessary or convenient, for inspecting the Project work done under this Contract. The City Project Manager, and all employees of the City bearing the City Project Manager's authorization shall be admitted at any time summarily and without delay at any place where the Project is being performed, or to inspect materials at any place or stage of their manufacture, preparation, shipment or delivery. The Contractor shall extend to the City full access to its manufacturing facilities, and those of its subcontractor(s) and supplier(s), during normal working hours so that the City can inspect and monitor the Contractor's compliance with its established quality assurance/control procedures and the Contract.

The City Project Manager shall be furnished with every facility, including but not limited to, tools, pits, hoists, scaffolds, platforms, other equipment, and assistance as may be necessary for inspections or tests for ascertaining whether the Project is in accordance with the requirement and intent of this Contract.

Any inspection hereunder shall not unreasonably disrupt the Contractor's performance of the Project.

### 3.9 Overpayment. (09/17)

If an audit discloses that payments to Contractor were in excess of the amount to which Contractor was entitled, then Contractor shall repay the amount of the excess to the City. Under no circumstances will the payment of previous invoices constitute an acceptance of the charges associated with those invoices.

### 3.10 Independent Contractor. (09/17)

Contractor is independent of the City and, accordingly, this Contract is not entered into as a joint venture, partnership, or agency between the Parties. No employment or agency relationship is or is intended to be created between the City and any individual representing Contractor. Employees of Contractor and any authorized Subcontractors shall perform their work under this Contract under Contractor's sole control.

### 3.11 Personnel.

#### 3.11.1 Security Requirements for Personnel. (09/17)

If required by the City, Contractor shall conduct a criminal history/records check of all personnel that will have access to City information, systems, or payments and ensure ongoing security requirements for personnel are maintained.

#### 3.11.2 Key Positions and Personnel. (09/17)

For the period of performance until Final Acceptance of a SCV has been completed, the Parties have identified Key Positions and Key Personnel as set forth in the table below, along with the percentage of their time to be allocated to the City's Project:

- Project Manager. (01/25) The Contractor shall appoint an individual acceptable to the City to serve as the full time Project Manager through Contract Closeout. The individual shall be responsible for the day-to-day activities for management and supervision of the Contract shall serve as the primary contact to the City. The Project Manager shall have a minimum of ten (10) years' experience managing similar type and size of project.
- Safety Supervisor (\*) The Contractor shall appoint an individual acceptable to the City to serve as the Safety Supervisor through Contract Closeout. The individual shall be responsible for all safety items.
- Lead Engineer(\*) The Contractor shall appoint an individual acceptable to the City to serve as the Lead Engineer through Contract Closeout. The Lead Engineer shall be responsible for the Design, Construction and testing of the SCV.

Name	Title/Role	% of Time	Company
	Project Manager		
	Safety Supervisor		
	Lead Engineer		

#### 3.11.3 Substitution of Key Personnel. (09/17)

Contractor shall make no substitutions of Key Personnel unless the substitution is necessitated by law, illness, death, resignation, or termination of employment. Contractor shall notify the City within ten (10) Calendar Days after the occurrence of any of these events.

Any substitutions or replacements of Key Personnel require the written approval of the City.

For any proposed substitute or replacement Key Personnel, Contractor shall provide the following information to the City: a detailed explanation of the circumstances necessitating the proposed substitution or replacement, a complete resume for the proposed substitute(s), and any additional information requested by the City. Proposed substitutes or replacements should have qualifications comparable to or better than those of the persons being replaced. No change in Contract prices may occur as a result of substitution or replacement of Key Personnel.

On-site Personnel, performing Safety Sensitive work, must comply with DOT rule 49 CFR part 40.

### 3.12 Termination. (06/19)

The following conditions apply to termination of this Contract. The City, on thirty (30) Calendar Days' written notice to Contractor, may terminate this Contract for any reason in the City's sole discretion. In the event of such termination, the City shall pay to Contractor the portion of the not-to-exceed price attributable to all Deliverables Accepted or Services performed and Accepted through the effective date of the termination. In the event of termination all of Contractor's Work Product to date shall be delivered to the City, and it will become and remain property of the City.

If this Contract is terminated while the Contractor has possession of Deliverables, the Contractor shall, upon direction of the City, protect and preserve the Deliverables until surrendered to the City or its agent. The Contractor and the City shall agree on payment for the preservation and protection of Deliverables. Failure to agree on an amount will be resolved under the Dispute clause.

### 3.13 Non-Availability of Funds. (\*)

Every obligation of the City under this Contract is conditioned upon the availability of funds appropriated or allocated for the fulfillment of the City's obligations. If funds are not allocated and available for the continuance of this Contract, the Contract may be terminated by the City at the end of the period for which the funds are available. No liability shall accrue to the City if this provision is exercised, and the City shall not be obligated or liable for any future payments as a result of termination under this paragraph.

### 3.14 Mutual Agreement. (09/17)

The City and Contractor, by mutual written agreement, may terminate this Contract at any time.

### 3.15 Suspension of Work(\*)

The City may at any time and for any reason within its sole discretion issue a written order to the Contractor suspending, delaying or interrupting all or any part of the Work for a specified period of time.

The Contractor shall comply immediately with any such written order and take all reasonable steps to minimize costs allocable to the Work covered by the suspension during the period of Work stoppage. Contractor shall continue the Work that is not included in the suspension and shall continue such ancillary activities as are not suspended. The Contractor shall resume performance of the suspended Work upon expiration of the notice of suspension, or upon written direction from the City's Authorized Representative.

The Contractor shall be allowed an equitable adjustment in the Contract price (excluding profit) and/or an extension of the Contract time, to the extent that cost or delays are shown by the Contractor to be directly attributable to any suspension. However, no adjustment shall be



made under this section for any suspension, delay or interruption due to the breach, fault, or negligence of the Contractor. As soon as reasonably possible after receipt of the written Suspension of Work notice, the Contractor shall submit to the City's Authorized Representative a detailed price and schedule impact Proposal for the impact of the suspension, delay or interruption.

### 3.16 Material Breach. (09/17)

Either Party may terminate this Contract in the event of a Material Breach of this Contract by the other. Prior to such termination, however, the Party seeking the termination shall give to the other Party written notice to cure the Material Breach and of the Party's intent to terminate. If the Party has not entirely cured the Material Breach within fourteen (14) Calendar Days of the notice, then the Party giving the notice shall have the option to: (a) terminate this Contract by giving a written notice of termination, (b) seek any remedies in this Contract, in law, or at equity, to the extent not otherwise limited by the terms of this Contract, or (c) any combination thereof.

### 3.17 Force Majeure. (09/17)

Either Party may terminate this Contract due to a Force Majeure event as set forth in Section 5.13, Force Majeure.

### 3.18 Bankruptcy. (09/17)

The City may terminate this Contract if Contractor: (a) becomes insolvent, makes a general assignment for the benefit of creditors; (b) suffers or permits the appointment of a receiver for its business or assets; (c) becomes subject to any proceeding under any bankruptcy or insolvency law whether domestic or foreign, and such proceeding has not been dismissed within a sixty (60) Calendar Day period; or (d) has wound up or liquidated, voluntarily or otherwise.

### 3.19 Void Assignment. (09/17)

In the event that Contractor assigns its obligations under this Contract to a third party in a manner other than as set forth in Section 5.8, Assignment, the City shall have the option to terminate this Contract without any notice or cure period or further obligation to Contractor or the assignee, and promptly receive a refund for fees paid for Products delivered and/or Services performed by the third party.

### 3.20 Waiver. (09/17)

No waiver of any breach of this Contract shall be held to be a waiver of any other or subsequent breach of this Contract. The failure of either Party to insist upon any of its rights under this Contract upon one or more occasions, or to exercise any of its rights, shall not be deemed a waiver of such rights on any subsequent occasions.

### 3.21 Severability. (09/17)

Any section of this Contract which is held or declared void, invalid, illegal or otherwise not fully enforceable shall not affect any other provision of this Contract and the remainder of this

Contract shall continue to be binding and of full force and effect. This Contract shall be binding upon and inure to the benefit of the City and its successors and assigns.

### 3.22 Business Tax Registration. (09/17)

Contractor shall register for a City of Portland business license as required by Chapter 7.02 of the Code of the City of Portland prior to execution of this Contract. Additionally, Contractor shall pay all fees or taxes due under the Business License Law and the Multnomah County Business Income Tax (MCC Chapter 12) during the full term of this Contract. Failure to be in compliance may result in payments due under this Contract to be withheld to satisfy amount due under the Business License Law and the Multnomah County Business Income Tax Law.

### 3.23 EEO Certification. (09/17)

Contractor shall be certified as an Equal Employment Opportunity Affirmative Action Employer as prescribed by Chapter 5.33.076 of the Code of the City of Portland and maintain its certification throughout the term of this Contract.

### 3.24 Non-Discrimination in Benefits. (09/17)

Throughout the term of this Contract, Contractor shall provide and maintain benefits to its employees with domestic partners equivalent to those provided to employees with spouses as prescribed by Portland Public Contracting Administrative Rules, PCR-1.01, Section 5.33, Goods and Services, Subsection 077, Equal Benefits.

### 3.25 Sustainability. (12 /18)

Pursuant to the City's Sustainable City Principles, which direct City Bureaus to pursue long-term environmental quality, and economic vitality through innovative and traditional mechanisms, Contractor is encouraged to incorporate these Principles into its scope of work with the City wherever possible. Therefore, in accordance with the Principles and the City's Sustainable Procurement Policy, it is the policy of the City of Portland to encourage the use of Products or Services that help to minimize the human health and environmental impacts of City operations. Contractor is encouraged to incorporate environmentally preferable Products or Services into its work performance wherever possible. "Environmentally preferable" means Products or Services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the Product or Service.

### 3.26 Packaging. (09/17)

All packaging should be minimized to the maximum extent possible without compromising product quality. The City encourages packaging that is reusable, readily recyclable in local recycling programs, is made from recycled materials, and/or is collected by Contractor for reuse/recycling.

### 3.27 News Releases and Public Announcements. (09/17)

Contractor shall not use the City seal or other representations of the City in its external advertising, marketing, website, or other promotional efforts, nor shall Contractor issue any news release or public announcements pertaining to this Contract or the Project without the express written approval of the City. Such approval may be withheld in the City's sole discretion. Contractor shall not use the City seal without specific written permission from the City Auditor.

### 3.28 Rule of Construction/Contract Elements/Headings. (09/17)

This Contract has been drafted by the City in the general format by the City as a convenience to the Parties only and shall not, by reason of such action, be construed against the City. Section headings are for ease of reference and convenience only and shall not affect or enter into the interpretation of any portion of this Contract.

### 3.29 Survival. (09/17)

All obligations relating to Confidential Information; indemnification; publicity; representations and warranties; remedies; proprietary rights; limitation of liability; dispute resolution; and obligations to make payments of amounts that become due under this Contract prior to termination or expiration shall survive the termination or expiration of this Contract and shall, to the extent applicable, remain binding and in full force and effect for the purposes of the ongoing business relationship by and between Contractor and the City.

### 3.30 Permissive Cooperative Procurement. (09/17)

Pursuant to ORS 279A.215, as additional consideration for this Contract, Contractor agrees to extend an option to purchase any Products or Services covered under this Contract at the same prices as are specified in Exhibit A: Contractor's Price, and under the same terms and conditions, to all public agencies. Each public agency shall execute its own contract with Contractor and shall have the option to negotiate its own terms and conditions.

## **SECTION 4 STATUTORY REQUIREMENTS, PUBLIC RECORDS AND CONFIDENTIALITY**

### 4.1 Governing Law and Jurisdiction. (\*)

This Contract shall be construed according to the laws of the State of Oregon without reference to the conflict of laws' provisions. Any litigation between the City and Contractor arising under this Contract or out of work performed under this Contract shall occur, if in the state courts, in the Multnomah County Circuit Court, and if in the federal courts, in the United States District Court for the District of Oregon.

Any proceeding initiated under this Section shall be deemed confidential to the maximum extent allowed by State Law and no Party shall make any disclosure related to the disputed matter or the outcome of any proceeding except to the extent required to seek interim equitable relief or to enforce an agreement reached or an award made hereunder. Notwithstanding the above, the Parties understand that City is subject to Oregon's public records laws delineated below.

#### 4.2 Public Records Request. (09/17)

Contractor acknowledges that the City of Portland is subject to the Oregon Public Records Act and Federal law. Third persons may claim that the Confidential Information Contractor submitted to the City hereunder may be, by virtue of its possession by the City, a public record and subject to disclosure pursuant to the Oregon Public Records Act. The City's commitments to maintain certain information confidential under this Contract are all subject to the constraints of Oregon and federal laws. All information submitted by Contractor is public record and subject to disclosure pursuant to the Oregon Public Records Act, except such portions for which Contractor requests and meets an exemption from disclosure consistent with federal or Oregon law. Within the limits and discretion allowed by those laws, the City will maintain the confidentiality of information.

#### 4.3 Public Records. (09/17)

The City will retain one (1) copy of any public records for the express purposes of complying with State of Oregon and Portland City Code public records and archiving laws.

#### 4.4 Confidentiality.

##### 4.4.1 Contractor's Confidential Information. (08/19)

During the term of this Contract, Contractor may disclose to the City, certain Contractor Confidential Information pertaining to Contractor's business. Contractor shall be required to mark Confidential Information CONFIDENTIAL with a restrictive legend or similar marking. If CONFIDENTIAL is not clearly marked, or the Contractor's Confidential Information cannot be marked with a restrictive legend or similar marking or is disclosed either orally or by visual presentation, Contractor shall identify the Confidential Information as confidential at the time of disclosure or within a reasonable time thereafter. This Contract itself shall not be considered Confidential Information. Subject to Section 4.2, Public Records Request, the City shall: (1) limit disclosure of Contractor Confidential Information to those directors, employees, contractors and agents of the City who need to know the Contractor Confidential Information in connection with the City Project and who have been informed of confidentiality obligations at least as strict as those contained in this Contract, and (2) exercise reasonable care to protect the confidentiality of the Contractor Confidential Information, at least to the same degree of care as the City employs with respect to protecting its own proprietary and confidential information.

##### 4.4.2 City's Confidential Information. (08/19)

Contractor shall treat as confidential any City Confidential Information that has been made known or available to Contractor or that Contractor has received, learned, heard, or observed; or to which Contractor has had access. Contractor shall use City Confidential Information exclusively for the City's benefit in the performance of this Contract. Except as may be expressly authorized in writing by the City, in no event shall Contractor publish, use, discuss or cause or permit to be disclosed to any other person such City Confidential Information. Contractor shall (1) limit disclosure of the City Confidential Information to those directors, officers, employees, subcontractors and agents of Contractor who need to know the City Confidential Information in connection with the City Project and who have agreed in writing to

confidentiality obligations at least as strict as those contained in this Contract, (2) exercise reasonable care to protect the confidentiality of the City Confidential Information, at least to the same degree of care as Contractor employs with respect to protecting its own proprietary and confidential information, and (3) return immediately to the City, upon its request, all materials containing City Confidential Information, in whatever form, that are in Contractor's possession or custody or under its control. Contractor is expressly restricted from and shall not use the Intellectual Property Rights of the City without the City's prior written consent.

#### 4.4.3 Scope. (09/17)

This Contract shall apply to all City Confidential Information previously received, learned, observed, known by, or made available to Contractor. Contractor's confidentiality obligations under this Contract shall survive termination or expiration of this Contract.

#### 4.4.4 Equitable Relief. (12/18)

Contractor acknowledges that unauthorized disclosure of City Confidential Information will result in irreparable harm to the City. In the event of a breach or threatened breach of this Contract, the City may obtain injunctive relief prohibiting the breach, in addition to any other appropriate legal or equitable relief. The Parties agree that, notwithstanding any other section of this Contract, in the event of a breach or a threatened breach of Contract terms related to Confidential Information or Intellectual Property Rights, the non-breaching Party shall be entitled to seek equitable relief to protect its interests, including but not limited to injunctive relief. Nothing stated herein shall be construed to limit any other remedies available to the Parties.

#### 4.4.5 Discovery of Documents. (06/19)

In the event a court of competent jurisdiction orders the release of Confidential Information submitted by one Party, the other Party will notify the Party whose Confidential Information is being requested to be disclosed of the request. The Party receiving the request shall allow the other Party to participate in the response at its own expense. Each Party will comply with any effective court order.

## **SECTION 5 CONTRACTOR PERFORMANCE AND WARRANTIES**

### 5.1 General Warranties. (09/17)

Contractor makes the following warranties:

#### 5.1.1 Capacity. (09/17)

Contractor warrants it has the legal authority and capacity to enter into and perform this Contract.

#### 5.1.2 Authority to Conduct Business. (08/19)

Contractor warrants it is lawfully organized and constituted and duly authorized to operate and do business in all places where it shall be required to do business under this Contract, and that it has obtained or will obtain all necessary licenses and permits required in connection with this Contract.

#### 5.1.3 Disclosure of Litigation. (09/17)

Contractor warrants that as of the Effective Date there are no suits, actions, other proceedings, or reasonable anticipation thereof, in any judicial or quasi-judicial forum that will or may adversely affect Contractor's ability to fulfill its obligations under this Contract. Contractor further warrants that it will immediately notify the City in writing if, during the Term of this Contract, Contractor becomes aware of, or has reasonable anticipation of, any lawsuits, actions, or proceedings in any judicial or quasi-judicial forum that involves Contractor or any Subcontractor and that will or may adversely affect Contractor's ability to fulfill its obligations under this Contract.

#### 5.1.4 Conflict of Interest. (09/17)

Contractor warrants it has no present interest and shall not acquire any interest that would conflict in any manner with its duties and obligations under this Contract.

#### 5.1.5 Compliance with Applicable Law. (09/17)

Contractor warrants it has complied and shall comply with all applicable federal, state, and local laws and regulations of its domicile and wherever performance occurs during the term of this Contract. Contractor warrants it is currently in compliance with all tax laws.

#### 5.1.6 Public Contracts. (09/17)

Contractor shall observe all applicable state and local laws pertaining to public contracts. ORS Chapters 279A and 279B require every public contract to contain certain provisions. To the extent applicable, the provisions of 279A and 279B are hereby incorporated by this reference herein.

#### 5.1.7 Compliance with Civil Rights Act. (09/17)

Contractor warrants it is in compliance with Title VI of the Civil Rights Act of 1964 and its corresponding regulations as further described at:

<https://www.portland.gov/policies/administrative/civil-rights/adm-1801-city-portland-civil-rights-title-vi-plan>.

#### 5.1.8 Respectful Workplace Behavior. (09/17)

The City is committed to a respectful work environment, free of harassment, discrimination and retaliation and other inappropriate conduct. Every individual has a right to work in a professional atmosphere where all individuals are treated with respect and dignity. The City's HR Rule 2.02 covers all employees of the City as well as contractors, vendors or consultants who provide services to the City of Portland. Contractor warrants its compliance with terms and conditions HR 2.02 as further described at: <https://www.portlandoregon.gov/citycode/27929>

## 5.2 Grant Funding. (\*).

This contract is funded by local government and Federal Transit Administration (FTA) funds. Contractor shall conform to all applicable FTA regulations and requirements as if all funds involved were FTA funds.

## 5.3 Compliance with Non-Discrimination Laws and Regulations.

### 5.3.1 Nondiscrimination. (06/19)

Pursuant to all City, State, and federal non-discrimination and civil rights laws, Contractor, with regard to the work performed by it during this Contract, shall not discriminate on the grounds of race, color, national origin, including limited English proficiency, sex, sexual orientation, gender identity, age, religion or non-religion, disability, veteran status, marital status, family status, or source of income, including in employment practices, the selection and retention of subcontractors, including procurements of materials and leases of equipment.

### 5.3.2 Solicitations for Subcontractors, Including Procurements of Materials and Equipment. (06/19)

In all solicitations either by competitive bidding or negotiation made by Contractor for work to be performed under a subcontract, including procurements of materials or leases of equipment, each potential subcontractor or supplier shall be notified by Contractor of Contractor's obligations under this Contract relative to nondiscrimination on the grounds of race, color, national origin, sex, sexual orientation, age, religion, disability, veteran status, marital status, or family relationships.

### 5.3.3 Sanctions for Noncompliance. (09/17)

In the event of Contractor's noncompliance with the nondiscrimination provisions of this Contract, the City shall impose such contract sanctions as it or any state or federal agency may determine to be appropriate, including, but not limited to withholding of payments to Contractor under this Contract until Contractor complies, and/or cancellation, termination, or suspension of this Contract, in whole or in part.

### 5.3.4 ADA Compliance. (07/18\*Compl)

Contractor shall comply with the Americans With Disabilities Act (ADA), including any duty the ADA may impose on City or Contractor as a result of the Products, Services or activities requested to be provided for City under this Contract.

At minimum, Contractor shall do the following:

Comply with Title 49 CFR Parts 37 and 38, Title 36 CFR 1191.

Contractor shall document each ADA request for modification to the Products or Services and Contractor's fulfillment of the request. If Contractor determines that it is unable to promptly fulfill the request for modification under the ADA, Contractor will contact the City contract manager within the same business day, proving reasons why Contractor is unable to fulfill the

request for modification and to identify alternate accessibility options that Contractor can perform.

Within twenty (20) Business Days after receipt, City and Contractor shall advise the other Party in writing, and provide the other Party with copies (as applicable) of any notices alleging violation of or noncompliance with the ADA relating to the Contract, or any governmental or regulatory actions or investigations instituted or threatened regarding noncompliance with the ADA and relating to the Contract or the programs, Products, Services or activities that Contractor is undertaking for City under this Contract.

#### 5.3.5 Required Reporting. (05/19)

If any person or class of persons files a complaint with Contractor alleging discrimination under Title VI of the Civil Rights Act of 1964 (race, color, or national origin, including limited English proficiency), Contractor will notify the City of Portland of the complaint and cooperate with any investigation related to the complaint. Notifications shall be sent to Title VI Program Manager, 1120 SW 5th Avenue, Suite 1048, Portland, Oregon 97204, or [title6complaints@portlandoregon.gov](mailto:title6complaints@portlandoregon.gov).

#### 5.4 Goods and Service(s) Warranties. (08/19)

Contractor makes the following warranties:

##### 5.4.1 No Third-Party Conflict or Infringement. (01/19)

As of the Effective Date, Contractor warrants the execution and performance of this Contract, shall not contravene the terms of any contracts with third parties or any third-party Intellectual Property Right; and, as of the Effective Date of this Contract, there are no actual or threatened legal actions with respect to the matters in this provision. Contractor agrees to promptly notify the City, in writing, if during the Term of the Contract, a potential third-party conflict or infringement of third-party Intellectual Property Rights arises.

##### 5.4.2 No Encumbrances. (08/19)

All Deliverables provided by Contractor under this Contract shall be transferred to the City free and clear of any and all restrictions of transfer or distribution and free and clear of any and all liens, claims, security interests, liabilities and encumbrances of any kind.

##### 5.4.3 Conformance with Specifications. (01/19)

Contractor warrants that the Goods and Services shall operate in conformance with the Specifications.

##### 5.4.4 No Material Defects. (08/19)

Contractor warrants that the Goods provided shall be free of any defects in design, material, and workmanship.

##### 5.4.5 Applicability. (\*)



Contractor warranties shall apply to all Goods and Services including SCV components, parts, and workmanship, whether performed or provided by the Contractor, subcontractors, or suppliers at any tier. Such warranties shall not apply to damages caused by the City's modification to the SCVs or components without the knowledge and concurrence of the Contractor.

#### 5.4.6 Excluded Warranties. (\*)

No implied warranties of merchantability or of fitness for purpose shall apply.

#### 5.4.7 Equipment, Parts, and Special Tools Warranty. (08/19)

Contractor warrants that all Goods and parts will be new, the latest model (or the one that meets the City's Specifications), and be free from Defects in design, material, and workmanship. Any Good(s) damaged during execution of the Project may be restored to new condition and incorporated into the Project, only if pre-approved by City. If Contractor proposes to provide refurbished, reclaimed, or remanufactured parts or Equipment to the City, Contractor shall request the City's approval in writing in advance of delivery of the Goods and the City retains the right to approve or refuse Contractor's use of refurbished, reclaimed, or remanufactured parts. If the City approves the use of refurbished, reclaimed, or remanufactured parts or Equipment, Contractor warrants such Equipment have the same warranty as that of new and current Equipment and are subject to all the same provisions of this Contract. If approved, all refurbished, reclaimed, or remanufactured parts or Equipment must be performed by the original equipment manufacturer (OEM) whenever possible. If Contractor uses refurbished, reclaimed, or remanufactured parts without the prior approval required by the City, Contractor may be required, at the City's sole discretion, to replace such parts and Equipment with new and current manufactured parts and Equipment at Contractor's sole expense.

#### 5.4.8 Fleet Defect Warranty. (\*)

The Contractor at its sole cost shall furnish, install and replace Fleet Defects in up to 100 percent of the Fleet, including those SCVs yet to be delivered and SCVs for which the Warranty has already expired, and all identical units contained in the City's stock, with new LLRU of improved design.

Contractor shall update, as necessary, all contractually required technical support information (parts, maintenance and operators' manuals) due to changes resulting from warranty repairs.

A Defect in design resulting in a safety hazard shall immediately upon discovery be deemed to be a Fleet Defect and the Contractor, at its sole cost, shall furnish, install and replace all defective LLRUs.

The Fleet Defect provisions shall not apply to Fleet Defects caused by the City's material non-compliance with the Contractor's minimum recommended normal preventative maintenance practices and procedures as contained in the Contractor supplied and City approved maintenance manuals; provided, however, the Contractor, in any denial of Fleet Defect status

must demonstrate by adequate proof that the City did not materially comply, and if adequate proof is not provided the Fleet Defect provisions shall apply.

#### 5.4.9 Planned Obsolescence. (01/19)

Contractor warrants that at the time of delivery of Goods, it has no plans in the next ten (10) years for announcing replacement products for those Goods delivered pursuant to this Contract or any plans that would result in reduced Maintenance or support for the Goods.

#### 5.4.10 Compliance with Law. (08/19)

Contractor warrants that the Goods conform to all requirements of applicable law, including all applicable health, safety, privacy, data security and environmental laws and regulations.

#### 5.4.11 Industry Standards. (01/19)

Contractor warrants that the Goods are compliant with generally accepted industry standards. Contractor warrants that the Services performed under this Contract will meet the standards of skill and diligence normally employed by persons performing the same or similar services.

#### 5.4.12 Substitution or Modification of Products at No Charge. (03/19)

In the event that Contractor substitutes or modifies the Deliverables, Contractor shall ensure that the new or modified Deliverables shall conform in all aspects to the Specifications. Such substitutions or modifications shall in no way degrade the performance or functionality of the Deliverables and shall not result in additional cost to the City.

#### 5.4.13 Warranty Remedies. (08/19)

The City may return to Contractor any Defective Goods identified by the City or Contractor, at Contractor's sole risk and expense. Contractor shall provide one of the following remedies for each defective Good in accordance with Contractor's standard return process: (i) repair the defective Good; (ii) replace defective Goods that cannot be repaired; or (iii) make an appropriate credit adjustment or refund the full amount of the price of the Defective Goods.

#### 5.5 Assignment of Manufacturers' Warranties. (01/19)

In all cases where Goods are covered by a Manufacturer's Warranty, Contractor will provide the City with all Manufacturer's Warranties. Contractor will assign to the City any Manufacturer's Warranty applicable to any respective Good. Notwithstanding the foregoing, Contractor shall be held responsible by the City for correction to or replacement of the Goods or any of its components during the period of Warranty and Maintenance.

#### 5.6 No Waiver of Warranties or Representation. (01/19)

Delivery of Goods or performance of Services shall not be construed to represent Acceptance nor relieve Contractor from its responsibility under any representation or warranty. If the City makes a payment prior to Final Acceptance of a SCV, the payment does not grant a waiver of any representation or warranty by Contractor.

#### 5.7 No Third Party to Benefit. (09/17)

This Contract is entered into for the benefit of the City and Contractor. Except as set forth herein, nothing in this Contract shall be construed as giving any benefits, rights, remedies or claims to any other person, firm, corporation or other entity, including, without limitation, the general public or any member thereof, or to authorize anyone not a Party to this Contract to maintain a suit for breach of contract, personal injuries, property damage, or any other relief in law or equity in connection with this Contract.

#### 5.8 Assignment. (08/19)

Neither Party shall assign, transfer, or delegate all or any part of this Contract, or any interest therein, without the other Party's prior written consent, which shall not be unreasonably withheld. For purposes of this Section, the acquisition, merger, consolidation or change in control of Contractor or any assignment by operation of law shall be considered an assignment of this Contract that requires the City's prior written consent. Notwithstanding the foregoing: (a) in the event that the City's business needs change or the City enters into an agreement with a provider for outsourcing services, Contractor agrees that the City shall have the right to assign this Contract to a successor of all, substantially all, or specified area(s) of the City's business, including an outsourcing provider, upon written notice to the other Party, and (b) Contractor may, without the City's consent, but upon prior written notice to the City, assign its right to payment under this Contract or grant a security interest in such payment to any third party without requiring that the third party be liable for the obligations of Contractor under this Contract. Any attempted assignment or delegation in violation of this Section shall be void.

#### 5.9 Notice of Change in Financial Condition. (09/17)

Contractor must maintain a financial condition commensurate with the requirements of this Contract. If, during the term of this Contract, Contractor experiences a change in its financial condition which may adversely affect its ability to perform the obligations of this Contract, Contractor shall immediately notify the City in writing. Failure to notify the City of such a change in financial condition is sufficient grounds for terminating this Contract.

#### 5.10 Notice of Change in Ownership. (09/17)

If, during the term of this Contract, Contractor experiences a change in ownership or control, Contractor shall immediately notify the City in writing. Failure to notify the City of such a change in ownership or control is sufficient grounds for terminating this Contract.

#### 5.11 Subcontractors. (08/19)

Contractor shall not subcontract any work under this Contract without the City's prior written consent. Contractor shall be fully responsible for the acts and omissions of its Subcontractors, including any Affiliates, at all levels, and of their agents and employees. Contractor shall ensure that all applicable provisions of this Contract (including those relating to Insurance, Indemnification, and Confidentiality) are included in all of its subcontracts. The City reserves the right to review any agreements between Contractor and its Subcontractors for Goods and Services authorized under this Contract.

In no event shall Contractor subcontract any work, assign any rights, or delegate any obligations under this Contract without the City's prior written consent.

A subcontractor may be rejected by the City if it has breached a contractual obligation or if that subcontractor failed to substantially perform the obligation, regardless of whether that failure was formally designated a breach of Contract by the City. Failure to complete performance of an obligation on time, including, but not limited to, failure to meet a Milestone date on a prior City contract, shall be deemed a failure to substantially perform that obligation.

#### 5.12 Flow-down Clauses. (01/19)

Contractor shall include the following clauses, or substantially similar language, in its subcontracts under this Contract:

- Section 4.4, Confidentiality
- Section 5.3, Compliance with Non-Discrimination Laws and Regulations
- Section 6.1, Hold Harmless and Indemnification
- Section 6.2, Insurance
- Exhibit E, Federal Requirements
- Section 5, General Warranties
- Section 7, Warranty

#### 5.13 Force Majeure. (01/19)

In the event that either Party is unable to perform any of its obligations under this Contract due to a Force Majeure Event not the fault of the affected Party, the Party who has been so affected immediately shall give notice to the other Party and shall do everything possible to resume performance. Upon receipt of such notice, the performance obligations affected by the Force Majeure event shall immediately be suspended.

If the period of nonperformance exceeds fourteen (14) Calendar Days from the receipt of notice of the Force Majeure Event, the Party whose ability to perform has not been so affected may, by giving written notice, terminate this Contract or any Statement of Work.

If the period of nonperformance due to a Force Majeure Event does not exceed fourteen (14) Calendar Days, such nonperformance shall automatically extend the Project schedule for a period equal to the duration of such events. Any Warranty Period affected by a Force Majeure Event shall likewise be extended for a period equal to the duration of such event.

If the period of nonperformance due to Force Majeure Event is longer than fourteen (14) Calendar Days, the Parties shall negotiate options for mitigation of the Force Majeure Event.

#### 5.14 Ownership of Property. (06/19)

All work product produced by the Contractor under this Contract is the exclusive property of the City. "Work Product" includes, but is not limited to: research, reports, computer programs, manuals, drawings, recordings, photographs, artwork and any data or information in any form. The Contractor and the City intend that such Work Product shall be deemed "work made for

hire” of which the City shall be deemed the author. If for any reason a Work Product is deemed not to be a “work made for hire,” the Contractor hereby irrevocably assigns and transfers to the City all right, title and interest in such Work Product, whether arising from copyright, patent, trademark, trade secret, or any other state or federal intellectual property law or doctrines. Contractor shall obtain such interests and execute all documents necessary to fully vest such rights in the City. Contractor waives all rights relating to work product, including any rights arising under 17 USC 106A, or any other rights of authorship, identification or approval, restriction or limitation on use or subsequent modifications. If the Contractor is an architect, the Work Product is the property of the Consultant-Architect, and by execution of this Contract, the Contractor-Architect grants the City an exclusive and irrevocable license to use that Work Product.

Notwithstanding the above, all pre-existing trademarks, services marks, patents, copyrights, trade secrets, and other proprietary rights of Contractor are and will remain the exclusive property of Contractor. Contractor hereby grants to the City a non-exclusive, perpetual, irrevocable license, with the right to sublicense, to disclose, copy, distribute, display, perform, prepare derivative works of and otherwise exploit any pre-existing Intellectual Property Rights incorporated into the Work Product(s).

#### 5.15 Software Escrow Account. (\*)

Prior to first Conditional Acceptance of SCV, the Contractor shall provide the City of Portland a list of all software comprising proprietary works (“Proprietary Software”). Source code for the Contractor’s proprietary software and third-party software, if the software is specifically developed for the City of Portland. All related documentation required for the use and modification thereof, and any revisions or derivative works based on the Proprietary Software developed exclusively for the City of Portland pursuant to the Contractor’s performance of the Contract (collectively, “Escrow Materials”) shall be deposited in an escrow account with a third party, as set forth in Attachment S, Sample Software Escrow Agreement. Contractor and the City of Portland shall decide on the escrow account to be used. The City of Portland shall pay all initial and future costs related to maintaining the escrow account. In the event of an unresolved dispute or breach of contract by the Contractor, the escrow materials shall immediately be obtainable and usable by the City of Portland. Additionally, in the event the Contractor fails to support the continued use of the Proprietary Software by the City of Portland, or upon termination or expiration of the term of the escrow.

## **SECTION 6 INDEMNIFICATION, INSURANCE, BONDING, LIQUIDATED DAMAGES**

### 6.1 Hold Harmless and Indemnification. (08/19)

Contractor shall indemnify, defend and hold harmless the City of Portland, its officers, agents, and employees, from all claims, demands, suits, and actions for all losses, damages, liabilities, costs and expenses (including all attorneys’ fees and costs), resulting from or arising out of the actions, errors, or omissions of Contractor or its officers, employees, Subcontractors, or agents under this Contract.

#### 6.1.1 Infringement Indemnity. (08/19)

Contractor shall indemnify, defend, and hold harmless the City, its directors, officers, employees, and agents from and against any and all claims, demands, suits, and actions for any damages, liabilities, losses, costs, and expenses (including reasonable attorney fees, whether or not at trial and/or on appeal), arising out of or in connection with any actual or alleged misappropriation, violation, or infringement of any proprietary right or Intellectual Property Right of any person whosoever. The City agrees to notify Contractor of the claim and gives Contractor sole control of the defense of the claim and negotiations for its settlement or compromise.

Contractor shall indemnify, defend, and hold harmless the City against any taxes, premiums, assessments, and other liabilities (including penalties and interest) that the City may be required to pay arising from Goods and Services provided by Contractor under this Contract. The City of Portland, as a municipal corporation of the State of Oregon, is a tax-exempt unit of local government under the laws of the State of Oregon and is not liable for any taxes.

#### 6.2 Insurance. (08/19)

Contractor shall not commence work until Contractor has met the insurance requirements in this section and Contractor has provided insurance certificates approved by the City Attorney. Contractor shall acquire insurance issued by insurance companies or financial institutions with an AM Best rating of A- or better and duly licensed, admitted and authorized to do business in the State of Oregon.

##### 6.2.1 Insurance Certificate. (08/19)

As evidence of the required insurance coverage, Contractor shall provide compliant insurance certificates, including required endorsements, to the City prior to execution of the Contract. The certificates shall list the City as certificate holder. Contractor shall maintain continuous, uninterrupted coverage for the Term of this Contract and to provide insurance certificates demonstrating the required coverage for the Term of this Contract. Contractor's failure to maintain insurance as required by this Contract constitutes a Material Breach of this Contract. Contractor must notify the City in writing thirty (30) Calendar Days prior to a cancellation, non-renewal, or changes to the insurance policy.

##### 6.2.2 Additional Insureds. (08/19)

For commercial general liability coverage, Contractor shall provide City with a blanket additional insured endorsement form that names the City of Portland, Oregon, and its officers, agents, and employees, as an additional insured. The additional insured endorsement must be attached to the general liability certificate of insurance.

##### 6.2.3 Insurance Costs. (08/19)

Contractor shall be financially responsible for all premiums, deductibles, self-insured retentions, and self-insurance.

##### 6.2.4 Coverage Requirements. (08/19)

Contractor shall comply with the following insurance requirements:

6.2.4.1 Commercial General Liability. (08/19)

Contractor shall acquire commercial general liability (“CGL”) and property damage insurance coverage in an amount not less than \$2 million per occurrence, including \$2M for products/completed operations liability, for damage to property or personal injury arising from Contractor’s work under this Contract.

☒ Required and attached ☐ Reduced by Authorized Bureau Director ☐ Waived by Authorized Bureau Director

6.2.4.2 Umbrella Liability. (08/19)

Contractor shall acquire (if not included in CGL Coverage noted above) Umbrella Liability Insurance covering Contractor’s or appropriate subcontractor’s liability for bodily injury and property damage resulting from products / completed operations incurred by Contractor, all arising out of the Goods delivered or Services (including transportation risk) performed under this Contract is required. The umbrella liability policy shall not be less than \$10 million.

An endorsement to the Commercial General Liability or Automobile Liability policy, covering Contractor’s or subcontractor’ liability for bodily injury and property damage resulting from products / completed operations costs incurred by the Contractor that arise from the Goods delivered or Services (including transportation risk) performed by Contractor under this Contract is also acceptable.

6.2.4.3 Automobile Liability. (08/19)

Contractor shall acquire automobile liability insurance to cover bodily injury and property damage in an amount not less than \$2 million for each accident. Contractor’s insurance must cover damages or injuries arising out Contractor’s use of any vehicle.

☒ Required and attached ☐ Reduced by Authorized Bureau Director ☐ Waived by Authorized Bureau Director

6.2.4.4 Workers’ Compensation. (08/19)

Contractor shall comply with Oregon workers’ compensation law, ORS Chapter 656, as it may be amended. If Contractor is required by ORS Chapter 656 to carry workers’ compensation insurance, Contractor shall acquire workers’ compensation coverage for all subject workers as defined by ORS Chapter 656 and shall maintain a current, valid certificate of workers’ compensation insurance on file with the City for the entire period during which work is performed under this Contract. Contractor shall acquire workers compensation coverage in an amount not less than \$1 million each accident, \$1 million disease each employee, and \$1 million disease policy limit.

☒ Required and attached ☐ Proof of exemption (Complete Independent Contractor Certification Statement)

#### 6.2.4.5 Professional Liability. (08/19)

Contractor shall acquire insurance to cover damages caused by negligent acts, errors or omissions related to the professional Services, and performance of duties and responsibilities of the Contractor under this Contract in an amount not less than \$1 million per occurrence and aggregate of \$3 million for all claims per occurrence. In lieu of an occurrence-based policy, Contractor may have claims-made policy in an amount not less than \$1,000,000 per claim and \$3,000,000 annual aggregate, if the Contractor acquires an extended reporting period or tail coverage for not less than three (3) years following the termination or expiration of the Contract.

☒ Required and attached ☐ Reduced by Authorized Bureau Director ☐ Waived by Authorized Bureau Director

#### 6.2.5 Insurance Requirements for Subcontractors. (\*)

Insurance policies required from the Contractor will be applicable to any and all subcontractor(s) performing Work under this Contract. Contractor shall either: 1) contractually require its subconsultants to acquire and maintain in effect until full performance of their Work under this Contract, insurance equal to the minimum coverage limits required above; or 2) provide evidence that any subcontractor who does not otherwise meet the required minimum coverage limits, is included as an insured under the Contractor's policy.

#### 6.3 Bonds / Performance Security. (\*)

Contractor shall furnish, at its own expense, the following securities:

##### 6.3.1 Performance Bond. (\*)

Contractor shall provide a Performance Bond equal to 50% of the amount specified in Exhibit A, Contractor's Price, Section A.2, Milestone Payment Schedule, Schedules A through D, as a guarantee of good faith that the terms of this Contract shall be complied with in every particular with a corporate surety or with two or more sufficient sureties to be approved by the City. The bond, or equivalent security, shall remain in full force and effect from Notice-to-Proceed until Final Acceptance of the last SCV.

##### 6.3.2 Letters of Credit. (\*)

Irrevocable Standby Letters of Credit ("LOC") in a form acceptable to the City in amounts and for durations as described above in this Section. Both the LOC issuing bank and advising bank shall be acceptable to the City.

##### 6.3.3 Warranty Bond. (\*)



At the time of the Conditional Acceptance of a SCV of the first SCV of the Order, and prior to release of the Performance Bond/Security by the City, the Contractor shall furnish, at its own expense, a Warranty Bond in a form satisfactory to the City or using the bond form included in the Contract equal to ten percent (10%) of the amount specified in Exhibit A, Contractor's Price, Section A.2, Milestone Payment Schedule, Schedules A through D, as a guarantee that the Contractor will provide full performance of warranty and service support terms of this Contract.

The Warranty Bond for the Contracted SCVs only shall remain in full force and effect until Warranty obligations have been fulfilled. The Warranty Bond amount may be reduced as follows:

1. To fifty (50) percent of the original amount when the warranty period of fifty (50) percent of the required number of SCVs has expired;
2. To zero (0) percent of the original amount when the warranty period of one hundred (100) percent of the required number of SCVs has expired.

The City must give its written consent to any substitution of surety and reserves the right to reject a proposed substitution. In lieu of Warranty Bonds, irrevocable Letters of Credit in a form approved by the City may be provided.

The Warranty Bond shall remain in effect until the final obligation under this Contract has expired, including specific extended warranty requirements and the 10-year guaranty of the availability of spare parts.

#### 6.4 Liquidated Damages. (\*)

The City may sustain significant damages as a result of the Contractor's failure to complete the Contract Milestones within the time periods stated in Exhibit B, Section B.3.1.1, Period of Performance. These damages include but are not necessarily limited to the following: Delays in completion and operation of the streetcar system; Increased costs of Contract Administration and Program Management; Increased costs from delays to other Project contractors; Increased costs from hired streetcar personnel unable to perform the duties for which they were hired; Increased consultant support costs; Lost streetcar revenues. Because the actual amount of these damages is and will be difficult to accurately determine, the Parties agree to the Liquidated Damages (LD) specified below.

For delay in completion of any of the following Contract Milestones, the Contractor shall pay the City as liquidated damages, and not as a penalty, the following sums for each day of delay:

Milestones    LD Amount per Day	Damages per day
SCV Preliminary Design CDRL(s), status Conditional Acceptance	\$500.00
SCV Final Design CDRL(s), status Conditional Acceptance	\$500.00
SCV Final Design CDRL(s), status Approved	\$1000.00

Shipment 1 <sup>st</sup> SCV	\$1000.00
Shipment for each remaining SCV	\$500.00
Conditional Acceptance of 1 <sup>st</sup> SCV	\$2500.00
Conditional Acceptance for each remaining SCV	\$2000.00
Completion of Operator Training	\$1000.00
Completion of Initial Maintenance Training	\$1000.00
Completion of all Training	\$500.00
Conditional Acceptance of all Draft Manuals and Training Materials	\$1000.00
Conditional Acceptance of all Manuals and Training Materials	\$500.00
Completion of Delivery of spare parts	\$500.00
Completion of Delivery of special tools and diagnostic test equipment	\$1000.00

The City may deduct the sum of liquidated damages from progress payments due or to become due under the Contract.

The City reserves the right to waive the liquidated damages for late delivery of SCVs where circumstances causing the late delivery are clearly beyond the control of the Contractor or where it is in the interest of the City to do so. In addition, the City reserves the right to waive Liquidated Damages due to delays caused by damages in transit which are of a significant enough nature to preclude a SCV from either Conditional Acceptance of a SCV or Final Acceptance of a SCV. If the damage sustained is through no fault of the Contractor, then the City may waive the Liquidated Damages for a reasonable period to enable the Contractor to undertake the repairs.

If completion of more than one milestone is delayed, whether concurrently with other milestones or not, the total amount of liquidated damages due shall be the sum of the amounts due for each milestone.

The total amount for liquidated damages in this Section shall not exceed ten percent (10%) of the overall Contract Not to Exceed amount. The City may deduct the sum of liquidated damages from progress payments due under this Contract.

#### 6.5 Rolling Estoppel. (09/17)

Unless otherwise notified by Contractor, it shall be understood that the City shall have met all its obligations under this Contract. The City will be conclusively deemed to have fulfilled its obligations, unless it receives written notification of a failure to meet such obligations in the next status report, or within ten (10) Business Days following such failure, whichever is sooner, and Contractor identifies the specific failure in that notification. The City's failure to meet obligations must be described in terms of how it has affected the Project schedule or a specific performance requirement of Contractor.

Contractor is estopped from claiming that a situation has arisen that might otherwise justify changes in Project timetable, the standards of performance under this Contract, or the Contract price, if Contractor knew of that problem and failed to provide notification to the City as set forth above or to include it in the applicable status report to the City's project manager.

In the event Contractor identifies a situation that is impairing Contractor's ability to perform for any reason, Contractor's notification should contain Contractor's suggested solutions to the situation. These suggestions should be in sufficient detail so that the City's Project Manager can make a prompt decision as to the best method of dealing with the problem and continuing the Project in an unimpeded fashion.

#### 6.6 Dispute Resolution. (09/17)

Contractor shall cooperate with the City to ensure that all claims and controversies which arise during this Contract will be resolved as expeditiously as possible in accordance with the following resolution procedure:

Any dispute between the City and Contractor shall be resolved, if possible by the Project Manager or their designee on behalf of the City and [REDACTED] on behalf of Contractor.

If the Project Manager or the Project Manager's designee and Contractor are unable to resolve any dispute within three (3) Business Days after notice of such dispute is given by either Party to the other, the matter shall be submitted to Deputy City Administrator on behalf of the City and [REDACTED] on behalf of Contractor for resolution, if possible.

Should any dispute arise between the Parties concerning this Contract that is not resolved by mutual agreement above, it is agreed that such dispute will be submitted to mandatory mediated negotiation prior to any Party's commencing arbitration or litigation. In such an event, the Parties to this Contract agree to participate in good faith in a non-binding mediation process. The mediator shall be selected by mutual agreement of the Parties, but in the absence of such agreement each Party shall select a temporary mediator and those mediators shall jointly select the permanent mediator. All costs of mediation shall be borne equally by the Parties.

Should an equitable solution not result from the foregoing, the City and Contractor shall be free to pursue other remedies allowed under this Contract.

Unless ordered by the City to suspend performance of all or any portion of Contractor's Services or delivery of Goods, Contractor shall proceed with the performance of such Services or delivery of Goods without any interruption or delay during the pendency of any of the foregoing dispute resolution procedures. During the pendency of any of the foregoing dispute resolution procedures, the City shall continue to make all payments that are not in dispute while having the right to withhold payments that are in dispute.

#### 6.7 Remedies. (09/17)

The remedies provided in this Contract are cumulative and may be exercised concurrently or separately. In the event of any Material Breach by Contractor, which Material Breach shall not have been cured as agreed to between the Parties, the City shall have the ability to pursue the City's rights at law or equity. The exercise of any one remedy shall not constitute an election of one remedy to the exclusion of any other.

#### 6.8 Cost of Cover. (09/17)

In the event of a Material Breach by Contractor, then the City may complete the Project itself, by agreement with another contractor, or by a combination thereof. In the event the cost of completing the Project exceeds the amount the City would have paid Contractor to complete the Project under this Contract, then Contractor shall pay to the City the amount of the reasonable excess.

### **SECTION 7 WARRANTY**

These provisions shall apply to all Maintenance Services. Should any ambiguities or conflicts arise between this SECTION 7 and any other terms within this Contract, this Section shall prevail in matters of Warranty.

#### 7.1 General Warranty Provisions

Warranties in this document are in addition to any statutory remedies or warranties imposed on the Contractor. Consistent with this requirement, the Contractor warrants and guarantees to the City each complete SCV and specific subsystems and components as follows.

##### 7.1.1 Extension of Warranties

In the event any subcontractor, supplier or manufacturer offers any extended warranty not specified herein, Contractor shall state the terms of such warranty or warranties in writing and shall extend same to the City without additional cost to the City.

##### 7.1.2 Other Warranties or Guarantees

All warranties and guarantees of subcontractors, suppliers of any tier and manufacturers, whether expressed or implied, are deemed to be made for the benefit of the City regardless of whether stated as such, and Contractor shall enforce such warranties and guarantees for the benefit of the City.

#### 7.2 Warranty of Spare Parts, Special Tools and Test Equipment

For any spare parts, special tools and test equipment delivered to the Agency in accordance with the Contract, the Contractor warrants the spare parts, special tools and test equipment to be free of defects in material and workmanship for 24 months from acceptance of the spare part, special tool or test equipment. In the event of defect or failure of the spare part, special tool or test equipment, the Contractor shall make and implement any modifications, repairs,

adjustments, and/or replacements determined to be necessary by the Contractor to correct the defective part. In the event of such modifications, repairs, adjustments, and/or replacements of a part by the Contractor only, the remaining warranty period shall apply.

### 7.3 Individual SCV Warranty

Each SCV shall be warranted to be free from Defects and related Defects for two (2) years from Final SCV Acceptance unless specified below.

#### 7.3.1 Carbody Structure Warranty

For each SCV, the carbody structure as defined in Exhibit C, Technical Specification, Section 14, Carbody, is warranted to be free from Defects and Related Defects for five (5) years including underframe, side walls and cladding, roof, support brackets, floor panels, FRP front end, exterior paint, etc.

#### 7.3.2 Truck Frame and Bolster

For each SCV the truck frame, axles, etc. as defined in Exhibit C, Technical Specification, Section 15, Trucks, is warranted to be free from Defects and Related Defects for five (5) years.

#### 7.3.3 Onboard Energy Storage System (OESS)

The OESS as defined in Exhibit C, Technical Specification, Section 12.6, Onboard Energy Storage System, is warranted to be free from defects and Related Defects for eight (8) years. The OESS energy storage devices are warranted to have a minimum life of eight (8) years. Notwithstanding anything herein, the OESS container, brackets, and structure is warranted to be free from Defects and Related Defects for fifteen (15) years.

### 7.4 Fleet Defects

#### 7.4.1 Occurrence and Remedy

The Contractor at its sole cost shall furnish, install and replace all Fleet Defects in up to 100 percent of the Fleet, including those SCVs yet to be delivered and SCVs for which the warranty has already expired, and all identical units contained in the City's stock, with new units of improved design. Improved design units shall meet or exceed all performance requirements. A correction plan shall be submitted for all Fleet Defects, submitted for the City approval by the Contractor no later than fifteen (15) days from the date a Fleet Defect is declared.

The warranty on units arising from Defects determined to be Fleet Defects shall apply to the entire Fleet of SCVs delivered or to be delivered under this Contract, and as to SCVs previously accepted by the City shall commence on the date remediation and correction by the Contractor is completed and accepted by the City on the entire Fleet accepted up to that date ("Corrected Date"). The period of warranty shall be the greater of (a) the full period of the entire original warranty on the defective unit or (b) one year from the Corrected date.

Contractor shall update, as necessary, technical support information (parts, maintenance, and operators' manuals) due to changes resulting from warranty repairs.

Safety hazards shall be determined by PTSAP. Any Defect in design in which constitutes a PTSAP safety hazard shall immediately upon discovery be deemed to be a Fleet Defect and the Contractor, at its sole cost shall furnish, install, and replace all defective units.

#### 7.5 Detection and Repair of Defects During Warranty

If the City detects a defect within a warranty period as defined herein, it shall promptly notify the Contractor's Representative. Each warranty reimbursement request must be submitted no more than sixty (60) days from the date of discovery or repair, whichever is later. All defective parts must be returned to the Contractor, when requested, not more than 45 days from date of repair.

##### 7.5.1 Repair Performance

The Contractor is responsible for all warranty-covered repair Work. The Agency will allow the Contractor or its designated representative to perform such Work. At its discretion, the Agency may perform such Work if it determines it needs to do so, based on Streetcar service or other requirements. Such Work shall be warranted and reimbursed by the Contractor.

##### 7.5.2 Repairs by the Contractor

The Contractor or its designated representative shall perform warranty covered repairs unless otherwise specified herein. If the City requires the Contractor to perform warranty covered repairs, the Contractor shall:

- (a) begin the work necessary to make repairs within 3 days; and
- (b) complete the work within 5 days after receiving Contractor's notification from the City.

The City shall make the SCV or LLRU available to complete repairs in a timely manner in coordination with the Contractor's repair schedule. Time extensions may be granted at the sole discretion of the City. The Contractor shall provide at its own expense all spare parts, tools and special equipment required to complete repairs.

At the City's option, the Contractor may be required to remove the unit, which may include the entire SCV, from the City's property while repairs are being affected. Repair procedures must be diligently pursued by the Contractor. The Contractor shall assume all liability for damage to the SCV or any unit from the time the unit is released from the City's custody until it is returned to the City's custody. Once the SCV is returned to service and the Work is completed, the Contractor shall provide a written statement detailing the following:

1. Diagnosis of the defect
2. The repairs made
3. Parts used
4. Hours of labor expended
5. Signature of Contractors' representative
6. Serial Number, if applicable
7. Completion date

Damage to the City's property caused by the Contractor, or its subcontractors or suppliers, while performing work shall be the sole responsibility of the Contractor, and shall be corrected at the Contractor's expense.

### 7.5.3 Repairs by the Agency

If the City decides in its sole discretion to perform warranty covered repairs, it shall make such repairs using Contractor specified LLRUs supplied by the Contractor specifically for this repair. Warranty claims for repairs covered by this warranty shall be submitted by the City to the Contractor for reimbursement on a regular basis. Contractor shall pay the City's warranty Labor Rate, including overtime, at the time of the repair for all the City labor required.

### 7.5.4 Replacement or Repaired Part Warranty

If any SCV or LLRU is repaired, rebuilt, or replaced pursuant to this Contract, the warranty period shall extend by the amount of time that the SCV or LLRU Defect was discovered until such time that the Defect was repaired, rebuilt or replaced. Any such SCV or LLRU which has been repaired, rebuilt or replaced shall have the unexpired warranty period of the original LLRU, or a minimum of two years after the repair is accepted by the City, whichever is greater.

The Agency may require that the Contractor supply new units for warranty covered repairs being performed by the Agency. These units shall be shipped prepaid to the City from any source selected by the Contractor. Replacement units shall be shipped directly to the City's Operations and Maintenance Facility located at 1516 NW Northrup, Portland, Oregon 97219.

#### 7.5.4.1 Defective Component Return

The Contractor may request that defective units covered by the warranty be returned to the manufacturing plant. The Contractor shall make such requests no later than 30 days after repairs are completed. The total cost for this action, including, but not limited to labor, packaging, and shipping, shall be paid by the Contractor. Units shall be returned in accordance with Contractor's instructions at Contractor's cost.

#### 7.5.4.2 Failure Analysis

The Contractor shall, upon specific request of the Agency, provide a failure analysis of Fleet Defect- or safety related parts, or major components, removed from SCV under the terms of the warranty, that could affect Fleet operation. Such reports shall be delivered within thirty (30) days of the receipt of failed parts.

#### 7.5.4.3 Reimbursement for Labor and Other Related Costs

The Contractor shall reimburse the City for all labor associated with the diagnosis and correction of Defect(s). The amount shall be determined by multiplying the number of labor hours required to diagnose and correct the Defect by the City's current warranty labor rate plus overtime if applicable. Contractor shall also pay the cost of transporting the SCV if such action was necessary.

Should the Contractor request the City to transport the SCV to a vendor/subcontractor for repairs, the Contractor shall reimburse the City for all expenses incurred including, but not limited to, labor, fuel, and transportation. The Contractor shall assume all liability for damage from the time the SCV is released from the City's custody until it is returned to the City's custody.

#### 7.5.4.4 Reimbursement for Parts

The Contractor shall reimburse the City for defective LLRUs and for additional parts (i.e., gaskets, connectors, etc.) that must be replaced to correct the Defect. The reimbursement shall be at the price indicated on the Contractor's master price list at the time of repair, and shall include taxes, where applicable, plus twenty (20%) percent handling charge.

#### 7.5.4.5 Reimbursement Requirements

Reimbursement for all City accepted requests shall occur no later than one hundred and twenty (120) days from the date of acceptance of a valid request. The parties also agree to review all requests at least once every ninety (90) days throughout the entire warranty period to ensure that open requests are being tracked and properly dispositioned.

#### 7.5.5 Warranty Processing Procedures

The following list represents information that must be included by the Agency in its request to the Contractor for warranty reimbursement:

- Warranty repair claim number;
- Portland SCV number;
- Section of SCV (A, B or C section);
- SCV mileage at time of repair;
- Date of failure/repair;
- Acceptance/in-service date;
- Repair order number;
- Contractor part number and description;
- Component serial number, if applicable;
- Repairs made;
- Description of failure; and
- All costs associated with each failure/repair (invoices may be required for the City's third- party repair costs)
- Labor Information
- Labor hours

## **SECTION 8 ACCEPTANCE, INSPECTION, AND ACCEPTANCE TESTING**

### **8.1 Right to Perform Acceptance Testing Generally. (08/19)**



Prior to Accepting Goods, Services or Deliverables, the City shall have the right to perform Acceptance Testing and determine which Deliverables require specific Acceptance Tests, or for Deliverables not requiring Acceptance Testing, the City shall have the right to evaluate the Deliverable(s) to ensure they meet Acceptance Criteria, as may be further defined in Exhibit B - Statement of Work. Contractor shall cooperate with the City in the development of Acceptance Criteria and the Acceptance Test Plan that shall codify and set forth the location, date, and other specifications of the test. Unless otherwise specified herein, no system(s), subsystem(s), and/or component(s) may be incorporated into any Goods, Services or Deliverables, without meeting the Acceptance Criteria or successfully completing Acceptance Testing. Acceptance Testing may occur in one or more phases, depending on the integration of contingent products, scalability, performance tuning or other measurable features or milestones. The City shall pay the costs of any testing it requests in addition to those otherwise specified herein.

## 8.2 Procedure and Timetable for Acceptance of Non-SCV Goods, Services, Deliverables, and Work. (09/17)

Unless otherwise specified in Sections 8.3, SCV Inspection and Testing; 8.4, SCV Shipping, Delivery and Acceptance; or 8.5, Service and Parts below, Acceptance will occur after successful completion of all testing (both initial acceptance testing and post- delivery acceptance testing) and the City's determination that the Work conforms in all respects to the Contract requirements.

Prior to Acceptance, Post Delivery Testing shall be conducted by the Contractor on the City's property in accordance with the Acceptance Test Plan and/or as may be delineated in Exhibit B, Statement of Work.

The Parties shall commence Acceptance Testing within a reasonable amount of time prior to shipment of and/or after receipt of any Goods, Services, or Deliverables.

If the City does not perform Acceptance Testing within sixty (60) days after Delivery for such Work(s), any applicable warranty will begin sixty (60) days after Delivery.

Contractor shall provide, at no additional cost, reasonable and appropriate support, assistance, and consultation in order to facilitate Acceptance Testing, including but not limited to any necessary testing instruments, apparatuses, labor, facilities and/or transport

The Parties will make all reasonable efforts to complete Acceptance Testing within the time period specified within the Project schedule mutually agreed upon by the Parties in writing. If an Acceptance Test is successful the City shall issue an Acceptance Certificate, a sample of which is attached in Exhibit G-2, Certificate of Acceptance.

The City shall pay the costs of any testing it requests in addition to that Acceptance Testing performed by the City shall not relieve the Contractor of the responsibility for conformance to the Contract.

### 8.2.1 Failure of Acceptance Test. (09/17)

The City will notify Contractor if a Deliverable or a portion of a Deliverable fails to pass an Acceptance Test and will specify in reasonable detail the identified failures and possible reasons for failure. After City's notification, Contractor shall correct the failure within ten (10) Business Days and notify the City that the correction has been completed. After Contractor's correction notification, the City shall perform a second Acceptance Test. If the Deliverable or portion of the Deliverable fails to pass the second Acceptance Test, the City shall notify Contractor in writing, and the City may, in its sole discretion: (a) terminate this Contract with no further liability; (b) require Contractor to replace the Deliverable or defective portion of the Deliverable at no additional cost to the City including, without limitation, the removal of said Deliverable from the Delivery Point, (c) require Contractor to make further corrections to prepare for retesting again; (d) Accept the Deliverable at a reduced cost to be negotiated between the Parties; or (e) issue an Acceptance Certificate for an "Acceptance with Exception(s)" in accordance with the Sections below.

If the City issues an Acceptance Certificate for an "Acceptance with Exception(s)" the City will list the exception(s) and the date for Contractor's correction of the Defect(s). If Defect(s) are corrected by the listed date(s) the City agrees to commence further Acceptance Testing of the Deliverable or affected portion(s). If the Deliverable passes the Acceptance Tests, the City will issue an Acceptance Certificate.

If a Deliverable fails a second or subsequent Acceptance Test (or in the event of a single Acceptance Test, the Acceptance Test) in no event shall there be an increase to the original price agreed to by the Parties for the Deliverable.

#### 8.2.2 City Acceptance of Failure. (05/19)

If the City elects to accept a Deliverable or any combination even with the failure(s), then the City may request that Contractor issue a refund to the City in an amount equal to a percentage of the full fee value of the Deliverable that the Parties mutually determine represents the loss of use or functionality.

#### 8.2.3 Revocation of Acceptance. (01/19)

The City shall have the right to revoke "Acceptance with Exception(s)" if the City granted an "Acceptance with Exception(s)" based on Contractor's commitment to correct the Defect within a reasonable period of time, but the Defect has not been so corrected. The City shall also have the right to revoke Acceptance if the City accepted Deliverable without discovery of the Defect, and the Acceptance was reasonably induced by Contractor's assurances or by the difficulty of discovery of the Defect before Acceptance. Revocation is effective only if it occurs within a reasonable time after the City discovers or should have discovered the reasons for revocation.

#### 8.2.4 Termination Based on Failure of Acceptance. (09/17)

If the Goods or Services fail to pass the Acceptance, after following the procedure in Sections 8.3, SCV Inspection and Testing; 8.4, SCV Shipping, Delivery and Acceptance ; or 8.5, Service and Parts. Contractor shall refund all costs paid for the unaccepted Goods, Deliverables, Services, and Work in U.S. Dollars within fifteen (15) Calendar Days of the date of receipt of notice non-acceptance. The refund may in the form of future credits from Contractor.

#### 8.2.5 No Waiver. (05/19)

Acceptance shall not relieve Contractor from its responsibility under any warranty. Payment for Deliverables, or any portion thereof, does not constitute Acceptance nor does it constitute a waiver of any warranty applicable to the City

### 8.3 SCV Inspection and Testing

#### 8.3.1 General

The City's Representative shall at all times have access to the Work, the Contractor and, through the Contractor, its Subcontractors and Suppliers. The Contractor, its Subcontractors, and its Suppliers shall furnish every reasonable facility for ascertaining that the materials and the workmanship are in accordance with the requirements of the Contract Documents. All Work done shall be subject to the City Representative's inspection and approval in accordance with the approved Work products developed as a result of the Contract Documents.

The Contractor shall inspect all materials, supplies and equipment that are to be used, or incorporated in the Work. In addition, Contractor shall conduct a continuous program satisfactory to the City's Representative of quality control for all Work performed under the Contract. The Contractor shall have the primary responsibility for inspecting the Work. The City's inspection is conducted to verify that the Contractor has performed its inspections properly. Any observation, verification, inspection or approval of the Work by the City shall not relieve the Contractor of any of its obligations to perform the Contract as prescribed. If the Contractor fails to execute its responsibility for quality control and inspection on any part of the Work within the contract requirements, then the City may, at its option, conduct quality control and inspection activities in lieu of the Contractor at the Contractor's expense. Such inspection shall not relieve the Contractor of its liability for defective or unsuitable Work, as described in 8.3.2 Non-Conforming Work. Work not meeting the requirements of the Contract shall be made acceptable by Contractor, and unsuitable Work may be rejected, notwithstanding that payment for such Work may have been previously authorized and included in a progress payment. After written notice, if the nonconformance is not resolved, a deduction may be made from subsequent progress payments and withhold until such time as the correction of such work not conforming to the Technical Specifications is accomplished. The amount of the deduction will be set by the City.

#### 8.3.2 Non-Conforming Work

If the City determines that materials, equipment, or workmanship proposed for or incorporated in the Work is non-conforming, then the Agency shall have the right to reject such Work by giving the Contractor written notice that such Work is non-conforming. The City, at its option, shall require the Contractor, within a designated time period as set forth, to either (1) promptly repair, replace or correct all Work not performed in accordance with the Contract at no cost to the City, or (2) provide a suitable corrective action plan at no cost to the City. Once accepted by the City, the Contractor shall implement the corrective action plan at no cost to the City. If the corrective action plan as accepted by the City does not remedy defective or non-conforming Work, then the Contractor shall remain responsible for remedying the non-conforming Work to the City's satisfaction and at no additional cost to the Agency. The Contractor shall also be responsible for repairing all property and work damaged by the

Contractor at no cost to the City. Under no circumstances shall the Contractor be entitled to additional time or money for the correction of defective or non-conforming work, or for the repair of damaged property.

The City's inspection of the Work or right to reject non-conforming Work shall not relieve the Contractor of its full responsibility for performing the Work in full conformance with the Contract Documents. No failure or forbearance of the City in notifying the Contractor of non-conforming Work shall relieve the Contractor of its Contract responsibility to ensure that the Work is performed in accordance with the Contract Documents.

### 8.3.3 Product Options, Supplier Approval and Substitutions

For products specified by brand name or manufacturer, whether or not followed by the words "or approved equal", the Contractor shall select any product or manufacturer named or shall submit a request to substitute an equal product or manufacturer. The Contractor may not make a substitution without the City's prior approval for Portland Specific Items.

The City may, at its option, approve requests from the Contractor for substitution of products in place of those specified if the Contractor demonstrates satisfaction of at least one of the following criteria:

1. The substitution is required for compliance with a final interpretation of code requirements or regulations that was not available or reasonably known to the Contractor prior to execution of Contract.
2. The substitution is due to the unavailability of the specified products, and the unavailability is not the Contractor's fault and was unknown to the Contractor prior to execution of Contract.
3. The specified product will not perform properly or fit into the designated space.
4. The manufacturer or fabricator does not certify or warrant performance of the specified product as required for the intended purpose.
5. The substitution is, in the City's judgment, in the best interest of the City.

The Contractor shall submit a separate request for each substitution. Each request shall include: Complete data, including price comparison between specified and proposed products, substantiating compliance of the proposed substitution with the Contract; product identification, including manufacturer's name and address; manufacturer's literature, including product description, performance and test data, and reference standards; samples, if appropriate; name and address of similar vehicle deliveries on which the product was used and date of installation; itemized comparison of proposed substitution with product or method specified; and data relating to changes in production schedules. Other requirements for requested substitutions may include mockup, tests in a suitable operating environment and qualification test records.

### 8.3.4 Portland Streetcar Field Inspection Offices

The City may employ inspectors, who shall be representatives of the City Project Manager. They shall have access to the design, fabrication, assembly, and testing of the SCV at all

times, wherever in progress at the Contractor's, Contractor's subcontractors', or the City's facilities.

Inspectors are employed solely for the City's benefit and are not intended as a source of advice for the Contractor's employees, subcontractors, or suppliers. The inspectors shall observe and may inspect the work and shall report their observations to the City Project Manager. Except as expressly authorized by the City Project Manager in writing, the inspectors shall have no authority to accept, reject, or approve the work, to stop the work, to authorize any changes in the work, or to direct any extra work.

The Contractor shall at no additional cost to the City provide any reasonable facilities including a private office that the inspectors may require for the performance of their duties.

A private office for engineering staff and inspection staff, as applicable, shall be provided at each of these facilities for the entire period in which the City engineering and/or field staff are stationed at the facilities. The office shall have internet access.

The office shall be provided with both heating and air conditioning. Said heating, ventilation, and air conditioning equipment shall be of such capacity to maintain temperatures between 68o F. and 72o F. under the severest of weather conditions.

If the office provided is a trailer, it shall have functioning lavatory facilities. If the offices are within a building, the City spaces shall be segregated from other spaces by floor to ceiling walls to assure privacy.

#### 8.3.5 Testing

The Contractor shall prepare an Inspection and Test Plan ("Test Plan") consistent with Exhibit C, Technical Specification, Section 18, Vehicle and Systems Testing, for review by the Project Manager. The Test Plan shall be forwarded to the Project Manager as soon as drafted. Review and approval of the Test Plan by the Project Manager does not relieve the Contractor of responsibility for the adequacy of the inspection and testing of the Work in accordance with the Contract Documents.

1. All tests required to be performed by Contractor shall be done as set forth in the Technical Specifications and shall be made at the expense of the Contractor.
2. The Project Manager shall be apprised of all such tests in advance to be able to witness any such tests.
3. No systems, subsystems or components required or proposed shall be incorporated into the Work until Project Manager has confirmed that they have passed the applicable tests and testing requirements as set forth in this Section, and in the Technical Specifications.
4. All tests must be in accordance with the approved test procedures and/or plan. In the event of a failure of any test; the Contractor shall be responsible for any necessary corrective action and retesting until the applicable certified test results have been approved by the Project Manager.

5. All tests required to show that all equipment and Work, including materials, are in accordance with the requirements of the Contract shall be made by and at the expense of the Contractor in the presence of the Inspector. Project Manager may authorize acceptance of certified copies of test results conducted in the absence of the Inspector. The Project Manager reserves the right to determine what tests are necessary. The necessary testing instruments and apparatus, and all labor and the facilities for the transportation of testing apparatus shall be furnished by the Contractor.
6. The City may waive a test provided:
  - a. At the first Project Meeting the Contractor will present the list of:
    - i. tests it would like the City to waive,
    - ii. any differences between the tested and proposed systems hardware and software,
    - iii. any differences between test requirements or procedures, and
    - iv. any estimated credit to the City should the City agree to approve a waiver.
  - b. After the first Project Meeting, but within thirty (30) Days after proposing to the City that a test be waived; the Contractor will present the detailed test procedures and reports for each of the proposed waived tests for the City's review and approval. If the City approves, the test will be waived.
  - c.
  - d. If the City agrees to grant a waiver, it will issue a Change Order for the waiver and the credit due to the City. However, the City is under no obligation whatsoever to accept any waiver.
7. The Contractor shall conduct SCV Acceptance tests on each SCV on the City's system as described in Exhibit C, Technical Specification, **Section 1**. SCV Acceptance Tests will only be conducted with SCVs with an approved Delivery Notice. The City shall make available to the Contractor SCV operating personnel and access to the City OMF management approved yard and line tracks of the City's system for the Contractor's SCV testing, to the extent and at such times possible for non-interference with and safety of the City system, as determined in the sole discretion of the City. Operation or movement of SCVs on the City's system at any location other than at the SCV work position made available to the Contractor within the SCV shop shall be only by the City operating personnel. The City shall exercise reasonable care in operation of SCVs for the Contractor's SCV Acceptance testing. The City shall be responsible for SCV operation during pre-acceptance activities and Acceptance testing. The Contractor shall furnish all personnel, supplies, tools, equipment, and other requirements for the SCV Acceptance tests, except as provided in this paragraph. The Contractor shall provide The City's Project Manager five (5) Working Days' notice of the scheduled date and time of each SCV Acceptance test, so that each such test may be witnessed by the City's Project Manager their designee.

#### 8.3.6 Use of Agency Facilities

The Contractor shall furnish:

- a) all personnel, supplies and tools for SCV commissioning and Work at the City's facility.
- b) all equipment and other requirements for the SCV pre-delivery not made available to the Contractor by the City.

The City shall furnish:

- a) one shop bay within the City's OMF. The City shall make available to the Contractor, to the extent possible as determined in the sole discretion of the City, electric power, storage for SCV components, and use of employee facilities at the City's OMF.
- b) Space available within the OMF for use by the Contractor's field service personnel. A workstation with normal furnishings for up to two (2) persons will be provided.

The City shall make SCV operating personnel and access to OMF management approved yard and mainline tracks of the City's system available for the Contractor's post-shipment SCV testing as specified in the Test Plan. The Contractor shall provide the City's Project Manager with a minimum of five (5) days' notice of the scheduled date and time of each SCV post-shipment test, so that the City's Project Manager or their designee may witness each test.

The Contractor shall cooperate with the City in scheduling and coordinating the Contractor's Work on the City's property with the Work and operations of Portland Streetcar.

Storage structures, portable offices and contractor SCVs located at the City OMF will be subject to Portland Streetcar OMF management approval and through the course of daily operations, the Contractor's space may be adjusted at the City's sole discretion.

#### 8.3.6.1 Care of Premises

At all times, the Contractor shall maintain its premises on the City property in a neat and orderly condition. The Contractor shall organize equipment, tools, and any other Contractor property in a clean and organized manner in accordance with the City policy. Upon Final Acceptance of all SCVs under this Contract, the Contractor shall remove all temporary buildings, structures, fences, scaffolding, surplus materials, and rubbish of every kind from the site of the Contractor's Work on the City's property within sixty (60) days. Failure of the Contractor to adhere to all of these and other rules at the Portland Streetcar OMF may result in immediate eviction from the property.

### 8.4 SCV Shipping, Delivery and Acceptance

#### 8.4.1 Omitted

#### 8.4.2 Shipment Authorization

Each SCV shipped from the Contractor's plant to the City shall be complete and in compliance with all provisions of the Contract, except as may be noted below. Prior to shipment of each SCV, the Contractor shall obtain a shipping release (see Section 8: Sample SCV Forms) signed by the City's Representative or designee. The shipping release shall certify that the SCV is complete, has passed all pre-shipment tests described in the Exhibit C, Technical

Specification, and complies with approved Contractor's drawings, samples, is accompanied by an up-to-date SCV History Book, and other agreed-upon conditions for shipping. To accommodate all tests that may be necessary, the Contractor shall provide a minimum of ten (10) days' notice to the City's Representative prior to each shipment. The City's Representative, at their sole discretion, may permit shipment of a SCV with minor Defects or open items approved by the City's Representative that will not affect revenue service and can easily be corrected after shipment. All known Defects and open items shall be submitted by the Contractor with the request for shipping release. The shipping release shall not be construed nor inferred to constitute SCV acceptance by the City.

#### 8.4.3 Shipment

All shipments shall be packaged and packed in a manner to ensure the integrity of the product during transportation, handling, and temporary storage. Due regard shall be given to protection from loss and pilferage, physical damage, and the effect of the elements and environmental conditions. The City reserves the right to review and approve a detailed shipping plan.

If shipped by sea, the contractor will provide below-deck shipping and storage for all SCVs or SCV components to provide enclosed protection against damage from handling and from exposure to the marine environment and adjacent shipments.

During shipment, each SCV shall be equipped with an impact recorder provided by the Contractor and approved by the City. The selection of and placement of the impact recorder shall be approved by the City. The purpose of the recorder is to record all handling impacts to ensure that shipment impacts have not exceeded levels customary for the manner of shipping selected. The recorder shall record all handling impacts. All records shall become the property of the City and shall be appended to the Car History Book.

The Contractor shall require shippers to log and record any incidents of damage or potential damage to the SCVs and SCV components, and of interruption of shipments. The Contractor shall report such shipment incidents to the City promptly upon the Contractor's receipt of such information, describing the nature of the shipment damage, potential damage or interruption, and the actions taken and to be taken to complete the shipment and repair any damage.

The Contractor shall assume full responsibility for determining the haul routes to be utilized and confirming that the jurisdiction through which its haul routes will pass will permit the hauling operations with respect to laden weights, type of SCV, frequency and dimension of loads, required traffic control, and hours of operation. All necessary permits, licenses or bonds shall be obtained and paid for by the Contractor.

All SCVs shall be shipped to the City's OMF in Portland, Oregon. Railroad access to the City OMF will not be available and the Contractor must provide final shipping by truck to the City OMF. If the SCVs are shipped by rail, from the Contractor's final assembly site, the Contractor shall provide its own ramp or other means for unloading of the SCVs at an intermediate location prior to final delivery by truck onto the City's track.



The Contractor shall be responsible for all work and all costs attendant to the placing of SCVs in a ready to run condition (condition where the Contractor can start the SCV acceptance testing as defined in the Exhibit C, Technical Specification, Section 18, Vehicle and Systems Testing) on the rails of the City's System.

#### 8.4.4 Evidence of Delivery and Shipping Destination (FOB point)

Delivery of the SCVs shall be free on board (FOB) destination. The Contractor is responsible for all delivery costs, including risk of loss, to the City's final destination on board the carrier's conveyance to the location specified below.

Delivery of rail SCV(s) shall be evidenced by signed receipt by the City's Project Manager or their designee at the following point of delivery:

City of Portland Streetcar  
Operation & Maintenance Facility  
1516 NW Northrup  
Portland, OR 97209

8.4.4.1 A receipt signed by the City's Representative upon delivery of the SCV does not constitute the City's acceptance of either the condition of the SCV or its conformance with the terms of the Contract. As stated in Section 3.4.1, Transfer of Title and Risk of Loss, title to material shall not pass to the City until written Conditional Acceptance per 8.4.7.1, Conditional Acceptance of a SCV

#### 8.4.5 Unloading

The Contractor shall be responsible for the unloading of SCVs, test equipment and spare parts at the designated delivery point as instructed by the City.

At no time shall the City be obligated to permit additional SCVs to arrive if there are more than three (3) SCVs which have arrived and are not yet received Conditional Acceptance of SCV. The City may, at its discretion, increase the limit on the number of SCVs to arrive at the City's facility.

After arrival at the City's facility, each SCV shall be examined jointly by City Representatives and the Contractor for shipping damage. The City then will issue a receiving notice to the Contractor, which will acknowledge receipt of the SCV and describe any missing parts or visible damage that may have occurred during shipment.

The Contractor shall notify the City's Project Manager of readiness for SCV unloading at least five (5) Working Days prior to such unloading. The Contractor shall obtain a permit in accordance with the City's policy for individual SCV deliveries at the City OMF. The Contractor shall furnish all personnel, supplies, tools, equipment, electric power, motive power, and any other requirements to perform.

#### 8.4.6 SCV Acceptance Testing

The Contractor shall conduct post-delivery static and dynamic tests and Acceptance Tests on each delivered SCV, subject to any inspection testing that the City has a right to witness. These tests shall be conducted in accordance with approved written Master Test Plans consistent with Exhibit C, Technical Specification.

The purpose of these tests is to confirm conformance to the Technical Specifications and to identify Defects that have become apparent between the time of SCV delivery and readiness for acceptance (or Conditional Acceptance of a SCV) by the City. The acceptance tests shall include visual inspection and SCV operations. No acceptance test shall apply criteria that are different from the criteria consistent with the Technical Specifications.

The Contractor shall record details of all Defects on the appropriate test forms and shall notify the City of all such Defects for each SCV after completion of the tests. The Defects detected during these tests shall be repaired.

#### 8.4.7 Conditional Acceptance of SCV, Final Acceptance of a SCV and Non-Acceptance

##### 8.4.7.1 Conditional Acceptance of SCV

Conditional Acceptance of SCV is defined as a completely assembled SCV, located at the vehicle acceptance facility, that has successfully completed tests outlined in accordance with Exhibit C, Technical Specification, Section 18, Vehicle and System Testing, and is ready to run in revenue service except for minor Defects that require corrective action but that will not materially affect revenue service operations. Conditional Acceptance of a SCV requires that all documentation for the Portland SCV, including the Car History Book, per Exhibit C, Technical Specification, Section 2, Program Control, Deliverables and Quality Assurance, has been delivered to and provisionally approved by the City.

The Contractor shall submit a corrective action program and schedule for each Conditionally Accepted SCV for the City's approval. If the Contractor fails to complete the program in accordance with the approved schedule, then repairs to the SCVs may be made in accordance with the procedures outlined in 7.5, Detection and Repair of Defects During Warranty.

The warranty period shall begin with Conditional Acceptance of a SCV except for parts and systems on the SCV, which require corrective action. Any Conditional Acceptance of a SCV for revenue service does not relieve the Contractor of the liability for correcting defects as required by the Contract. The City will issue a SCV Conditional Acceptance of a SCV Inspection and Certificate of Title form to the Contractor for each SCV when the SCV meets the conditions specified in this section. (See Section 8: Sample SCV Forms).

##### 8.4.7.2 Final Acceptance of a SCV

The City shall issue Final Acceptance of a SCV when:

1. the SCV has been completed in full accordance with the Technical Specifications, including all testing, approved engineering submittals, and Change Orders;

2. all corrective actions identified at Conditional Acceptance , including systematic failures and Fleet Defects have been completed; and
3. All required documentation for the SCV has been received and approved by the City.

#### 8.4.7.3 Non-Acceptance

If the arrival inspection of a SCV discloses that it is, in the opinion of the City's Project Manager, unfit for service, or if the SCV had been Conditionally Accepted but the Contractor has failed to remedy the Open Items per the provisions of 8.4.7.1 Conditional Acceptance of a SCV and or 8.4.7.2 Final Acceptance of a SCV, within the time specified, a Notice of Non-Acceptance may be given to the Contractor indicating that such car is rejected. At the Agency's discretion, such SCV may be returned to the Contractor at the Contractor's expense for corrective action to make the SCV fully meet the Technical Specification. Non-Acceptance shall vitiate "received" and "Delivery" for all purposes and shall subject the Contractor to appropriate contract enforcement remedies such as liquidated damages. All expenses and costs incurred by the City in connection with non-acceptance, including, without limitation, the removal of said SCV from the Delivery Point, re-inspection, and retesting, shall be borne by the Contractor. Risk of loss for any Delivered or Conditionally Accepted SCVs rejected hereunder shall be borne by the Contractor upon issuance of the Notice of Non-Acceptance.

#### 8.4.7.4 Manufacturer Certification of Origin (MCO) and Warranty of MCO

MCO to each SCV shall vest in the City upon Conditional Acceptance of a SCV. The MCO received by the City shall be considered full legal MCO with rights to unconditional possession and ownership. The Contractor, shall, within five (5) days after receipt of the notice of Conditional Acceptance of a SCV with respect to any SCV, deliver to the City a bill of sale or other instrument and shall be evidence that the Agency has acquired full MCO to such SCV free and clear of all liens, claims, security interests or encumbrances of any kind.

### 8.5 Service and Parts

#### 8.5.1 Delivery of Special Tools, Test Equipment, Spare Parts, and Manuals

Spare parts shall be of production configuration and successfully tested. Documentation representing all factory tests and Certificates of Compliance shall accompany the delivery of all spare parts, special tools, and test equipment. Delivery shall be completed in accordance with the Milestone Schedule.

Acceptance of spare parts will be deemed to have occurred after delivery, successful completion of Agency receiving inspection, relevant functional testing, and written notification of Acceptance by the City's Representative.

Delivery of special tools and diagnostic equipment shall be completed in accordance with the Milestone Schedule.

Delivery of manuals shall be made in two stages with interim deliverables likely to be required to ensure that manuals remain up to date with SCV production and delivery. The initial delivery of draft manuals is shown in the milestone schedule and shall consist of full sets of all manuals. The final delivery shall consist of the complete updated manuals and the electronic media. Acceptance of the manuals will be deemed to have occurred after delivery of the final manuals upon written notification by the City Representative.

The City reserves the right to refuse delivery of SCVs if spare parts, special tools, test equipment or manuals are not delivered in accordance with the Milestone Schedule.

#### 8.5.2 Parts Availability Guarantee

The Contractor agrees to provide necessary information, at no cost to the City, about the spare parts, software, and all equipment to the lowest component level necessary to maintain and repair the SCVs supplied under the Contract during the life of the SCVs. Parts shall meet form, fit and function of the original equipment.

If the Contractor is unable to provide requested parts, information about or availability of spare or replacement parts, software or any equipment necessary to maintain and repair the SCVs within 90 days of request, or if the purchase price exceeds the original procurement price by an amount exceeding normal inflationary cost, then the Contractor shall provide the City with all detail that would allow the City to have these parts specially manufactured, including any drawings, design and material information, and proprietary documentation.

#### 8.5.3 Interchangeability

Unless otherwise agreed, all units and components procured under the Contract, whether provided by Suppliers or manufactured by the Contractor, shall be duplicates in design, manufacture, and installation to ensure interchangeability among SCVs in this procurement.

In the event that the Contractor is unable to comply with the interchangeability requirement, the Contractor must notify the City and obtain the City's prior written approval, including any change in pricing. All special tools, training, maintenance manuals and all other documentation shall be provided at no additional cost to the City or reimburse the City for the same.

The City shall review proposed product changes on a case-by-case basis and shall have the right to require extended warranties to ensure that product changes perform at least as well as the originally supplied products.

#### 8.5.4 Agency-Furnished Equipment

In the event that equipment or other goods or materials are specified in the Technical Specifications to be furnished by the City to the Contractor for incorporation in the Work, the following provisions shall apply:

- The City retains title to all Furnished Equipment.
- The City shall provide Furnished Equipment in a timely manner so as not to delay Contract delivery or performance dates.

- The parties must conduct a joint inspection of the Furnished Equipment before the Contractor takes possession to document its condition.
- If Contractor receives Agency-Furnished Equipment in a condition not suitable for the intended use, then the Contractor shall promptly notify the City in writing, detailing the facts.
- The Contractor shall provide appropriate protection for all Furnished Equipment during the progress of the Work
- Upon receipt, the Contractor assumes liability for any damage to the City's Furnished Equipment due to action of the elements or from any other cause.
- Should any Furnished Equipment be damaged by the Contractor or its subcontractors, the Furnished Equipment shall be repaired or replaced at the Contractor's expense to the satisfaction of the City.
  - No extension of time will be allowed for repair or replacement of Furnished Equipment.
  - The Contractor's failure to repair or replace any damaged Furnished Equipment, may result in the City taking corrective action and deducting the cost of any repair or replacement from sums owed to the Contractor.
- In the event that the City's equipment or actions cause subsequent damage to the SCV or the Contractor, the Contractor shall not be responsible for the delay or damages caused by the City's provision of the equipment.

The City's provision of any Furnished Equipment pursuant to this section shall not limit the Contractor's obligation to provide SCVs in compliance with all Contract specifications. Nor shall Agency's provision of any equipment indicate acceptance of any SCV in whole or in part. Warranty administration and enforcement for Furnished Equipment are the responsibility of the City unless the parties agree to transfer warranty responsibility to the Contractor.

## SIGNATURE PAGE

(08/19)

Contractor represents that Contractor has had the opportunity to consult with its own independently selected attorney in the review of this Contract. Neither Party has relied upon any representations or statements made by the other Party that are not specifically set forth in this Contract.

This Contract constitutes the entire agreement between the City and Contractor and supersedes all prior and contemporaneous proposals and oral and written agreements, between the Parties on this subject, and any different or additional terms on a City purchase order or Contractor quotation or invoice.

The Parties agree that they may execute this Contract and any Amendments to this Contract, by electronic means, including the use of electronic signatures.

This Contract may be signed in two (2) or more counterparts, each of which shall be deemed an original, and which, when taken together, shall constitute one and the same agreement.

IN WITNESS WHEREOF, the Parties hereby cause this Contract to be executed.

CONTRACTOR

\_\_\_\_\_  
Authorized Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed Name and Title

Address: \_\_\_\_\_

\_\_\_\_\_

Phone: \_\_\_\_\_

Email: \_\_\_\_\_

Contract Number: XXXXXXXXX

Amendment Number: XX

Contract Title: STREETCAR VEHICLES, PARTS & TOOLS

CITY OF PORTLAND SIGNATURES

By: \_\_\_\_\_ Date: \_\_\_\_\_  
City Administrator

Approved:

By: \_\_\_\_\_ Date: \_\_\_\_\_  
Office of City Auditor

Approved as to Form:

By: \_\_\_\_\_ Date: \_\_\_\_\_  
Office of City Attorney

**Exhibit G-2: FINAL ACCEPTANCE CERTIFICATE**  
(08/19)

On this \_\_\_\_ day of \_\_\_\_\_, 20\_\_, the City certifies **Final** Acceptance of **(name Deliverable(s))**, in accordance with Contract No. \_\_\_\_\_. This Certificate of Acceptance is issued subject to and in accordance with the Contract, all defined terms having the meanings as set forth in the Contract, and without prejudice to any claims which subsequently may arise in connection with Defects in the **Deliverables** (or combination of Goods) described herein.

-- OR --

**FINAL ACCEPTANCE CERTIFICATE WITH EXCEPTIONS**

On this \_\_\_\_ day of \_\_\_\_\_, 20\_\_, the City certifies **Final** Acceptance of **(name of Deliverable(s))**, in accordance with Contract No. \_\_\_\_\_. This Certificate of **Final** Acceptance is issued subject to the following exceptions:

- 1.
- 2.
- 3.

Exceptions must be completed by \_\_\_\_\_. If Exceptions are not completed by \_\_\_\_\_, the City may revoke **Final** Acceptance of the Deliverables.

This Certificate of **Final** Acceptance is issued subject to and in accordance with the Contract, all defined terms having the meanings as set forth in the Contract, and without prejudice to any claims which subsequently may arise in connection with Defects in the Deliverable(s) described herein.



**CITY OF PORTLAND**


\_\_\_\_\_  
Authorized Signature                      Date

\_\_\_\_\_  
Printed Name

\_\_\_\_\_  
Title

SAMPLE

## Exhibit G-2: CHANGE ORDER

	<b>BUREAU NAME</b>	<b>LOGO</b>

### CHANGE ORDER

<b>Contractor</b>		<b>Project Title</b>	
<b>Contract No.</b>		<b>Change Order No.</b>	*SAMPLE*
<b>Contract Date</b>		<b>Change Order Date</b>	

Select	Type	Description and Reason for Change	Modification to:
<input type="checkbox"/>	Time		Project Schedule and/or Contract
<input type="checkbox"/>	Scope or Specifications		Statement of Work Acceptance Test Plan
<input type="checkbox"/>	Deliverables		Statement of Work Acceptance Test Plan
<input type="checkbox"/>	Price		Statement of Work and/or Contract
<input type="checkbox"/>	Terms and Conditions		Request Amendment to Contract
<input type="checkbox"/>	Other		

1. Additional time is necessary and the Project Schedule for the Statement of Work or a specific Deliverable is hereby extended through **(DATE)** or modified as shown on the attached Project Schedule.
2. Additional work or a change in work or Specifications is necessary. **For example, changes to the Statement of Work, Deliverables and/or the Acceptance Test Plan.**
3. A price adjustment is necessary for the following Deliverables. These changes will NOT affect the total not-to-exceed value of the Contract. **For example, price changes that show the original price and the modified price.**
4. An Amendment to the Contract is requested for the following reasons. **For example, any change to the total value of the Contract, the term or ending date of the Contract, or the Contract terms and conditions requires an Amendment.**

The Change Order is subject to the terms and conditions of the above-referenced Contract.

The rest of the Statement of Work shall remain unchanged and in full force and effect.

**CITY OF PORTLAND**

**CONTRACTOR**

\_\_\_\_\_  
Authorized Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Authorized Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed Name

\_\_\_\_\_  
Printed Name

\_\_\_\_\_  
City Project Manager

\_\_\_\_\_  
Title

\_\_\_\_\_  
Title

## **EXHIBIT B: STATEMENT OF WORK**

### **B.1 SUMMARY**

Contractor shall provide up to fifteen (15) new streetcar vehicles, along with the spare parts, special tools, training, manuals, and field support to support the ongoing operations at the City.

The Technical Specification (TS), Exhibit C, defines the functional, performance, and interface design requirements for the streetcar vehicles, program control, quality assurance, Testing, system support, and deliverables.

### **B.2 SCOPE OF WORK**

#### **B.2.1 General Requirements**

The streetcar vehicles supplied by Contractor will be a 100% low-floor modern streetcar, designed to be safe, reliable and maintainable.

The Contractor will have the following responsibilities:

1. Design, manufacture, test, and deliver the products as described by the Technical Specifications.
2. Design and integrate vehicle systems such that Specified requirements are achieved without conflict or error within or between onboard systems and between vehicle systems and wayside systems.
3. Ensure that designers, suppliers, and subcontractors are informed of Specified requirements and that appropriate engineering management tools are used to ensure that coordination and communication occurs between the designers of inter-related systems.

#### **B.2.2 Technical Specification**

The Technical Specification defines the functional, performance, and interface design requirements for the vehicles and Contract-required support systems.

Technical Specification is divided into sections according to technical discipline.

1. The format is for convenience only and does not imply or suggest a preferred system integration approach.
2. 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 the requirements in this document, whether referenced or not.

The Technical Specification requires submittal of the following Contract Deliverables for review by the City to verify compliance with the Specified requirements, and for after-delivery support of the streetcar vehicles:

1. Contract Deliverable Requirements List items (CDRLs), which include drawings, documents, analyses, technical data, test procedures and results, manuals, schedules, and similar. These are listed at the conclusion of each section under the heading Contract Deliverables Requirements List.
2. Design review packages.
3. Test procedures and reports
4. Samples.
5. Training
6. Manual and Catalogs
7. Special tools and diagnostic equipment
8. Spare parts
9. Technical support personnel

### **B.2.3 Materials and Workmanship**

The Contractor shall be responsible for all materials and workmanship in the construction of the SCVs and all accessories used, whether the same are manufactured by the Contractor, Subcontractor or purchased from a Supplier. This provision excludes any equipment leased or supplied by the City, except insofar as such equipment is damaged by the failure of a part or component for which the Contractor is responsible, or except insofar as the damage to such equipment is caused by the Contractor during the manufacture of the vehicles.

Unless specifically provided for in the Technical Specification, all materials and parts furnished by the Contractor shall be new and free from Defects.

### **B.2.4 Conformance with Specifications and Drawings**

Materials furnished and Work performed by the Contractor shall conform to the requirements of the Technical Specifications and other Contract Documents. Notwithstanding the provision of drawings, technical specifications or other data by the City, the Contractor shall have the responsibility of supplying all parts and designs required to make the SCVs complete and ready for service even though such details may not be specifically mentioned in the drawings and specifications. Items that are installed by the City shall not be the responsibility of the Contractor.

## **B.3 PROJECT SCHEDULE**

### **B.3.1 Period of Performance and Delivery Schedule**

#### **B.3.1.1 Period of Performance**

The period of performance, excluding warranty, is from the date of Notice to Proceed through Notice of Completion. Time is of the essence in the Contract.

<b>Milestone</b>	<b>Time from NTP</b>
Contractual Shipment of 1st SCV	No later than 36 months after NTP
Contractual Shipment of 2nd SCV	No later than 39 months after NTP
Contractual Shipment of 3rd SCV	No later than 41 months after NTP
Contractual Shipment of 4th SCV through the 15th SCV	At a nominal rate of one vehicle per month, starting no later than 43 months after NTP and completing no later than 51 months after NTP
Contractual Delivery of 1st SCV	No later than 41 months after NTP
Contractual Delivery of 2nd SCV	No later than 44 months after NTP
Contractual Delivery of 3rd SCV through 15th SCV	No later than 46 months after NTP  At a nominal rate of one vehicle per month, starting no later than 46 months after NTP and completing no later than 55 months after NTP
Contractual delivery of 50% of Spare Parts	No later than 36 months after NTP
Contractual delivery of all Spare Parts	No later than 42 months after NTP
Completion of contractual training, except Overhaul Training	No Later than 42 months after NTP
Delivery of initial draft of all manuals	No later than 30 months after NTP
Delivery of final draft of all manuals	No later than 36 months after NTP
Contractual delivery of completed manuals	No later than 41 months after NTP
Contractual delivery of special tools and test equipment	No later than 36 months after NTP

<b>Milestone</b>	<b>Time from NTP</b>
Contractual delivery of all as-built drawings	No later than 49 months after NTP

### **B.3.2 Progress Schedule and Progress Reports**

Within 30 Days after Notice to Proceed (NTP), the Contractor shall furnish to the City for the City's approval a detailed written progress schedule. During the entire term of Contract performance, the Contractor shall report to the City in writing at least monthly on the progress of performance. If any of the Contractor's monthly reports indicate any potential delay in any of the critically dependent events identified on the schedule, the Contractor shall submit a detailed statement of action it intends to take to avoid the delay.

#### **B.3.2.1 Progress Schedule**

The progress schedule shall include a narrative introduction describing the approach to the project and schedule, fabrication, manufacturing and assembly plants and methods, shipping method, coding structure, other schedule systems used by the project and their relations to the critical path method (CPM) schedule. Activities shall be discrete items of Work that must be accomplished under the Contract and that when complete, produce definable, recognizable entities or stages within the project. The project schedule shall have all critical paths indicated, showing all major Work tasks, including the following:

- Payment milestones
- Contractor and Subcontractor/Supplier submittals including review cycles
- Design review meetings
- Drawing packages requiring approval
- Major off-site inspections and acceptance tests
- Major steps of carbody fabrication
- Major subsystem deliveries
- Assembly milestones
- All progress payments

The schedule shall show the project milestones in working days, with the NTP as the starting date and project activities with duration shown in working days. The project milestones and activities shall be logically connected with NTP as a start date and Final Completion as an end date.

The CPM schedule report shall be time scaled, have a clearly marked critical path, and include the following: activity identification number, activity description, original duration, remaining duration, percent complete, early, and late start, total float, and activity area with bars.

#### **B.3.2.2 Monthly Progress Report**

The Contractor shall prepare a progress report each month for the City, starting with the first full month after NTP. The schedule update shall be due on the 5th day of the following month. At the kickoff meeting, the Contractor shall present for the City's approval a monthly progress report format. The Monthly Progress Report shall be based upon actual progress of the Work and shall include at a minimum:

- A summary of Work accomplished during the month, including actual completion dates and start dates;
- Description of any late schedule activities and workarounds needed to recoup schedule losses;
- Major Work activities planned for the following month, including estimated remaining durations
- for activities in progress and estimated start dates;
- Date and location for the forthcoming inspection and testing activities for the next three months,
- with the updates, if there are any, easily identifiable;
- An updated engineering change status report and description of any delays due to changes;
- Status of all Contractor and Subcontractor drawings;
- An updated project schedule;
- Status of correspondence;
- Updated status on required Contract deliverables; and
- Status of any Claims and Notices of Intent to Claim.

### **B.3.3 DELAYS.**

**B.3.3.1 Any delay to the Project Schedule herein will result in a Change Order or Amendment. Any Change Order or Amendment granted under this Section shall be its sole and exclusive remedy for the consequences of any delay described herein. Delays by Contractor.**

Delays by Contractor may occur when the Contractor is delayed in the progress of the Project by an act, omission, or neglect of the Contractor, its agents or representatives, or an act or omission of any of its subcontractor(s).

In the event of a delay by Contractor, Contractor must request a Change Order in writing within thirty (30) days after the Contractor knows or should have known of the basis for a claim, whichever is earlier.

In case the Contractor is delayed at any time or for any period by two or more of the causes specified in this Section, the Contractor shall not be entitled to a separate extension for each one of the causes but only one period of extension will be granted for the delay.

### **B.3.3.2 Delays by Force Majeure**



Delays by Force Majeure may occur when either Party, or either Party's contractor(s), subcontractor(s) or supplier(s) at any tier are delayed in the progress of the Project due to a Force Majeure event.

Should either Party be affected by delays of Force Majeure, the Parties shall consult with each other to revise the Project Schedule pursuant to Sections 3.3, Changes to Contract, and 5.13, Force Majeure.

#### **B.3.3.3 Delays by City.**

Delays by the City may occur when the Contractor is delayed in the progress of the Project by an act, omission, or neglect of the City, its agents or representatives, or an act or omission of another contractor in the performance of a separate contract with the City.

In the event of a delay by City, Contractor must request a Change Order in writing within seven (7) days after the commencement of such delay for the portion of the Project so delayed. Unless the above notice and appropriate requests are filed with the City pursuant to this Section within seven (7) days after commencement of the delay, or such other times as may be prescribed herein, no extension of time will be made or additional compensation allowed.

Contractor may submit a revised Change Order request for an extension of time and/or additional compensation within fourteen (14) days following the cessation of such delay. In the case of a continuing cause of delay, only one request is necessary.

#### **B.3.3.4 Non-excusable Delays**

No extension of time will be granted under this Section for any delay to the extent that performance would have been so delayed by any Contractor-induced causes, including but not limited to the fault or negligence of the Contractor or its subcontractors; or for which remedies are provided or excluded by any other provision of the Contract. Only the actual delay necessarily resulting from the causes specified in this Section shall be grounds for extension of time; or An extension of time will not be granted for a delay caused by a shortage of materials, except the City-furnished materials, unless the Contractor furnishes to the City documented proof that it has made every effort to obtain such materials or approved substitutions from every known source within reasonable reach of the Project. The Contractor shall also submit proof, in the form of network analysis data, that the inability to obtain such material when originally planned, did in fact cause a delay in completion of any Contract Milestone which could not be compensated for by revising the sequence of operations. Only the physical shortage of material will be considered under these provisions as a cause for extension of time. No consideration will be given to any claim that material could not be obtained at a reasonable, practical, or economical cost, unless it is shown to the satisfaction of the City that such material could have been obtained only at exorbitant prices, entirely inconsistent with current rates taking into account the quantities involved and the usual practices in obtaining such quantities and that such fact could not have been known or anticipated at the time the Contract was entered into.

### **B.3.4 MAINTENANCE DURING DELAY**

In the event of any Delays by City which result in a temporary suspension of work, the Contractor shall take every reasonable precaution to prevent damage to or deterioration of the Project. The Contractor shall repair or replace at no cost to the City any Goods, Services, or Deliverables that are damaged or have deteriorated during such a work suspension due to the Contractor's failure to comply with this Paragraph. If the City finds that the Contractor is not taking a reasonable precaution and the Contractor fails to take the precaution within five (5) days after written notice from the City, the City may cause the precaution to be taken and recover the reasonable cost of taking the precaution from the Contractor.

### **B.4 Vehicle TASKS AND DELIVERABLES**

The individual Deliverables are described in more detail below, detailed requirements for each CDRL are listed within the Technical Specification; the first number in the CDRL represent the Technical Specification section.

#### **B.4.1 Program Management**

##### **B.4.1.1 Deliverables due 30 days after NTP**

- CDRL 2-1 Management Plan
- CDRL 2-3 CPM Schedule – First Vehicle
- CDRL 2-5 Correspondence and Contract Deliverable Coding Scheme
- CDRL 2-8 Meeting Minutes Format
- CDRL 2-19 QA Manager Qualifications

##### **B.4.1.2 Deliverables due Monthly**

- Documentation per Milestone C-2: C.3
  - CDRL 2-2 Monthly CPM Schedule Update
  - CDRL 2-4 Monthly Progress Report
  - CDRL 2-6 CDRL Report
  - CDRL 2-7 Contract Deliverables Status Report
- Documentation per Milestone A-1: A.1
  - CDRL 2-10 Specification Compliance Matrix (SCM)
- CDRL 2-9 Meeting Minutes
- Buy America Report

##### **B.4.1.3 Deliverables due 60 days after NTP**

- Documentation per Milestone A-1: A.1
  - CDRL 2-14 Modification and Configuration Control Manual
  - CDRL 2-15 ECR Form and Procedure
  - CDRL 2-20 Quality Assurance Plan (QAP)

#### B.4.1.4 Deliverables due 120 days after NTP

- CDRL 2-21 FAI List
- CDRL 2-17 Draft Training Plan for Manufacturing Workers
- CDRL 2-24 Quality Control and Inspection Plan (QCIP)

#### B.4.2 Conceptual Design Review

##### B.4.2.1 Deliverables

- Documentation per Milestones A-1: A.3
- Approval of CDRLS:

CDRL	Description	CDRL	Description
4-4	General Arrangement Drawings	7-4	Vehicle Data Network Design Package, Item 1
4-5	Vehicle Detail Dimensions	7-6	Software Quality Assurance (SQA) Plan
4-6	Weight Plan and Calculations	9-1	Door System Design Package, Item 1 and 2
4-7	Vehicle Excursions	9-2	Door-Platform Interface Design Report
4-8	WRIS Plan, Schedule, and Report, Item 1	9-5	Bridgeplate Design Package, Item 3
4-13	Propulsion, OESS and Braking System Performance	10-1	Calculations
5-2	Cab Controls Design Package, Item 3	13-3	Propulsion System Run Time Simulations
6-1	Initial Interior and Exterior Design Package	14-4	CEM and Collision Survivability Plan
6-8	Mobility Aid Parking Area Design Package	14-6	Vehicle-Body Stress Analysis and Tests Plan
6-13	Operator's Cab Design Package, Item 1	14-7	Stress Analysis Report
6-15	Exterior Design Package, Item 1	14-9	FEA Model Report
7-1	Vehicle System Functional Description (SFD)	16-4	Friction Brake Run Time Simulations

#### B.4.3 Preliminary Design Review

### B.4.3.1 Deliverable

- Documentation per Milestone C-1: C.1
  - Except C-1: C.1.17
- Conditional Approval of the following CDRLs:

CDRL	Description	CDRL	Description
2-12	List of Final Drawings	9-4	Door Indication and Warning Design Package
2-13	Final Drawings	9-5	Bridgeplate Design Package
2-16	Vehicle History Books (VHB)	10-1	Calculations
3-1	Operator's Instruction and Troubleshooting Manual	10-2	HVAC Unit Design Package
3-2	Maintenance and Servicing Manual	10-3	Air Distribution Design Package
3-3	Heavy Repair Manual (HRM)	10-4	HVAC Control Design Package
3-4	Illustrated Parts Catalog	10-5	Floor Heat Design Package
3-5	Training Manuals	10-6	In-Factory Charging and Testing Booklet
3-6	Special Tools and Diagnostic Equipment Manuals	10-7	Operator's Cab Air Comfort System Design Package:
3-7	Integrated Schematic Diagrams for Troubleshooting	11-1	Lighting System Design Package
3-8	Labor Guide	11-2	Emergency Lighting System Design Package
3-9	Draft Training Plan	12-1	One-Line Power Distribution Diagrams
3-10	Required Spare Parts	12-2	AC and DC Load Calculations
3-11	Recommended Spare Parts	12-3	Safety Grounding Design Package
4-1	Vehicle system functional description	12-4	Ground Brush Design Package
4-2	Individual system SFDs	12-5	Ground Fault Detection and Protection Design Package
4-3	Vehicle Curve Capabilities:	12-6	Primary Power System Design Package
4-4	General Arrangement Drawings	12-7	Pantograph Design Package

CDRL	Description	CDRL	Description
4-5	Vehicle Detail Dimensions	12-8	Shop Power Design Package
4-6	Weight Plan and Calculations	12-9	OESS Design Package
4-7	Vehicle Excursions	12-10	OESS Thermal Capacity Calculations
4-8	WRIS Plan, Schedule, and Report	12-11	AC Auxiliary Power Supply (APS) Design Package
4-9	Load Compensation Design Package	12-12	Failure Management Design Package
4-10	Emergency Brake System Design Package	12-13	Low-Voltage DC Power System Design Package
4-11	Spin/Slide System Design Package	12-14	Line Filters
4-12	No-Motion Detection Design Package	12-15	Electrical Panels, Components, and Devices Design Package
4-13	Propulsion, OESS and Braking System Performance	13-1	Propulsion System Design Package
4-14	EMI/EMC Design Package	13-2	Inverter Design Package
4-15	Vehicle Safety Design Package	13-3	Propulsion System Run Time Simulations
4-16	Mitigation of Hazards Design Documentation	13-4	Traction Motor Design Package
4-17	Mitigation of Hazards Construction Documentation	13-5	Gear Drive Design Package
4-18	Predicted Reliability Design Package	13-6	Brake Resistor Design Package
4-20	Predicted MTTR	13-7	Control Logic Design Package
4-21	Scheduled Maintenance Plan	13-8	Interface with Friction Brakes Design Package
5-1	Master Controller Group Design Package	13-9	Fault Monitoring Design Package
5-2	Cab Controls Design Package	14-1	Jacking Pad Design Package
5-3	Control Configuration and Interlocks Design Package	14-2	Roof Shroud Design Package
6-1	Initial Interior and Exterior Design Package	14-3	Skirt Design Package

CDRL	Description	CDRL	Description
6-2	Interior Design Package	14-4	CEM: CEM and Collision Survivability Plan
6-3	Walls and Ceiling Design Package	14-5	CEM: Crashworthiness Analysis Report
6-4	Acoustical Insulation Design package	14-6	Vehicle-Body Stress Analysis and Tests Plan
6-5	Thermal Insulation Design Package	14-7	Stress Analysis Report
6-6	Floor Covering Design Package	14-8	Equipment Support Stress Analysis Report
6-7	Passenger Seat Design Package	14-9	FEA Model Report
6-8	Mobility Aid Parking Area Design Package	14-10	FEA Report
6-9	Stanchions, Handrails, and Windscreens Design Package	14-11	FEA Input and Output Data on Electronic Media
6-10	Fare Collection Design Package	15-1	Truck Design Package
6-11	Key Design Package	15-2	Truck Clearance Design Package
6-12	Windows Design Package	15-3	Truck-to-Vehicle-Body Connection Design Package
6-13	Operator's Cab Design Package	15-4	Suspension Design Package
6-14	Windshield Wiper and Washer System Design Package	15-5	Journal Bearings Design Package
6-15	Exterior Design Package	15-6	Axle Strength Design Package
6-16	Rain Gutters and Water Drainage Design Package	15-7	Wheel-Axle Assembly Design Package
6-17	Equipment Enclosures Design Package	15-8	Flange Lubricator Design Package
6-18	Signage Design Package	15-9	Truck Stress Analysis and Testing Plan
7-1	Vehicle System Functional Description (SFD)	15-10	FEA Model Package
7-2	Individual Systems SFDs	15-11	Truck Stress Analysis Report
7-3	Vehicle Control System Design Package	15-12	FEA Input and Output Data

CDRL	Description	CDRL	Description
7-4	Vehicle Data Network Design Package	15-13	Welding Analysis Report
7-5	Monitoring and Diagnostic System Design Package	15-14	Service Proven Design
7-6	Software Quality Assurance (SQA) Plan	16-1	Friction Brake System Design Package
7-7	Software Requirements Specification (SRS)	16-2	Track Brake Design Package
7-8	Software Design Description (SDD)	16-3	Friction Brake Control Design Package
7-9	Software Verification and Validation Plan (SVVP)	16-4	Friction Brake Run Time Simulations
7-10	Software Verification and Validation Report (SVVR)	16-5	Sanding System Design Package
7-11	Software User Manual (SUM)	16-6	Friction brake redistribution scheme
8-1	Public Address Design Package	17-1	Coupler Design Package
8-2	Intercom Design Package	19-1	Recommended Cleaning Agents:
8-3	Automatic Passenger Information System Design Package	19-2	Certification of No Prohibited Materials:
8-4	Warning Devices Design Package	19-3	Proposed Materials Not Covered by Specification or Standard:
8-5	Radio Design Package	19-4	Safety Data Sheets (SDS):
8-6	CCTV Design Package	19-5	Fasteners Design Package:
8-7	Vehicle Position Design Package	19-6	Stainless Steel Test and Inspection Plan:
8-8	Wi-Fi Router Design Package	19-7	Structural Steel Test and Inspection Plan:
8-9	Event Recorder Design Package	19-8	Steel Casting Qualification Test Report:
8-10	Automatic Passenger Counting Design Package:	19-9	Steel Casting Radiographic Inspection Sampling Frequency

CDRL	Description	CDRL	Description
8-11	Automatic Vehicle Locator Design Package:	19-10	Aluminum Test Reports:
8-12	Traffic Light Priority Design Package	19-11	Paints, Graphics, and Coatings Design Package:
8-13	ATS Design package	19-12	Flammability, Smoke Emission, and Toxicity Design Package:
8-14	TWC Design Package	19-13	Conduit and Raceways Design Package:
9-1	Door System Design Package	19-14	Wire and Cable Design Package:
9-2	Door-Platform Interface Design Report	19-15	Wire and Cable Connections Design Package
9-3	Door Control System Design Package		

#### B.4.4 Final Design Review

##### B.4.4.1 Deliverable

- Documentation per Milestone C-1: C.2
  - Except C-1: C.2.17
- Approval of the following CDRLs:

CDRL	Description	CDRL	Description
2-12	List of Final Drawings	9-4	Door Indication and Warning Design Package
2-13	Final Drawings	9-5	Bridgeplate Design Package
2-16	Vehicle History Books (VHB)	10-1	Calculations
3-1	Operator's Instruction and Troubleshooting Manual	10-2	HVAC Unit Design Package
3-2	Maintenance and Servicing Manual	10-3	Air Distribution Design Package
3-3	Heavy Repair Manual (HRM)	10-4	HVAC Control Design Package
3-4	Illustrated Parts Catalog	10-5	Floor Heat Design Package
3-5	Training Manuals	10-6	In-Factory Charging and Testing Booklet



CDRL	Description	CDRL	Description
3-6	Special Tools and Diagnostic Equipment Manuals	10-7	Operator's Cab Air Comfort System Design Package:
3-7	Integrated Schematic Diagrams for Troubleshooting	11-1	Lighting System Design Package
3-8	Labor Guide	11-2	Emergency Lighting System Design Package
3-9	Draft Training Plan	12-1	One-Line Power Distribution Diagrams
3-10	Required Spare Parts	12-2	AC and DC Load Calculations
3-11	Recommended Spare Parts	12-3	Safety Grounding Design Package
4-1	Vehicle system functional description	12-4	Ground Brush Design Package
4-2	Individual system SFDs	12-5	Ground Fault Detection and Protection Design Package
4-3	Vehicle Curve Capabilities:	12-6	Primary Power System Design Package
4-4	General Arrangement Drawings	12-7	Pantograph Design Package
4-5	Vehicle Detail Dimensions	12-8	Shop Power Design Package
4-6	Weight Plan and Calculations	12-9	OESS Design Package
4-7	Vehicle Excursions	12-10	OESS Thermal Capacity Calculations
4-8	WRIS Plan, Schedule, and Report	12-11	AC Auxiliary Power Supply (APS) Design Package
4-9	Load Compensation Design Package	12-12	Failure Management Design Package
4-10	Emergency Brake System Design Package	12-13	Low-Voltage DC Power System Design Package
4-11	Spin/Slide System Design Package	12-14	Line Filters
4-12	No-Motion Detection Design Package	12-15	Electrical Panels, Components, and Devices Design Package
4-13	Propulsion, OESS and Braking System Performance	13-1	Propulsion System Design Package
4-14	EMI/EMC Design Package	13-2	Inverter Design Package

CDRL	Description	CDRL	Description
4-15	Vehicle Safety Design Package	13-3	Propulsion System Run Time Simulations
4-16	Mitigation of Hazards Design Documentation	13-4	Traction Motor Design Package
4-17	Mitigation of Hazards Construction Documentation	13-5	Gear Drive Design Package
4-18	Predicted Reliability Design Package	13-6	Brake Resistor Design Package
4-20	Predicted MTTR	13-7	Control Logic Design Package
4-21	Scheduled Maintenance Plan	13-8	Interface with Friction Brakes Design Package
5-1	Master Controller Group Design Package	13-9	Fault Monitoring Design Package
5-2	Cab Controls Design Package	14-1	Jacking Pad Design Package
5-3	Control Configuration and Interlocks Design Package	14-2	Roof Shroud Design Package
6-1	Initial Interior and Exterior Design Package	14-3	Skirt Design Package
6-2	Interior Design Package	14-4	CEM: CEM and Collision Survivability Plan
6-3	Walls and Ceiling Design Package	14-5	CEM: Crashworthiness Analysis Report
6-4	Acoustical Insulation Design package	14-6	Vehicle-Body Stress Analysis and Tests Plan
6-5	Thermal Insulation Design Package	14-7	Stress Analysis Report
6-6	Floor Covering Design Package	14-8	Equipment Support Stress Analysis Report
6-7	Passenger Seat Design Package	14-9	FEA Model Report
6-8	Mobility Aid Parking Area Design Package	14-10	FEA Report
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CDRL	Description	CDRL	Description
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6-13	Operator's Cab Design Package	15-4	Suspension Design Package
6-14	Windshield Wiper and Washer System Design Package	15-5	Journal Bearings Design Package
6-15	Exterior Design Package	15-6	Axle Strength Design Package
6-16	Rain Gutters and Water Drainage Design Package	15-7	Wheel-Axle Assembly Design Package
6-17	Equipment Enclosures Design Package	15-8	Flange Lubricator Design Package
6-18	Signage Design Package	15-9	Truck Stress Analysis and Testing Plan
7-1	Vehicle System Functional Description (SFD)	15-10	FEA Model Package
7-2	Individual Systems SFDs	15-11	Truck Stress Analysis Report
7-3	Vehicle Control System Design Package	15-12	FEA Input and Output Data
7-4	Vehicle Data Network Design Package	15-13	Welding Analysis Report
7-5	Monitoring and Diagnostic System Design Package	15-14	Service Proven Design
7-6	Software Quality Assurance (SQA) Plan	16-1	Friction Brake System Design Package
7-7	Software Requirements Specification (SRS)	16-2	Track Brake Design Package
7-8	Software Design Description (SDD)	16-3	Friction Brake Control Design Package
7-9	Software Verification and Validation Plan (SVVP)	16-4	Friction Brake Run Time Simulations
7-10	Software Verification and Validation Report (SVVR)	16-5	Sanding System Design Package

CDRL	Description	CDRL	Description
7-11	Software User Manual (SUM)	16-6	Friction brake redistribution scheme
8-1	Public Address Design Package	17-1	Coupler Design Package
8-2	Intercom Design Package	19-1	Recommended Cleaning Agents:
8-3	Automatic Passenger Information System Design Package	19-2	Certification of No Prohibited Materials:
8-4	Warning Devices Design Package	19-3	Proposed Materials Not Covered by Specification or Standard:
8-5	Radio Design Package	19-4	Safety Data Sheets (SDS):
8-6	CCTV Design Package	19-5	Fasteners Design Package:
8-7	Vehicle Position Design Package	19-6	Stainless Steel Test and Inspection Plan:
8-8	Wi-Fi Router Design Package	19-7	Structural Steel Test and Inspection Plan:
8-9	Event Recorder Design Package	19-8	Steel Casting Qualification Test Report:
8-10	Automatic Passenger Counting Design Package:	19-9	Steel Casting Radiographic Inspection Sampling Frequency
8-11	Automatic Vehicle Locator Design Package:	19-10	Aluminum Test Reports:
8-12	Traffic Light Priority Design Package	19-11	Paints, Graphics, and Coatings Design Package:
8-13	ATS Design package	19-12	Flammability, Smoke Emission, and Toxicity Design Package:
8-14	TWC Design Package	19-13	Conduit and Raceways Design Package:
9-1	Door System Design Package	19-14	Wire and Cable Design Package:
9-2	Door-Platform Interface Design Report	19-15	Wire and Cable Connections Design Package
9-3	Door Control System Design Package		

## **B.4.5 FAI**

### **B.4.5.1 Deliverables**

- Approval of the following CDRLs
  - 2-21 FAI List
  - 2-22 FAI Packages
  - 2-23 FAI Reports
- Completion of Milestone A-1: A.6

## **B.4.6 Test Procedures**

### **B.4.6.1 Deliverables**

- Documentation per Milestone C.1.17 and C.2.17
- Approval of Test procedures in Technical Specification Section 18
- CDRLs 18-26 through 18-42, 18-47, 18-48 and 18-49
- All test procedures per Milestone D

## **B.4.7 Test Reports**

### **B.4.7.1 Deliverables**

- Approval of Test reports Technical Specification Section 18
  - CDRLs 18-26 through 18-42, 18-47, 18-48 and 18-49
- Approval of all test reports per Milestone D

## **B.4.8 SCV Manufacture**

### **B.4.8.1 Deliverables**

- Manufacture SCV
- Equipment order per Milestone A-1: A.4
- Equipment receipt per Milestone A-1: A.5
- Completion of Milestone A-1: A.7
- Completion of Milestone A-1: A.8
- Approval CDRL 2-18 Control Samples

## **B.4.9 SCV shipment**

### **B.4.9.1 Deliverables**

- Completion of Milestone A-1: A.9
- Approval of the following CDRLS
  - CDRL 2-11 Construction Photographs
  - CDRL 2-12 List of Final Drawings
  - CDRL 2-13 Final Drawings

- CDRL 2-16 Vehicle History Books (VHB)

## **B.4.10 SCV Onsite testing**

### **B.4.10.1 General**

See Technical Specification Section 18.9 through 18.11 for details on test requirements.

See Technical Specification Section 18.1.4 Test Classifications for details.

### **B.4.10.2 Deliverables**

#### ***Vehicle-level Type Dynamic Tests***

- Approval of the following CDRLs
  - 18-43 Vehicle-Level Type Dynamic Tests
  - 18-44 Ride Quality Type Test
  - 18-45 Noise and Vibration Type Test
  - 18-46 EMI/EMC Type Test

#### ***Vehicle-level Routine Tests***

- Approval of CDRL 18-47
- Approval of CDRL 18-48

## **B.4.11 SCV Acceptance**

## **B.4.12 SCV Burn-in**

### **B.4.12.1 General**

Perform after SVC has been Conditionally Approved by the City; Burn-in is a Condition of SCV Acceptance, and shall be tested using the following procedure:

- Operate the vehicle:
  - First vehicle a minimum of 1609 km (1000 mi) on the City alignment in simulated revenue service.
  - Remaining vehicles a minimum of 1207 km (750 mi) on the City alignment in simulated revenue service.
- Stop at each station and cycle the doors and Bridgeplates on both sides of the vehicle.
- During the last 161 km (100 mi), there must be no failures, using the same criteria as that used for Reliability in Technical Specification Section 4, Design and Performance Criteria.

Retest: If a failure occurs in the last 161 km (100 mi), Contractor shall correct any problem, and the City shall restart the 100 km (100 mi) portion of the test.

#### **B.4.12.2 Deliverable**

- Approval of CDRL 18-49

### **B.5 Spare Parts and Special Tools Task and Deliverables**

The individual Deliverables are described in more detail below, detailed requirements for each CDRL are listed within the Technical Specification; the first number in the CDRL represent the Technical Specification section.

#### **B.5.1 Spare parts**

##### **B.5.1.1 General**

The Contractor will furnish the spare parts listed in the Contract Documents, see Exhibit A.3 Contract Allowance for Spare Parts, Special Tools, and Test Equipment.

##### **B.5.1.2 Deliverables**

- Delivery of Agreed upon Spare Parts Milestone E.
- Approval of the following CDRLs
  - CDRL 3-10 Required Spare Parts
  - CDRL 3-11 Recommended Spare Parts

#### **B.5.2 Special tools and Test Equipment**

##### **B.5.2.1 General**

The Contractor will furnish the spare parts listed in Contract Documents, see Exhibit A.3 Contract Allowance for Spare Parts, Special Tools, and Test Equipment.

See Technical Specification Section 3.2 Special Tools and Diagnostic Equipment for specific requirements.

##### **B.5.2.2 Deliverables**

- Delivery of Agreed upon Special Tools and Test Equipment, Milestone F.
- Special Tools required per Technical Specification Section 3.2.2.
- Portable Test Units required per Technical Specification Section 3.2.4

### **B.6 Field Support Task and Deliverables**

The individual Deliverables are described in more detail below, detailed requirements for each CDRL are listed within the Technical Specification; the first number in the CDRL represent the Technical Specification section.

## **B.6.1 Field Support, Technical Support Personnel**

### **B.6.1.1 Deliverables**

The Contractor will provide technical support personnel, Milestone C-5: C.7.

Per Technical Specification Section 3.5:

- Language: Fluent in English.
- Availability: Any of three eight-hour shifts, as may be required by the City.
- Purpose:
  - Assist during inspection, operation, testing, modification programs, and adjustment of vehicles both before and after Acceptance by the City.
  - Assist in training that may be required, in addition to the training Specified above, both before and after Acceptance by the City.
- Field Service Engineer:
  - Quantity: Minimum one.
  - Location: At the City's facilities.
  - Qualifications: Knowledgeable in each of the vehicle's systems to the level of competent troubleshooting.
  - Availability: Full time.
  - Time period: One month before the arrival of the first vehicle until two years after acceptance of the last vehicle.
- Suppliers: Ensure 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 vehicle and equipment malfunctions.
- Additional on-site technical assistance: If requested by the City, furnish as follows:
  - Delivery of first vehicle to Final Acceptance of last vehicle: Within 48 hours from receipt of request.
  - Warranty Period: Within 72 hours from receipt of request.

## **B.7 Training and Manuals Task and Deliverables**

The individual Deliverables are described in more detail below, detailed requirements for each CDRL are listed within the Technical Specification; the first number in the CDRL represent the Technical Specification section.

### **B.7.1 Training**

#### **B.7.1.1 Deliverables**

##### ***General***



The Contractor will provide Training, Milestone C-3: C.5. See Technical Specification Sections 3.3.1 and 3.3.2 for specific training requirements

### ***Training Plan***

- CDRL 3-9, Draft Training plan

### ***Operator***

See Technical Specification Section 3.3.3 Operator Training for specific requirements.

### ***Maintenance***

See Technical Specification Section 3.3.4 Maintenance Training.

## **B.7.2 Manuals**

### **B.7.2.1 Deliverables**

#### ***General***

The Contractor will provide Manuals, Milestone C-4: C.6. See Technical Specification Section 3.1 Manuals and Catalogs

#### ***Initial Draft Manuals***

Condition Approval of the following Technical Specification Section 3 CDRLs.

- CDRL 3-1 Operator's Instruction and Troubleshooting Manual
- CDRL 3-2 Maintenance and Servicing Manual
- CDRL 3-3 Heavy Repair Manual (HRM)
- CDRL 3-4 Illustrated Parts Catalog
- CDRL 3-5 Training Manuals
- CDRL 3-6 Special Tools and Diagnostic Equipment Manuals
- CDRL 3-7 Integrated Schematic Diagrams for Troubleshooting
- CDRL 3-8 Labor Guide

#### ***Final Draft Manuals***

Approval of the following Technical Specification Section 3 CDRLs.

- CDRL 3-1 Operator's Instruction and Troubleshooting Manual
- CDRL 3-2 Maintenance and Servicing Manual
- CDRL 3-3 Heavy Repair Manual (HRM)

- CDRL 3-4 Illustrated Parts Catalog
- CDRL 3-5 Training Manuals
- CDRL 3-6 Special Tools and Diagnostic Equipment Manuals
- CDRL 3-7 Integrated Schematic Diagrams for Troubleshooting
- CDRL 3-8 Labor Guide

### ***Completed Manuals***

Submittal of all Manuals Per Technical Specification 3.1.2, Hard Copy Format and Soft Copy Format.

- CDRL 3-1 Operator's Instruction and Troubleshooting Manual
- CDRL 3-2 Maintenance and Servicing Manual
- CDRL 3-3 Heavy Repair Manual (HRM)
- CDRL 3-4 Illustrated Parts Catalog
- CDRL 3-5 Training Manuals
- CDRL 3-6 Special Tools and Diagnostic Equipment Manuals
- CDRL 3-7 Integrated Schematic Diagrams for Troubleshooting
- CDRL 3-8 Labor Guide

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Section 1 General topics and definitions

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## 1.1 Scope

This Section includes requirements that apply to every section in the Technical Specification.

## 1.2 General Requirements

The vehicles will be modern articulated, low floor streetcars, designed to be safe, reliable, and maintainable.

The Contractor will have the following responsibilities:

1. Design, manufacture, test, and deliver the products as described by the Technical Specifications. Deviations from these requirements are permitted only with specific written approval of the City, as Specified in the Contract Documents.
2. Design and integrate vehicle systems such that Specified requirements are achieved without conflict or error within or between onboard systems and between vehicle systems and wayside systems.
3. Ensure that designers, suppliers, and subcontractors are informed of Specified requirements and that appropriate engineering management tools are used to ensure that coordination and communication occurs between the designers of inter-related systems.

## 1.3 Technical Specification

The Technical Specification defines the functional, performance, and interface design requirements for the vehicles and Contract-required support systems.

The Technical Specification is divided into sections according to technical discipline and traditional supplier arrangements.

1. The format is for convenience only and does not imply or suggest a preferred system integration approach.
2. 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 the requirements in this document, whether referenced or not.

The Technical Specification requires submittal of the following Contract deliverables for review by the City to verify compliance with the Specified requirements, and for after-delivery support of the vehicles:

1. Contract Deliverable Requirements List items (CDRLs), which include drawings, documents, analyses, technical data, test procedures and results, manuals, schedules, and similar. These are listed at the conclusion of each section under the heading Contract Deliverables Requirements List.
2. Design review packages.
3. Samples.

Unless otherwise noted in the Contract Documents, each item Specified for submittal must be both reviewed and Approved by the City, whether this is specifically stated or not. The City reserves the right to request additional drawings, documents, analyses, technical data, test procedures and results, or similar information, as required to clarify and amplify the intent of Contract deliverables submitted.

## 1.4 Access to Contractor Facilities

The City has the right to visit facilities of the Contractor and its subcontractors:

1. Visits are to assess progress, monitor work being performed, conduct QA/QC audits, conduct quality inspections, and witness testing.

2. The City will have the right to photograph, at its expense, any or all phases of vehicle or equipment construction, including subcontractor work.

### 1.5 Materials and Equipment

Name brands, specific equipment, or specific materials may be referenced in the Technical Specification:

1. Such equipment has been shown to be successful in previous applications, where correctly applied and integrated with other equipment; however, such references should not be interpreted as pre-approval of Contractor designs or applications.
2. The Contractor is responsible for the selection, application, and integration of equipment and materials as necessary to conform to the Specified requirements.

Equipment provided under this Contract must be new:

1. Rebuilt or refurbished equipment is prohibited.
2. New equipment damaged during performance of this Contract may be restored to new condition only were Approved in writing by the City on a case-by-case basis, any restorations must be performed by the original equipment manufacturer.

### 1.6 Industry Standards and Regulations

Comply with the following:

1. Where standards, codes, or reference books are referenced in the Technical Specification, use the most current version available at the time of proposal submission, unless otherwise noted.
2. Where laws, statutes, or regulations are Specified, such as the Code of Federal Regulations (CFR), use the version in force at the time of proposal submission.
3. References to laws, statutes, or regulations are included in the Technical Specification to aid the Contractor. Whether referenced or not, applicable federal, state, and local laws, statutes, and regulations must be included in this Contract.

### 1.7 Americans With Disabilities Act (ADA)

The Americans with Disabilities Act (ADA) prohibits discrimination based on disability in the provision of transportation services by public and private entities:

1. The Department of Transportation (DOT) issues legally enforceable regulations to implement the transportation provisions of the ADA, codified in 49 CFR Parts 37 and 38, and compliance with these regulations is mandatory whether referenced in the Technical Specification or not.
2. Compliance with interpretations by the Federal Transit Administration (FTA) in Administrators Policy Letters is also mandatory.

References are furnished to these parts in the Technical Specification:

1. 49 CFR 38, ADA Accessibility Specification for Transportation Vehicles: Technical requirements for vehicles are primarily found in this part.
2. 36 CFR 1191, ADA Accessibility Guidelines for Buildings and Facilities, Appendix D, Technical: Adopted by DOT in 49 CFR 37, Appendix A by reference with some modifications. In some cases, requirements from this part are applied to vehicles.

## 1.8 System of Units

International System of Units (SI) units are shown with United States customary units following in parentheses:

1. Rounding: If a difference exists between SI and U.S. customary units due to rounding, SI units are the primary units.
2. Exception: Where laws, statutes, or regulations give dimensions only in U.S. customary units, the U.S. customary units are the primary units.

## 1.9 English Language

Communication with the City will be conducted in the English language only, including but not limited to meetings, correspondence, Contract deliverables, other documents submitted to the City and all Work Product produced under the Contract.

## 1.10 Definitions

The following terms may appear in this document. They are defined as indicated, whether capitalized or not:

Acceleration, Average: The arithmetic difference between ending speed and initial speed, divided by the time elapsed between those speeds.

Acceleration, Instantaneous: The value of acceleration at a specific instance of time, or speed.

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 the City or the City's Engineer. In no instance will an approval by the City constitute an authorization to deviate from Contract requirements. Any deviation from Contract requirements must be accomplished by amendment to the Contract. In addition, no approval by the City will constitute a waiver of the City's right to later require compliance with Contract requirements and the correction of Defects.

Approved or Approved Type: Design, type material, procedure, or method given approval by the City or the City's authorized representative.

Auxiliary, Auxiliaries: Circuits and systems for loads other than propulsion.

Auxiliary loads: Loads other than propulsion, such as lighting and HVAC.

AW0: Weight of empty vehicle.

AW1: Weight of vehicle with a full seated load, including one operator.

AW2: Weight of vehicle with a full seated load, including one operator, plus standees at four passengers/m<sup>2</sup>.

AW3: Weight of vehicle with a full seated load, including one operator, plus standees at six passengers/m<sup>2</sup>.

AW4: Weight of vehicle with a full seated load, including one operator, plus standees at 6.6 passengers/m<sup>2</sup>.

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.



1 Burn-In: Operating a component, system, or device in a test mode, often in an extreme or cycled  
2 temperature environment, for a Specified period or distance, to confirm reliable operation.

3 Coast: The mode of operation in which no propulsion or braking efforts are in effect, except for normal  
4 drivetrain losses.

5 Component: Portions of equipment not typically repaired or disassembled, such as nuts, bolts, resistors,  
6 fittings, single-piece castings. Used interchangeably with “parts.”

7 Contract Deliverables Requirements List (CDRL): List of select documents and other deliverable items that  
8 the Contractor is required to deliver to the City. CDRL is also used to refer to a specific item on the list.

9 Contract Drawings: Drawings and Technical Specification furnished by the City as part of this procurement.

10 Contractor: The person or persons, firm, partnership, corporation, or combination thereof that has  
11 entered into a procurement Contract with the City to supply the vehicles.

12 Contractor's Drawings: Items such as general drawings, detail drawings, graphs, diagrams, sketches,  
13 calculations, and catalog cuts prepared by the Contractor for use in its manufacturing facility, assembly  
14 facility, or shop, to fabricate, assemble, and install parts of the vehicle whether manufactured by it from  
15 raw materials or purchased from others in a ready-to-use condition.

16 Data: Written presentations, plans, reports, schedules, forms, drawings, calculations, analyses,  
17 procedures, samples, photos, and other items prepared by the Contractor, its subcontractors, or suppliers  
18 in response to requests from the City or its authorized representative or to otherwise meet the  
19 requirements of the Contract Documents.

20 Days: Unless otherwise designated, days as used in the Contract Documents will be understood to mean  
21 calendar days; that is, including weekends and holidays.

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

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

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

29 Dynamic Braking: Braking effort produced by using the traction motors as generators, dissipating vehicle  
30 energy by rheostatic braking, regenerative braking, or a combination of both.

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

32 Failsafe: A system is “failsafe” when it is designed such that a malfunction will not cause the system to  
33 achieve an unsafe state.

34 Failure: A condition in which equipment does not function as Specified, designed, or expected.

35 Failure Rate: The frequency of failure, expressed as failures per hour or failures per mile. Failure rate is  
36 the mathematical reciprocal of Mean Time Between Failures (MTBF) or Mean Distance Between Failures  
37 (MDBF).

38 First Article: The first item of production that fixes and defines each subsequent production item. First  
39 articles are production units intended for review by the City.

- 1 Furnish: To supply and deliver to project site.
- 2 Grab handle: A safety device mounted on the aisle-side corner of a seat and designed to be grasped by  
3 the hand to enable a person to maintain balance.
- 4 Grab rail: A horizontal safety device mounted across the back of a seat and designed to be grasped by the  
5 hand to enable a person to maintain balance.
- 6 Handhold: A vertical safety device mounted to a wall or other vertical surface and designed to be grasped  
7 by the hand to enable a person to maintain balance.
- 8 Handrail: A horizontal safety device mounted to a wall or windscreen or hung from the ceiling and  
9 designed to be grasped by the hand to enable a person to maintain balance.
- 10 High-Voltage DC: DC power from the OCS, OESS or regenerative braking.
- 11 Hotel loads: The same as auxiliary loads (see definition above).
- 12 Inspector: The person(s) or firm designated by the City as its quality control representative.
- 13 Install: To place in position for service or use.
- 14 Interface: The points where two or more systems, subsystems, components, or structures meet, and  
15 transfer energy or information.
- 16 Jerk: Time rate of change of acceleration and deceleration, equal to the second derivative of velocity.
- 17 Light: The transparent portion of a window.
- 18 Liner (as in interior liner): The visible covering material for the walls, ceiling, and other interior surfaces.
- 19 Load Weighing: The measurement of passenger load for the purpose of adjusting tractive effort to  
20 produce a constant acceleration or braking rate regardless of load.
- 21 Low-Voltage DC: DC power from the low-voltage dc power system or vehicle battery.
- 22 Lowest Level Replaceable Unit (LLRU): The lowest unit (component) of a system or subsystem, which is  
23 removable and replaceable from an installed position by standard attachments (e.g., by bolts and nuts or  
24 quick-disconnects).
- 25 Manufacturer: The builder or producer supplying materials, equipment, or apparatus for installation on  
26 the vehicle.
- 27 Mask, Window: Interior liner that surrounds the windows, often molded to include the sill and other  
28 portions of the sash.
- 29 Mean Distance Between Failures (MDBF): The mean operating mileage between independent failures.
- 30 Mean Time Between Failures (MTBF): The mean operating time between independent failures.
- 31 Mean-Time-To-Repair (MTTR): The average time required to repair a failed component or device.
- 32 Mode Change Dead Time (MCDT): The time for a system to fully cease one state and initiate another state.  
33 Usually measured from the time of a command signal until the second state has achieved 10% of the full  
34 state change.
- 35 Nominal, as in “nominal voltage”: Exists in name only, not implying an actual operating value.
- 36 No Motion Speed: The lowest speed detectable by the vehicle control systems.

Normal, as in “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.

Part: See Component, above.

Project: The Vehicle Project as described and defined in Section 1 of the Request for Proposals in the Contract Documents.

Proof (used as a suffix), as in “splashproof” or “dustproof”: The device and contents are impervious to, or unharmed by, application of the indicated action or material.

Provide: To design, furnish, and install, complete and ready for intended use.

Regenerative Braking: Electrical energy produced by motors acting as generators, putting electrical power onto the distribution system for use by other equipment.

Reliability: The probability of performing a Specified function, without failure and within design parameters, for the period indicated.

Rheostatic Braking: Electrical energy produced by motors dissipated as heat in resistors.

Safe: Free from unreasonable risk of harm, injury, or danger.

Safety: The condition in which persons are free from unreasonable risk of danger, harm, or loss arising from the design, manufacture, assembly, malfunction, or failure of the vehicle or any of its components or systems.

Service, as in “service use” or “service braking”: The operation of the vehicles under normal conditions.

Service proven design:

Unless otherwise specifically defined with respect to a particular system or subsystem, "service proven" means the following:

1. Systems and subsystems:

- a. Used in revenue rail operation for at least three years; and
- b. Used in revenue rail operation for at least 1 million vehicle miles with at least 75 thousand miles per vehicle (i.e., 25 thousand miles per year per vehicle); and
- c. Has a minimum fleet size of 12 vehicles.

2. Complete vehicle:

- a. Used in revenue rail operation for at least two years; and
- b. Has a minimum operating fleet size of six vehicles.

Will: Denotes a mandatory specification or requirement.

Shop: The City’s vehicle maintenance facility.

Simulated Revenue Service: Operation of a vehicle through the City alignment, stopping at each station and cycling the doors and bridgeplates at each station stop.

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.

Specified, as Specified: Additional requirements referenced within Contract Documents or Standards reference within Contract Documents.

Speed:

1. Balancing Speed: The speed attained by the vehicle when resisting forces exactly equal the maximum available tractive forces.
2. Base Speed: The speed at which the maximum constant acceleration can be maintained at the nominal line voltage.
3. Civil Speed: The operating speed limit assigned to each track segment.
4. Maximum Operating Speed: The maximum speed at which the vehicle will be operated in normal service.
5. Schedule Speed: The average speed of a vehicle, 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.
6. Vehicle Design Speed: The speed at which the vehicle can operate continuously without damage to equipment, independent of any speed limits imposed by vehicle controls.

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.

Stanchion: A vertical safety device mounted to the floor and ceiling or from top of seat back or seat back grab rail to the ceiling and designed to be grasped by the hand to enable a person to maintain balance.

Stop, Emergency: The stopping of a vehicle by an emergency brake application.

Stop, Service: The stopping of a vehicle by application of service braking.

Subassembly: A collection of components used to perform a distinct function, usually in conjunction with other subassemblies and components, as part of a larger system. Subassemblies are usually replaceable as units, such as circuit boards, bearings, and valves.

Tight (used as a suffix), as in “watertight” or “airtight”: Enclosed or protected to completely exclude the indicated material from passage.

Time, Build-Up: In response to a step-forcing function (as in control signal), 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, Down: The time during which equipment is not capable of doing useful work because of maladjustment, malfunction, or maintenance in progress.

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 can perform its intended function.

Tolerance: The total amount a specific dimension is permitted to vary, indicated either as plus or minus values or as a maximum value.

1 Traction System: The system of wheels, motors, gears, brakes, axles, direct controls, and appurtenances  
2 that propels or retards a vehicle in response to control signals.

3 Train: Any number of vehicles, from one to the maximum, coupled together and moving as one.

4 Tram: “In tram” is the condition of ideal truck geometry in which the axles are perfectly parallel, and the  
5 wheels are in perfect longitudinal alignment. The centers of the journal bearings represent the corners of  
6 a perfect rectangle. Verification that a truck is “in tram” is determined by measuring the diagonal and  
7 longitudinal distance between reference points on the axle bearing housings.

8 Truck: An assembly of structural frame, with axles and four wheels, associated motors, gear units, friction  
9 brake components, magnetic track brakes, safety bars, and suspension elements that support a portion of  
10 the vehicle weight. Also known as a Bogie.

11 Vehicle: A complete assembly as described by the Technical Specification, ready to operate.

12 Vital: A term applied to a device or circuit that has known failure modes, certain of which occur with  
13 extreme rarity.

14 Wainscot: The lower portion of a wall, especially if finished differently from the upper portion.

15 Warp, Track: The vertical distance between the plane of any three of four rail head contact points (two on  
16 each rail) forming a rectangle and the remaining point.

17 Wheelset: An assembly that includes an axle and two wheels or, for stub-axle designs, two laterally  
18 opposed wheels and their associated stub axles.

19 Yard: The City’s vehicle storage yard.

## 20 [1.11 Acronyms and Abbreviations](#)

21 The following acronyms and abbreviations may appear in this document. They are defined as indicated:

22 AAR Association of American Railroads

23 ADA Americans with Disabilities Act

24 AISC American Institute of Steel Construction

25 AISI American Iron and Steel Institute

26 ANSI American National Standards Institute

27 AOCP Accessible On-Board Circulation Path

28 APC Automatic Passenger Counter

29 APIS Automatic Passenger Information System

30 APS Auxiliary Power Supply

31 APTA American Public Transportation Association

32 AQL Acceptance Quality Limit

33 ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers

34 ASME American Society of Mechanical Engineers

35 ASTM American Society for Testing and Materials

36 ATS Automatic Trip Stop

1	AVL	Automatic Vehicle Locator
2	AWG	American Wire Gauge
3	AWS	American Welding Society
4	BAFO	Best and Final Offer
5	CCN	CANopen Consist Network
6	CCT	Correlated Color Temperature
7	CDRL	Contract Deliverables Requirements List
8	CDS	Central Diagnostic System
9	CFR	Code of Federal Regulations
10	CGHAZ	Coarse Grain Heat Affected Zone
11	CMOS	Complementary Metal Oxide Semiconductor
12	COTS	Commercial Off-The-Shelf
13	DB	Dry Bulb
14	DBTT	Ductile-to-Brittle Transition Temperature
15	DIN	Deutsche Industrie Norm (German Industrial Standard)
16	DOI	Distinctiveness of Image
17	EB	Emergency Brake
18	ECN	Ethernet Consist Network
19	ECR	Engineering Change Request
20	ECU	Electronic Control Unit
21	EMC	Electromagnetic Compatibility
22	EMI	Electromagnetic Interference
23	EN	European Norm (European Standards)
24	FAA	Federal Aviation Administration
25	FAI	First Article Inspection
26	FCC	Federal Communications Commission
27	FDR	Final Design Review
28	FEA	Finite Element Analysis
29	FRA	Federal Railroad Administration
30	FRP	Fiber-Reinforced Plastic, or Polymer
31	MSB	Maximum Service Brake
32	FTA	Federal Transit Administration
33	GPS	Global Positioning System

1	GUI	Graphical User Interface
2	HPCU	Hydraulic Pressure Control Unit
3	HSCB	High Speed Circuit Breaker
4	HSLA	High-Strength Low-Alloy (Steel)
5	HVAC	Heating, Ventilating, and Air Conditioning
6	ICEA	Insulated Cable Engineers Association
7	IEC	International Electrotechnical Commission
8	IEEE	Institute of Electrical and Electronics Engineers
9	IGBT	Insulated-gate, bipolar transistor
10	IPDR	In-Process Design Review
11	ISO	International Organization for Standardization
12	JIC	Joint Industrial Council
13	LDTs	Local Diagnostic and Test System
14	LED	Light Emitting Diode
15	Li-Ion	Lithium-Ion
16	LLRU	Lowest Level Replaceable Unit
17	LRU	Line Replaceable Unit
18	LRV	Light Rail Vehicle
19	LVPS	Low-Voltage Power Supply
20	max	maximum
21	MB	Maximum Brake
22	MC	Master Controller
23	MCDT	Mode Change Dead Time
24	MDS	Monitoring and Diagnostic System
25	MIL	U.S. Military Specification
26	min	minimum
27	MOV	Metal Oxide Varistor
28	MS	Margin of Safety
29	MDBF	Mean Distance Between Failures
30	MTBF	Mean Time Between Failure
31	MTP	Master Test Plan
32	MTTR	Mean Time to Repair
33	MVB	Multifunction Vehicle Bus

1	NBS	National Bureau of Standards
2	NCR	Non-Conformance Report
3	NDT	Nil-Ductility Temperature
4	NEC	National Electrical Code
5	NEMA	National Electrical Manufacturer's Association
6	NFL	No Field Lubrication
7	NFPA	National Fire Protection Association
8	NiCd	Nickel Cadmium
9	NiMH	Nickel Metal Hydride
10	NIST	National Institute of Standards and Technology
11	NTP	Notice to Proceed
12	OCS	Overhead Contact System
13	OESS	Onboard Energy Storage System
14	OIL	Open Items List
15	OSI	Open Systems Interconnection
16	PA	Public Address
17	PDR	Preliminary Design Review
18	PI	Passenger Intercom
19	PIV	Peak Inverse Voltage
20	PMTTR	Predicted Mean Time to Repair
21	ppm	parts per million
22	PTU	Portable Test Unit
23	PTASP	Public Transportation Agency Safety Plan
24	PWM	Pulse Width Modulation
25	QA	Quality Assurance
26	QAP	Quality Assurance Plan
27	QC	Quality Control
28	QCIP	Quality Control and Inspection Plan
29	RF	Radio frequency
30	RFI	Radio frequency interference, Request for Information
31	RFP	Request for Proposal
32	rms	root mean square
33	ROW	Right of Way



1	RSTP	Rapid Spanning Tree Protocol
2	SAE	Society of Automotive Engineers
3	SB	Service Brake
4	SCM	Specification Compliance Matrix
5	SDS	Safety Data Sheet
6	SFD	System Functional Description
7	SHA	Safety Hazards Analysis
8	SHGC	Solar Heat Gain Coefficient
9	SI	International System of Measurement
10	SIC	Standard Industrial Code, U.S. Department of Labor
11	SoC	State of Charge
12	SPB	Shortest Path Bridging
13	SSP	System Safety Program
14	SVPU	Shop Vehicle Power Unit
15	TCP/IP	Transmission Control Protocol/Internet Protocol
16	TCN	Train Communication Network
17	TIG	Tungsten Inert Gas
18	TIR	Total Indicated Runout
19	TOD	Train Operator Display
20	TOR	Top of Rail
21	TS	Technical Specification
22	TVM	Ticket Vending Machine
23	TWC	Train to Wayside Communication
24	UL	Underwriters Laboratories, Inc.
25	USASI	United States of America Standards Institute
26	USDOT	United States Department of Transportation
27	UV	Ultraviolet (light)
28	VCU	Vehicle Control Unit
29	VNC	Vehicle Network Controller
30	VPI	Vacuum Pressure Impregnation
31	VSWR	Voltage Standing Wave Ratio
32	WAAS	Wide Area Augmentation System
33	WB	Wet Bulb

1    1.12 Units of Measure

2	A	ampere
3	A/V	ampere per volt
4	Btu/h	British thermal units per hour
5	C	Celsius
6	cd	candela
7	cm	centimeter
8	dB	decibel
9	dba	decibel on the 'A' weighted scale
10	F	Fahrenheit
11	fc	footcandle
12	fps	frames per second
13	ft	foot
14	ft <sup>3</sup>	cubic foot
15	ft-lbf	foot pounds force
16	ft <sup>3</sup> /min	cubic feet per minute
17	g	acceleration due to gravity (9.81 m/s <sup>2</sup> )
18	g	gram
19	gpm	gallons per minute
20	h	hour
21	in	inch
22	in/s	inch per second
23	Hz	hertz
24	J	joule
25	K	kelvin
26	kg	kilogram
27	kgf	kilogram force
28	kg/mm	kilogram per millimeter
29	kHz	kilohertz
30	km	kilometer
31	km/h	kilometers per hour
32	kN	kilonewton
33	kWh	kilowatt-hour

1	l	liter
2	lb	pound
3	lbf	pound force
4	lb/in	pound per inch
5	l/s	liter per second
6	m	meter
7	m <sup>3</sup>	cubic meter
8	mg	milligram
9	MHz	megahertz
10	mi	mile
11	ml	milliliter
12	mm	millimeter
13	mm/s	millimeters per second
14	MPa	megapascal
15	mph	miles per hour
16	mph/s	miles per hour per second
17	ms	millisecond
18	m/s	meters per second
19	m/s <sup>2</sup>	meter per second squared
20	μsec	microsecond
21	mV	millivolt
22	μV	microvolt
23	N	newton
24	N-m	newton-meter
25	oz	ounce
26	Pa	pascal
27	ppm	parts per million
28	psi	pounds force per square inch
29	s	second
30	V	volt
31	Vac	volt alternating current
32	Vdc	volt direct current
33	Wh	watt hour

- 1 Wh/m<sup>2</sup> watt hour per square meter
- 2 [1.13 Contract Deliverables Requirements List \(CDRL\)](#)
- 3 No CDRLs are required for this Section.
- 4

## Section 2 Program Control, Deliverables and Quality Assurance

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## 2.1 Program Control

The design, production, and commissioning of the Vehicle will be controlled by the Contractor to ensure that a high-quality product suitable for a long and trouble-free life in the City environment, is produced on time, and that the performance and functional requirements of the TS are met in full.

The City will, at its option, monitor any or all Contractor and sub-supplier activities, review any or all Vehicle related designs, and inspect or test any or all equipment. The Contractor must not hinder or limit such activities.

All business is to be conducted in the English language, including all meetings, correspondence and project documentation that will be submitted to the City.

## 2.2 Program Management

### 2.2.1 Project Management Plan

The Contractor must submit, within 30 days of NTP, a Project Management Plan for City review and approval, including a Project Management Organization Chart, Project Organization Chart, Project Schedule, Project Document Control Procedures, Quality Assurance Manual, and Contract Deliverables Requirements List. Additionally, confirm the proposed Contractor Project Manager from their Proposal.

The Contractor Project Manager must be full-time on this Contract, from Notice to Proceed through Conditional Acceptance of the last Vehicle, and will have no other responsibilities within the Contractor's organization except for management of this Contract; alternative arrangements may be proposed for review and Approval by the City.

#### *Project Management Organization Chart*

The Contractor must develop and submit, for City review and Approval, a Project Management Organization Chart. The chart will start with the Contractor's chief project executive and illustrate the management structure in designing, purchasing, manufacturing, testing, commissioning, and warranty of the Vehicle. The chart will include the responsibilities of the Contractor, Subcontractors, and suppliers working on the Project. Vehicle systems integration responsibilities for all major interfaces must be included in the chart.

All changes to the Project Management Chart must be proposed to the City for review and Approval.

The following information must be provided for all personnel listed in the Project Management Chart:

1. Company Name
2. Affiliation
3. Principal Contact and position
4. Location work will be performed.

#### *Project Organization Chart*

The Contractor will develop and submit, for City review and Approval, an organization chart for the Contractor's staff. The chart will include primary personnel, subcontractor personnel, and supplier personnel, involved in this Project. The chart will depict the roles and responsibilities of all Project personnel working on the Project. The chart will be organized using a workflow diagram to illustrate the phases of the Project, design, purchasing, testing, commissioning, and warranty of the Vehicle.

The following information must be provided for all personnel listed in the Project Organization Chart:

1. Role
2. Responsibility
3. Position and/or title
4. Manager
5. Contact information
  - a. Phone numbers



- b. E-mail
- c. Physical work address
- 6. Resume demonstrating experience.

All changes to the Project Organization Chart must be proposed to the City for review and Approval.

#### *Workflow Diagram*

The Contractor will develop and submit a workflow diagram:

- 1. Clearly depict the design, manufacturing, testing, and inspection workflow, including Hold and Witness inspections.
- 2. Indicate responsibilities of the Contractor and each subcontractor or supplier for all systems and major components described in the TS.
- 3. Information furnished will be consistent with and expand upon the Contractor's Proposal that is incorporated into the Contract Documents.
- 4. This Workflow Diagram and any changes must be Approved by the City and may be modified with the City's approval during the Contract.

#### *Program Schedule*

The Contractor will develop and submit, for the City Approval, a baseline Project schedule demonstrating how the Contractor will meet the Contract Milestones. The schedule will use a work breakdown structure to indicate critical paths, project tasks, manufacturing work packets, Milestone completion, the City approvals as may be required by the TS and the Contract Data Requirements List.

The Contractor and all Project Stakeholders will develop a Critical Path Method (CPM) schedule, using the work breakdown structure presented in the Baseline Schedule, as a guide. The CPM schedule will be submitted to the City for review and approval. An up-to-date schedule will be included in the Monthly Progress Report.

The Project Schedule will have adequate details so the City can monitor the progress of the Project. Of particular importance is the early identification and constant monitoring of all Critical Path activities.

The levels of detail will be as follows:

- 1. Provide an overview listing all Milestones.
- 2. Detail all major activities required to meet the milestones.
- 3. Break down the major activities into their various component tasks.

All scheduled tasks will be clearly described, include start date, finish date, duration, and any float. All activities that constitute critical path items will be identified. The interdependencies of activities, particularly those that depend on the completion of one or more other activities, will be shown.

The Project Schedule will be used by the Contractor for all Project planning, organizing, and directing of Project activities and to serve as the basis for the Monthly Progress Report.

#### *Project Document Control Procedures*

The Contractor will develop and submit, for City Approval, a Project Document Control Procedure. The procedure will provide how project documentation and communication will be organized, stored, and disseminated within the Contractor's organization, subcontractors, and suppliers.

#### *Quality Assurance Manual*

The Contractor will develop and submit, for City Approval, a Quality Assurance Plan. The plan will describe the methods, correspondence control, and communications to monitor, oversee, and control the Project

progress schedule, technical performance, program changes, subcontracts, material procurement, manufacture, test, and warranty.

#### *Contract Deliverables Requirements List*

The Contractor will develop and submit a Contract Data Requirements List (CDRL) Report. The CDRL Report will contain a consolidated listing of all CDRL submittals required, the estimated submittal dates, and status. The Report will be updated monthly and submitted within the Monthly Progress Report, TS 2.2.2.

#### *Correspondence Control*

The Contractor will identify all correspondence and submittals according to a coding scheme provided by the City.

### **2.2.2 Monthly Progress Report**

The Contractor will submit a Project progress report to the City each month. The report will be submitted no later than 5 days after the end of the reported month. The report will include the following elements.

#### **1. Project Compliance and Schedule**

- a. Updated Project Schedule
- b. Schedule Variance: identification, explanation, and corrective action plan.
- c. Updated Change log
- d. Updated Contract Compliance Log
- e. Updated CDRL Log
- f. Updated Action Item List

#### **2. Design**

- a. Summary of work accomplished the previous month.
- b. Identification, explanation, and corrective action plan for scheduled work not started, or completed.
- c. Summary of work to be performed in the current month.
- d. Updated vehicle weight estimate
- e. Updated Open Items List
- f. Updated Engineering Change Notice list

#### **3. Manufacturing**

- a. Summary of work accomplished the previous month.
- b. Identification, explanation, and corrective action plan for scheduled work not started, or completed.
- c. Summary of work to be performed in the current month.
- d. Updated Parts Shortage and at-Risk list
- e. Updated Engineering Change Request list

#### **4. Qualification Testing**

- a. Summary of work accomplished the previous month.
- b. Identification, explanation, and corrective action plan for scheduled work not started, or completed.
- c. Summary of work to be performed in the current month.
- d. Updated Qualification Testing Matrix

#### **5. Commissioning**

- a. Summary of work accomplished the previous month.
- b. Identification, explanation, and corrective action plan for scheduled work not started, or completed.
- c. Summary of work to be performed in the current month.

d. Updated Commissioning Matrix

The reporting format, and level of detail, shall be submitted for the City Review and Approval with the Project Management Plan, TS 2.2.1.

### 2.2.3 Document Management

The Contractor will comply with the following requirements for document management:

1. Identify correspondence and Contract deliverables according to an Approved coding scheme:

- a. Correspondence and Contract deliverables will be numbered separately.
- b. Propose a scheme suitable for the anticipated quantity of correspondence and Contract deliverables.
- c. If any CDRL is submitted in more than one part, include a scheme for identifying each part of a CDRL package such that each part has a unique identifier, and all parts belong to the same CDRL package.
- d. See the CDRL Detail section, below, for details of the Correspondence and Contract Deliverable Coding Scheme CDRL.
- e. Furnish a consolidated listing of all CDRLs required by the TS. See the CDRL Detail section, below, for details of the CDRL Report.

2. Drawing and Document Status:

- a. Maintain a continuous record of Contractor and subcontractor drawing and document status and submit monthly.
- b. Retain copies of all records and make them available to the City for a minimum of 10 years after expiration of all warranty periods, unless otherwise Specified.

See the CDRL Detail section, below, for details of the Contract Deliverables Status Report.

### 2.2.4 Project Meetings

#### *General*

Meetings will be held between the Contractor and the City on a regular basis for the purpose of reviewing program progress and other program activities that cannot be readily resolved by correspondence. The Contractor will ensure that persons knowledgeable in the topics to be discussed, including subcontractors, are present or available at all meetings.

#### *Meeting Minutes*

The Contractor is responsible for taking all meeting minutes and maintaining the action items list.

Meeting minutes must be taken at all meetings, the minutes will include a summary of all topics discussed and a listing of all understandings and agreements reached, including action items. Closure of items shall be submitted to the City for review and Approval. The format for the meeting minutes and the action item list shall be submitted within the Project Management Plan, TS 2.2.1.

The meeting minutes must be submitted to the City 1 day after the meeting. Neither the meeting minutes nor their implications will be considered valid until reviewed and Approved by the City.

#### *Kick-off Meeting*

A Project Kick-off meeting will be held within 30 days of NTP at a time and location designated by the City. At this meeting, the Contractor shall present the Management Plan, as detailed in TS 2.2.1, and introduce key project personnel, including main subcontractors. This meeting will include:

1. Presentation of Baseline Schedule
2. Development of CPM schedule

3. A line-by-line review of all Contract Documents to clarify the City's intent and identify any areas which require further clarification, all Contractor contractual questions, pertaining to this Contract must be discussed in this meeting.
4. Development of Contract Compliance Matrix.

#### *Partnering Session*

All Stakeholders and key project personnel involved in this contract must be present for the first partnering session which will be held no more than 30 days after the Kick-off meeting.

The purpose of the session(s) is for participants to build rapport and communication between key project personnel. To create better alignment between all parties, identify needs, expectations and establish mutually agreed upon goals and guidelines in accordance with the contract requirements. The Contractor will present the completed CPM schedule.

Subsequent partnering re-connect meetings will occur at regular intervals over the life of the project.

#### *Project Review Meetings*

Program Review Meetings will be held each month. The purpose of the meeting is to review and discuss the Monthly Progress Report, TS 2.2.2. Additional items may be presented and discussed, open action items, design problems and issues, questions raised by Project members, or other contractual matters.

#### *2.2.5 Design Progression*

##### *Specification Review*

Within 30 calendar days of NTP, conduct a TS Review Meeting. During this meeting the Contractor's Project Manager and technical specialists, major subcontractors and suppliers, and the City will populate the Specification Compliance Matrix (SCM) Specified in the Contract Deliverables Requirements List (CDRL) section, below.

Use the SCM to document the Contractor's compliance with each Specification requirement in spreadsheet format.

Update the SCM on a regular basis and submit monthly, as Specified in the CDRL Detail section, below.

##### *Vehicle Conceptual Design Definition*

At the start of the design review phase, conduct working sessions with the City on the layout and concept of the Vehicle. Submit a System Functional Description (SFD) and Individual Systems SFDs, as Specified in Design and Performance Criteria, Section 4 .

##### *Design Review*

Design Review Meetings will be held in conjunction with the monthly Progress Review Meeting, supplemental design review meetings will also be required. As directed by the City, these meetings will be held in Contractor, the City or other facilities deemed to be most relevant for discussing the main topic of interest for each meeting. The Contractor will ensure that a person(s) knowledgeable in the topics to be discussed, including appropriate subcontractors and suppliers, are present as required at these meetings.

The Contractor will present their design work in accordance with a previously Approved agenda, addressing design approaches, concepts, design details, and system interfaces. During these design review meetings, action items will be identified, with each action item assigned to an individual for disposition by a pre-determined response date. A Design Review Action Item Log will be maintained by the Contractor.

The Contractor must submit to the City an agenda and a data package covering the information to be addressed in the meeting 30 days before the start of the design review.

The sequence of Design Review Meetings should be logical, in accordance with the CPM Schedule, Contract Documents, including Project Milestones. At least three levels of design completion shall be addressed:

1. Conceptual Design Review (CDR)

- a. After the Kick-off meeting, the Contractor must prepare and submit a Vehicle Preliminary Design Package for review by the City. Three weeks after receipt of the CDR package, a Preliminary Design Review Meeting (CDR) will be held.
- b. The design package will include, but not limited to, the following.
  - i. Vehicle concept, layout, and functional description
  - ii. Major equipment suppliers, design documentation and functional description
  - iii. Items listed on the critical path according to the CPM Schedule

2. Preliminary Design Reviews (PDR)

- a. As the design progresses, a series of reviews of the design progress and the work performed in making the transition from conceptual design to final design will be conducted. The Preliminary Design Reviews (PDR) are to serve the following purposes:
  - i. Determine the progress of the design and engineering work.
  - ii. Verify Contract compliance.
  - iii. Serve as a forum to discuss design problems and alternative solutions, and to answer questions raised by the City, or the Contractor and its Subcontractors or Suppliers

3. In-process Design Review (IPDR)

- a. If the City determines that an IPDR is necessary, demonstrate that design is progressing as expected by the City, based on the PDR.

4. Final Design Review (FDR)

- a. The Final Design Review (FDR) will take place when the design is essentially complete. The FDR is to provide the opportunity to review, revise, and agree on the details of the final design prior to release of the designs for manufacture.

## 2.3 Contract Deliverables

### 2.3.1 Contractor's Submittals

All submittals, except where other formats are required in the TS, will be in portable document format (PDF). Scanned documents for submittal must be Approved prior to submission; documents scanned into PDF files shall be processed for text recognition and made searchable prior to document assembly and submittal. Documents shall not require a password to open, documents containing sensitive information will have the information redacted, as Approved by the City; unredacted documents must be available to the City for the life of the Vehicle. The contractor shall use a document/submittal tracking system Approved by the City.

The Contractor will present information in a top-down process to enable the City to readily determine and review the design and interface relationships between systems and parts. As the design matures, subsequent submittals should expand on the previous submittals until the design, manufacture, operation and maintenance of all parts, systems and vehicle have been documented in accordance with the requirements of this Contract. Details of this process will be jointly determined by the City, the Contractor and Sub-Contractors during the partnering sessions, TS 2.2.4.

Submittals must be accompanied by appropriate drawings, calculations, material specifications, process specifications, flammability and smoke emissions data, and test data required to support review and

approval of the submittal. Detailed parts drawings should not be submitted unless requested by the City to permit review of another drawing; detailed parts drawings must be included in the Parts Catalog.

The City reserves the right to request additional drawings, documents, and data to support the review process. All documents submitted by the Contractor must be in the English language.

#### *CDRL Packages*

Each CDRL package submitted should be complete. Partial CDRL packages may be submitted, permitted only if the submitted parts do not depend on the omitted parts, and if a listing is provided for the complete CDRL. Any CDRL packages determined to be incomplete by the City, will be returned without review.

#### *Drawings, Documents and Data*

All dimensions will be expressed in the metric system; but all wording must be in the English language. The equivalent English measurements may be added, leaving the metric dimensions intact and readable.

All drawings submitted by the Contractor will be in a format to be Approved by the City, include the drawing number, title, issue date, revision number or letter, date of revision, the initials of the Contractor's responsible engineer authorizing and checking the revision, a description of the change, the reason for making the change, contract number, reference to next higher assembly, and relevant Contractor approval signatures. Contractor and subcontractor drawings will be in a suitable scale and detail density to clearly convey content. Drawing sizes shall conform to international standards.

The following standards for the preparation of drawings will apply, or Approved equal:

1. ASME Y14.38, Abbreviations and Acronyms for Use on Drawings and Related Documents
2. IEEE 315, Graphic Symbols for Electrical and Electronics Diagrams
3. IEEE 91, Graphic Symbols for Logic Functions.

Every assembly drawing must include a complete list of materials and parts lists, including the Contractor's part number, on the field of the drawing or on a separate sheet of the same drawing, describing all parts or sub-assemblies, and including subcontractor-furnished items, which form a part of the assembly, subassembly, or piece depicted. Every assembly drawing will also include the weight of the assembly.

All drawings supplied by the Contractor must be organized in a way that permits the wiring, piping, and mechanical interface relationships between components and equipment furnished by the Contractor and its subcontractors to be clearly identifiable and easily understandable.

Whenever reference is made on a drawing to a material or process utilizing the Contractor's own specification or process, the drawing will also give the commercial equivalent. If there is no commercial equivalent, the Contractor must provide copies of its specification or process.

Totally integrated vehicle schematics must be provided that relate all electrical, hydraulic, and pneumatic systems, including component identification, component values, wire identification, connector identification, and connector pin numbers. All components on PC boards will be individually shown in the schematics. Schematics will be comprehensive in nature and thoroughly detailed to permit CP/EV LRT shop personnel to troubleshoot and repair vehicle systems.

The Schematic location (page or other reference number, for example) of the actuating portion of each device (such as the coil in a relay) must be noted adjacent to the operating control portions (such as relay interlocks) of the device to assist in understanding circuit operation.

A set of device tables will be in a single section at the rear of the schematic book. This table will be arranged in logical fashion by system device type. This table will include the following data for all electrical, electronic, hydraulic, pneumatic, and refrigerant system and subsystem components:



1. Location in schematic and schematic designation
2. Type, model, and part number
3. Location on vehicle
4. Function
5. Schematic symbol
6. Ratings data

The integrated schematic drawings for this Contract must be grouped by subsystem, using identical device symbols and wire and pipe designators for each subsystem. All interfaces, from page to page, and subsystem to subsystem, must be clearly delineated. The integrated schematic and narrative must 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 will select lettering and detail size to be legible for a schematic page reduced to a size of 8 ½ in. x 11 in.; however, the schematic will be submitted in an 11 in. x 17 in. page format.

Wiring diagrams must be integrated connection diagrams and a wire list in book form based on the integrated schematic. The diagrams must show all wiring, raceways, conduits, and connections.

The wire list must 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 will be provided for each wire segment:

1. Wire identification (schematic designation)
2. Origin (FROM device and terminal)
3. Destination (TO device and terminal)
4. Wire size
5. Voltage rating
6. Length
7. Wire specification
8. Jacket color
9. If applicable, harness designation

#### *Final Drawings*

Within 90 days following Acceptance of the first streetcar, the Contractor must supply Final Drawings in electronic format for the following (CDRL):

1. All Contractor's and suppliers' drawings, details, bills of material, and catalog cuts that are required by the City for future installation, maintenance, repair, and overhaul purposes.
2. All assemblies, subassemblies, and arrangements of the vehicle as finally furnished, modified, and accepted.
3. All electrical schematics, electronic circuits, and wiring diagrams
4. All interface control drawings down to the lowest level replaceable unit (LLRU)
5. All items which are special purpose or fabricated by the Contractor.
6. 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 will not be considered acceptable.

All Contractor Final Drawings will be in the as-built configuration and will be supplied in electronic media which are fully compatible with AutoCAD, the latest version.

*Additional Submittals*

The City reserves the right to request additional drawings and other data to support the review of assembly and installation drawings, or when needed to understand the Contractor's design.

**2.3.2 The City's Review**

COP is not obligated to review more than 20 submittals, 50-pages maximum per submittal, in a 30-day period. Manuals and Catalogs will be reviewed within 90-days but will count toward the 30-day maximum for submittals.

Within 30 calendar days of receipt, all submittals requiring review and approval, will be assessed by COP during the review process and marked as belonging in one of the five following categories:

1. Approved as submitted.
2. Conditionally Approved.
  - a. The Contractor may proceed in accordance with changes indicated and will revise and resubmit the document, drawing, and data for Approval.
3. Disapproved.
  - a. The Contractor will revise and resubmit the document, drawing, and data for Approval prior to commencing the affected portion of the work.
4. Received for Information Only.
  - a. 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.
5. Closed.
  - a. An open action item has been addressed to COP's satisfaction.

**Limitations of Approval:**

1. Approval does not relieve the Contractor of the obligation to meet all the requirements of the Contract.
2. Approval of Contract deliverables that contain deviations from, or violation of the TS does not constitute authority for that deviation or violation. Deviations must be specifically submitted to the City for approval.
3. Approval is intended to mean that the City 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 were checked and verified.

No Contractual delays will be granted for revision of Contractor's submittals. Such submittals will be resubmitted for review and Approval, these submittals will count towards the 20 submittals per month limit.

The Contractor will maintain a detailed record of the status of submittals, and submit within the monthly Progress Report, TS 2.2.2.

All Contractor submissions must be Approved before manufacture of component parts or vehicles commences. However, the Contractor may proceed with manufacture at their own risk prior to approval but must modify or replace any parts as required so that an Approved version is supplied.

All Contractor submissions for approval must be classified as Approved and all Action Items classified as Closed before Vehicle Final Acceptance will be granted.



*Contract Deliverable Approval and Procurement of Materials*

Allow adequate time for review and discussion of designs in the procurement schedule.

Procurement of materials before City approval of Contract deliverables is at the Contractor's risk and the material must be identified as not Approved for use.

Contract deliverable schedules should be timely and consistent with the Contractor's procurement schedules.

## **2.4 Modification and Configuration Control**

### **2.4.1 General**

The Contractor will use a configuration control system that encompasses the entire vehicle, all material, parts, systems, and components. Changes to released and Approved documents, drawings, and data must be controlled by the processing of engineering change requests (ECRs). The Contractor's change control system must include provisions for The City's review and approval of all changes.

To avoid slippage during the design process, the Contractor and the City will mutually agree upon a date for design freeze. The date will be chosen to reflect a point when the design is substantially complete. The Contractor and subcontractors are not required to submit every in-process change to the City for review and approval prior to the design freeze date. This requirement does not relieve the Contractor and subcontractors from meeting any other submittal requirement in the contract.

Changes requiring approval will be defined as hardware, material, or software changes which affect previously Approved documents and drawings, or interchangeability with previously produced components.

Changes that would modify TS requirements or any other aspects of this Contract shall additionally be processed as change orders.

### **2.4.2 Change Control**

Any changes to Approved CDRLs, documents, drawings and data must be initiated and controlled using Engineering Change Requests or Contractor's equivalent. The request form must be submitted to the City for approval.

The request form should include as a minimum, the following:

1. Request number
2. Request initiator (The City, Contractor, Subcontractor, Supplier by name)
3. Change Request Number (when applicable)
4. Request date
5. Request Class (Class 1 or 2)
6. Request Priority (Emergency, Urgent, Routine)
7. Description of problem including any documentation, sketches, or photos, etc. (or Value Engineering Proposal)
8. Description of item(s) requiring change including relevant drawing numbers, part numbers, etc.
9. Detailed description of changes to be made, including any retrofit work.
10. Applicability (to be implemented on vehicle numbers, spare part numbers, by date, etc.)
11. Contract cost impact (if applicable)
12. Contract schedule impact (if applicable)
13. Initiator Approval and Date
14. City Approval, Comments and Date
15. Completion Verification, Comments and Date

Engineering Change Requests will be classed as either Class 1 or Class 2.

1. Class 1 requests will be defined as any change that affects vehicle performance, requirements of the technical provisions, previously Approved submittals, interchangeability with previously produced components or at the request of the City via a Change request.
2. Class 2 requests are for any other minor changes. Minor Changes to previously Approved submittals such as corrections or dimensional additions to details drawings from FAI inspections, etc. shall be considered Class 2 requests.

Prior to implementation,

1. Class 1 requests must be submitted to the City for review and approval: complete, with relevant documentation.
2. Class 2 requests must be submitted to the City for information only. The City reserves the Right to review and disposition any Class 2 ECNs.

The time taken for the City's review of change requests and any possible associated schedule relief will be established on a case-by-case basis, the City will make every effort to respond to Routine requests within 15 days. For Emergency change requests, the City may, at its sole discretion, grant verbal approval to expedite the corrective work being conducted, prior to completion of the formal approval process.

Any requests initiated to change the requirements of any Contract Documents will be processed as a Change in accordance with the Contract Section 3.3 Changes to Contract. Within 15 days of receipt of any Change Request, the Contractor must respond with an Engineering Change Request covering all items listed in the Change Request and including a detailed breakdown of all additional costs and schedule impacts.

The Contractor will maintain an Engineering Change Status Report which will list all changes, status, implementation, and completion dates. This report will be included in the Monthly Progress Report, TS 2.2.2.

#### *Vehicle Configuration Control*

The Contractor must maintain a Vehicle configuration control system, from RFP through Project completion.

All vehicle systems and major components shall be permanently identified with the supplier's name, part number, serial number, and revision level, method and content will be Approved by the City. Provisions will be made for updating the revision level when upgrades are implemented. These items shall also be provided with a permanent bar code identifying the item's City's part number.

The serial numbers of all major components installed on each vehicle shall be recorded in the Vehicle History Book when the vehicle is delivered.

For spare parts, any item(s) not covered by the above requirements shall be provided with a durable bar code displaying the City's part number, affixed to the part itself, or any protective packaging. A list of serial numbers shall be provided when the spare components are delivered to the City.

#### *Component Identification and Serial Numbers (Bar Coding)*

Permanently identify all equipment with a supplier's name, part number, and revision level:

Use an Approved system compatible to identify all LRUs, LLRUs and other replaceable components on the vehicles, all PTUs and BTEs, gauges, special tools, and spare parts.

The data for each part will be as Approved and will include at least the following:

1. Manufacturer
2. Model number
3. Part number
4. Serial number
5. Date of manufacture
6. City Catalog Number

Furnish a serialization plan, by system, indicating those items to be serialized, the location of the serial number tag (or engraving), and the method of revision control.

If a separate tag is required for configuration control, the plan will address this.

Serial numbers and configuration numbers (if used) will be provided to the City in an Approved electronic format.

#### *Vehicle History Books*

Each vehicle manufactured will have a Vehicle History Book (VHB), which reflects the current configuration and test status of the vehicle. The format and contents of the VHB will be reviewed and Approved by the City. The VHB will accompany the vehicle through production and be presented to the resident City representative for review of accuracy, completeness, and clarity prior to each vehicle delivery.

The VHB will accompany the vehicle to the City's OMF. It is the Contractor's responsibility to maintain and to update each book as tests or modifications are completed until contract closeout.

As a minimum, each book will contain the following information:

1. Description, completion dates, and approval status of vehicle modifications, and list of modifications pending with expected completion dates.
2. Hold-point inspection reports, as Specified for the Quality Control and Inspection plan (QCIP), after all discrepancies have been eliminated.
3. List of vehicle defects that were identified by Contractor QA or the City's personnel during construction and the disposition of each as verified by inspection.
4. List of serial-numbered apparatus
5. Results of the pre-shipment inspection, as Specified in the QCIP.
6. Shipping documents
7. Results of the post-shipment inspection, as Specified in the QCIP.
8. Results and approval status of each test performed on the vehicle or any part of the vehicle.
9. A truck section that includes wheels, journal bearings, and gear mounting records, including pressing charts and truck weigh tickets
10. A record of any abnormalities that occur during the manufacture of the vehicle or any of its subsystems, including their authorized, validated, repair procedures.
11. Open item status list
12. Vehicle weight and computer-generated weigh tickets

Submit the format and the vehicle history book. See the CDRL Detail section, below, for detailed requirements.

## 2.5 Manufacturing Control

### 2.5.1 Communication Between Engineering and Manufacturing

The Contractor will establish a process to ensure regular communication between the Contractor's manufacturing group and its engineering group, assigning specific employees in each group to communicate the following:

1. Engineering changes that affect manufacturing.
2. Manufacturing issues that require engineering input.
3. Engineering solutions to manufacturing issues.

### 2.5.2 Manufacturing

The Contractor will comply with the following requirements and prohibitions:

1. Documentation:
  - a. All manufacturing activities must include written procedures, drawings, parts lists, dimensions and tolerances, and explicit criteria defining acceptable results.
  - b. Establish a process to verify that procedures, drawings, and other written material used by workers are always the current revision.
2. Fabrication:
  - a. Establish methods that comply with design documents and use appropriate jigs, fixtures, tooling, and the like to ensure consistent installations.
  - b. Prove the accuracy of production jigs, fixtures, tooling masters, templates, patterns, and similar devices at formally established intervals and adjust, replace, or repair as required to maintain quality and comply with the requirements for standards of workmanship in Section 16, Materials and Workmanship.
  - c. Sufficiently develop design, manufacturing, and QC processes such that all vehicle components are identical, interchangeable, fit without interference, and can be assembled without alterations.
3. Prohibited manufacturing activities include:
  - a. Modification of parts
  - b. Cut-to-fit assembly.
  - c. Match drilling
  - d. All other hand-fitting activities

### 2.5.3 Worker Training

Workers must be trained in the work to which they are assigned, including the following:

1. Specific training related to the standards of workmanship as Specified in the TS.
2. Specific training relating to the following manufacturing procedures, drawings, and processes.
3. Instruction on correct use of tooling, jigs, and fixtures for control of the work.
4. Clear instructions to not proceed if parts do not fit, manufacturing procedures are inadequate, tooling, jigs, and fixtures are poorly maintained or inefficient, or other defects are noted, and to promptly notify QC or manufacturing supervisors.

Certify workers have successfully completed training and demonstrated acceptable work. Uncertified workers will not perform work on the City's project.

### 2.5.4 Supervision

The Contractor must provide sufficient supervision to ensure that manufacturing complies with manufacturing procedures and good practice. Supervision must detect and retrain, or remove, workers

not performing in accordance with the Specified standards of workmanship and manufacturing processes.  
Coordinate manufacturing supervision and QC such that there is consistency in expectations and results.

#### 2.5.5 Control Samples

Prepare and submit control samples:

1. Retain copies of signed validation forms with each sample.
2. Furnish Approved samples to the subcontractor or supplier, with additional Approved samples retained by the Contractor and the City.

### 2.6 Quality Assurance (QA) and Quality Control (QC)

#### 2.6.1 Standards

The Contractor will plan, establish, and maintain a Quality Assurance (QA) and Quality Control (QC) program that complies with the following standards:

1. ANSI/ISO/ASQ 9001, Quality Management Systems – Requirements (or Approved equal)
2. FTA-PA-27-5194-12.1, Quality Management System Guidelines

The Contractor and subcontractors must be in compliance with these standards, but Certification to these standards is not mandatory.

#### 2.6.2 Subcontractor/Supplier QA/QC

The Contractor's QA/QC program will be imposed upon all entities within the Contractor's organization and on all subcontractors whenever Contract work is performed.

1. The Contractor may accept established QA/QC plans from its subcontractors and incorporate these plans as part of its overall QA/QC program.
2. The Contractor will require that each supplier maintains a QA and QC program for the services and supplies that it delivers to the Contractor.
3. The Contractor's QA organization will perform QA activities related to subcontractors, including FAI's, PSI's, and audits, as detailed in the Quality Assurance Plan (QAP).
4. Inspect and test materials delivered by subcontractors for conformance to Specification requirements:
  - a. Identify and document materials that have been inspected, tested, and Approved as acceptable to the point of use in the manufacturing or assembly processes.
  - b. Establish controls to prevent inadvertent use of nonconforming materials.

#### 2.6.3 QA Organization

##### Scope

The Contractor's "QA organization" includes the entire QA/QC management structure within the Contractor's organization, and quality personnel assigned to this Contract.

At the Contractor level, the QA organization must include the following:

1. A dedicated QA Manager
2. A single point of contact for Quality accountability for the entire Contract
3. Each person proposed to conduct QA activities, such as FAI's, PSI's, or audits.
4. Each person proposed to perform QC activities, such as inspections or tests.
5. A Material Review Board or Approved equal.
6. The City has the right to approve or disapprove of each person proposed in the QAP as part of the Contractor's QA organization at the Contract level.

*Responsibilities*

Responsibilities of the QA organization include:

1. Establishing processes and activities focused on the prevention of defects in the vehicles through all Contractor and subcontractor/supplier phases from design through manufacture and preparation for delivery.
2. Developing, implementing, and auditing a QC system, including development of a QCIP.

*Authority*

The Contractor will comply with the following requirements for authority within the QA organization:

1. Authority for the QA function within the QA organization will be established such that the quality of products under the terms of this Contract will not be compromised to meet schedule and cost projections.
2. Management responsible for QA will have sufficient authority and organizational freedom to ensure that a nonconforming or discrepant product will not be delivered to the City at any location providing product or services for use on this Contract.

*QA Manager*

The Contractor's QA Manager will have appropriate training, experience, and qualifications.

1. The QA Manager must have a minimum of three years of recent, continuous experience in Quality Management of a similar type of vehicle manufacture.
2. Once Approved, the QA Manager will not be removed without the approval of the City unless the QA Manager voluntarily leaves the employ of Contractor.
3. The QA Manager will verify that the QAP and QCIP are fully implemented.
4. The QA Manager must report to an officer within the Contractor's organization or a top-level manager within the QA organization.
5. The QA Manager will not report to the Contractor's Project Manager or Production Manager.

*QC Personnel*

The Contractor will comply with the following requirements for QC personnel:

1. Furnish QC personnel qualified to perform inspections or tests as follows:
  - a. With prior experience and training
  - b. Certified where required and verified by testing where applicable.
  - c. Maintain records of quality personnel certification and qualifications and make available for the City's review.
  - d. Contractor's production personnel may not be used to perform QA or QC activities unless specifically Approved by the City.

**2.6.4 QA/QC Records**

The QA organization will maintain its own quality records and data from its QA and QC activities for the effective operation of the QA/QC program. These records and data will be available for review by the City for a minimum of three years after acceptance of the last vehicle.

**2.6.5 Quality Assurance Plan (QAP)**

*Scope*

The Contractor will submit a Quality Assurance Plan (QAP) for review and Approval within 60 days of NTP. The QAP will be specific to this Contract, describing in detail the Contractor's methods for planning, implementing, and maintaining quality, during design and construction of the Vehicles. The QAP will contain a company policy statement which clearly defines the authority and responsibilities of the

Contractor's Quality Assurance personnel. The Contractor must appoint a dedicated QA Manager with appropriate training and experience.

At a minimum, the following QA and QC principles must be included in the QAP and applied throughout the course of the Project.

1. The quality assurance organization will 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.
2. The quality assurance organization will 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.
3. The QA Manager will report to an officer or top-level manager within the Contractor's organization. The QA Manager shall not report to the Project Manager or the Production Manager.

#### *QA Activities*

The Contractor's Quality Assurance Plan will provide requirements affecting both manufacturing and acceptance site operations, assigning the authority and means to implement procedures that control the activities listed below. The Contractor must submit written procedures for Approval, assuring 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:

1. Design and Drawing control, including technical documentation, engineering changes, deviations, waivers, and FMIs.
2. Transmission of all quality assurance requirements to procurement sources
3. Surveillance of subcontractors and suppliers
4. Receiving, source, in-process, and final inspections
5. Special Processes (for example paint operations)
6. Evaluation of procured articles against purchase order requirements
7. Production and process control
8. Equipment calibration and certification
9. Skilled personnel qualifications and certifications
10. Materials control
11. Discrepancy control
12. Functional testing
13. Quality assurance records
14. Shipping, handling, and storing.
15. Internal and external audits

The Contractor must verify that all applicable TS requirements are properly included or referenced in purchase orders of articles to be used on the Vehicles.

The Contractor will ensure that all basic production operations, as well as all other processing and fabricating, are performed under controlled conditions. Establishment of these controlled conditions will be based on documented work instructions, adequate production Equipment, and special working environments.

The quality assurance organization will monitor the Contractor's System for controlling nonconforming Materials. The System will include procedures for identification, segregation, and disposition.



Subject to Approval, statistical analysis, tests, and other quality control procedures may be used when appropriate in the quality assurance processes.

#### *Supplier Quality Assurance*

The Contractor will require each supplier, subcontractor, and manufacturer to maintain a quality assurance and quality control program for the services and supplies that it provides. The Contractor's quality assurance organization will inspect, and test materials provided by suppliers for conformance with the TS 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.

#### *Personnel*

An organization chart will be included within the QAP to show the reporting relationships of all QA staff engaged in the Project, as well as the relationship of the QA Manager and QA Department with top management. Resumes of all the Contractor's QA personnel engaged in this Project will be included in the QAP, COP has the right to Approve or disapprove all such personnel.

Contractor production personnel performing Work, including inspections, or tests, must be qualified for such activity by virtue of prior experience and training, certified where required, and verified by testing, where applicable. The QAP will list all certification requirements and describe the process for verification. Records of personnel certification and qualifications will be maintained and available for COP review upon demand.

#### *Records*

The Contractor will maintain Drawings and other documentation that completely describe a qualified Vehicle meeting all the requirements of the Approved Design. The QAP will describe how the quality assurance organization shall maintain and use records and data essential to the effective operation of its program. These records and data will be available for Approval for a minimum of three years after final Acceptance of the last Vehicle.

### **2.6.6 Measuring Equipment and Tools**

#### *Measuring and Testing Devices*

The Contractor will ensure the validity of measurements and tests using suitable inspection, measurement, and test equipment of the range and type necessary to determine conformance with Contract requirements:

1. Furnish and maintain the necessary gauges and other measuring and testing devices to verify that components, systems, and vehicles conform to the Approved design.
2. Make available the Contractor's gauges and other measuring and testing devices for use by the City to verify that the vehicles conform to all Specification requirements.
3. If necessary, make available Contractor personnel to operate the devices and to verify their condition and accuracy.
4. The City has the right to approve or disapprove inspection, measurement, and test equipment that is not of the proper range or type required.

#### *Control and Calibration*

The Contractor will ensure that inspection, measuring, and test equipment is identified, controlled, maintained, and calibrated by an accredited Laboratory Approved by the City:

1. Establish an effective time-cycled or usage-cycled calibration and certification program.
2. Include tooling, jigs, and fixtures used as media for inspection or manufacture in this program.



3. Provide an indication on every verified or calibrated device showing its status and the date (or other basis) on which inspection or recalibration is next required.
4. Promptly recalibrate devices yielding inconsistent measurements or clearly flawed data before the stated recalibration date.
5. Promptly re-inspect work performed using incorrect, unapproved, or out of calibration equipment. The work is considered invalid, whether delivered to production or to the field.

#### *Calibration Records*

The Contractor will record calibration certifications and include them as part of the QA records.

### **2.7 Quality Control and Inspection**

#### **2.7.1 First Article Inspections**

The Contractor will perform a First Article Inspection (FAI) jointly with the City on all major components, subassemblies, and the fully assembled vehicle.

1. City participation in an FAI will be at the discretion of the City.
2. FAIs may be waived only at the discretion of the City.
3. FAI's will be conducted at the point of manufacture on the first piece, component, assembly, or system constructed using production materials, tooling, conditionally Approved or Approved design.
4. An FAI will not be conducted until the design drawings, test procedures, inspections, and control samples of the article have been Conditionally Approved or Approved as Submitted. If Conditionally Approved drawings are used, the City's conditions for approval must be satisfied at the FAI and represented by the inspection article.
5. Transmit an individual notice to the City for each FAI a minimum of 30 calendar days before the FAI.
6. Schedule no more than one FAI per day and two FAIs per week without prior written approval by the City.
7. When appropriate, display the inspection article on a stand or table in a well-lit workspace with skilled labor and all necessary inspection tools and gauges available for any checking or disassembly work required by the City.

Contract deliverables: See the CDRL Detail section, below, for detailed submittal requirements.

1. FAI List: Submit a list of Contractor and subcontractor-supplied equipment that is expected to receive an FAI.
2. FAI Package: Submit for each FAI that identifies product readiness for the FAI.
3. FAI Report: Submit for each FAI performed.

After the City's approval of the initial FAI:

1. Equipment will be shipped from the point of manufacture only after an FAI has been Approved or waived by the City.
2. Corrections required because of the FAI will be incorporated into all equipment prior to shipment.
3. The Approved FAI item will be retained by the Contractor, subcontractor, or supplier for use as a reference production standard, except as Approved by the City.
4. Retained FAI items will be maintained and upgraded to the latest Approved design configuration. Shipment of the retained FAI unit with all its maintenance and upgrade records will require authorization by the Contractor and the City.
5. Changes to product, design, production process, materials, or location of manufacture will be the basis for another FAI. The scope of the subsequent FAI will be at the sole discretion of the City.

2.7.2 Quality Control and Inspection Plan (QCIP)

*General*

The Contractor's quality assurance organization will 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) will prescribe inspection of Materials, Work in progress, identify major manufacturing and inspection points in a flow chart, and completed articles. The QCIP will contain a list, and a collection of all forms proposed to be used for the Contractor's quality control and inspection activities.

1. Use enough trained inspectors to perform inspections in accordance with the QCIP.
2. Except as otherwise Specified or specifically Approved by the City, independent testing laboratories will be in the United States and will require City approval.

*Inspection Status*

The Contractor will maintain a System to identify acceptance, rejection, or non-inspection status of Materials and components. The method of identifying inspection status will be submitted for Approval.

*Control of Non-Conformance*

The Contractor will provide written procedures for control of non-conforming material and components in all its facilities. The procedures will address the identification, segregation, and disposition, of all non-conformances. The Material Review Board (MRB) will evaluate and determine the disposition of all non-conforming material, components and parts.

Non-conforming items will be inspected and dispositioned by the MRB; repair, rework, use-as-is, or scrap. The City will evaluate all non-conformances and determine the final disposition. Items will be plainly marked and controlled to prevent installation on the Vehicle. Inspection dispositions noted as repair and use-as-is will require City Approval prior to use. Items that become obsolete because of engineering changes or other actions will be controlled to prevent unauthorized assembly or installation. Discrepant items will be identified, documented, and placed in a bonded hold area pending disposition. Items found to be unusable will be scrapped.

Corrective action will extend to all suppliers, including subcontractors and manufacturers, Methods to correct discrepant Materials or activities in the Contractor, subcontractors', and suppliers' operations will be documented and effective. Discrepancies noted by the Contractor or the City during assembly will 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 will 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 will verify all corrective actions and mark the discrepancy record. If discrepancies cannot be corrected by replacing the nonconforming Materials, the City will Approve (or disapprove) the modification, repair, or method of correction to the extent that the TSs are affected.

*Levels of Inspection*

The Contractor will perform 100 percent or sampling inspection for discrete items of work if not otherwise required in the TS.

1. Develop sampling procedures in accordance with MIL-STD-1916, ANSI/ASQ Z1.9, ANSI/ASQ Z1.4, or other Approved approach and submit.
2. Sampling inspection AQL requirements should not exceed an AQL of 1.5 without the City's approval.
3. Submit sampling procedures as part of the QCIP. See the CDRL Detail section, below, for detailed CDRL requirements.

*Receiving Inspection/Pre-Shipment Inspection*

The Contractor will perform inspections at source and/or upon receipt to verify conformance to acceptance criteria of specifications and drawings:

1. Perform inspections to purchase order requirements, Specifications, and drawing requirements.
2. Retain material certifications and test reports.
3. Specify 100 percent or sampling inspection for all major subsystem equipment to be purchased.
4. Submit procedures as part of the QCIP. See the CDRL Detail section, below, for detailed CDRL requirements.

*Inspection of Work In-Process*

The Contractor's QA organization will maintain and direct a force of inspectors to verify that work in its facilities is performed in compliance with the Approved design drawings, the Specifications, and the Approved QCIP:

1. Regularly check dimensions, tolerances, and quality of work against the drawings on each sub-assembly and vehicle.
2. Record discrepancies in the work in accordance with the Approved QCIP and notify departments responsible for the work of the need for corrections.
3. Document and submit corrective actions.
4. After re-inspection in accordance with the QCIP, notify responsible manufacturing supervision of rework that is rejected, if any.
5. Re-inspection acceptance status will be indicated by the inspectors by their date and stamp or initials on the original of the discrepancy report, prior to offering the inspection to the City for consideration.

*Hold- and Witness-Point Inspections*

The Contractor will comply with the following requirements:

1. Hold-Point Inspections: Mandatory inspection points that must be presented for City inspection:
  - a. Inform the City of a hold-point inspection with sufficient advance notice to allow City participation.
  - b. Hold points will be used to inspect completed operations or installations and to inspect items that are about to be concealed by subsequent operations.
  - c. Post the inspection forms at or near the point of inspection for each vehicle and include them in the Vehicle History Book when all discrepancies have been eliminated.
  - d. Nonconforming products will not be released from a hold-point area until all discrepancies have been corrected.
  - e. Vehicle movement beyond any hold point without the City's approval is prohibited.
  - f. Witness-Point Inspections: Mandatory inspection points that must be presented for City inspection:
    - g. Inform the City of a witness-point inspection with sufficient advance notice to allow the City's participation.
    - h. The City's participation in a witness-point inspection will be at the City's discretion.
2. Minimum hold-point inspections:
  - a. Inbound material requiring Mill Reports
  - b. Each underframe
  - c. Each vehicle roof section
  - d. Each articulation unit after installation
  - e. Each vehicle shell body section before painting

- f. Each vehicle shell body section after painting
- g. Each truck frame.
- h. Each assembled truck, prior to installation under a vehicle
- i. Each vehicle roof after equipment installation
- j. Vehicle piping
- k. Each vehicle floor panels and covering prior to seat installation.
- l. Each vehicle watertightness test prior to installation of insulation and interior finishings
- m. Each vehicle final watertightness test
- n. The interior wiring of each vehicle, including wiring in electrical cabinets, empty wireway, conduit before being covered by panels.
- o. Each vehicle's interior, including floor heaters, windscreens, seats, interior walls, ceiling, and similar.
- p. Each vehicle exterior
- q. Static and dynamic testing
- r. Vehicle complete in all respects.
- s. Final walk-through prior to shipment
- t. Upon arrival on City's property
- u. After rework or repairs have been performed on equipment that has completed formal inspection
- v. After implementation of design changes and retrofit modifications

If work is concealed without conducting a hold- or witness-point inspection listed in the Approved QCIP, the Contractor will, at no cost to the City, expose the work and demonstrate conformance of the work with Contract requirements.

#### *Final Inspection*

The Contractor will perform a final inspection and schedule and facilitate final inspection by the City:

#### Contractor Final Inspection:

- 1. Perform for each vehicle before the City's final inspection:
  - a. Correct each workmanship item covered by prior inspection reports before the inspection begins.
  - b. Perform after all work is completed according to written procedures.
  - c. Include the following:
    - i. Inspection and test
    - ii. Watertightness
    - iii. Vehicle leveling
    - iv. Weighing

#### City's Final Inspection:

- 1. Before scheduling, present all open documentation and action items, including the following:
  - a. Open discrepancies including missing parts.
  - b. MOC open items
  - c. Engineering Change/ modification open items, etc.
- 2. Allow one day for the inspection.
- 3. During the inspection, all systems must be operational with the use of Approved special equipment or power supplies.

4. Make available qualified personnel to accompany the City with the authority to act upon issues encountered during the inspection.
5. Make available labor and appropriate tools to remove or open and reinstall covers and doors.
6. City approval is a prerequisite to shipping the vehicle from the Contractor's plant to the City's facilities.

#### *Pre-Shipment Inspection*

After final inspection by the City and resolution of any outstanding items, prepare each vehicle to preclude damage during shipment.

1. Conduct and document a pre-shipment inspection in accordance with the Approved QCIP.
2. The inspection will be performed for each vehicle scheduled for shipment.
3. The inspection will confirm that all shipping precautions and checks have been accomplished.
4. The pre-shipment inspection will also include a walk-through visual inspection to ensure completeness, cleanliness, and workmanship.
5. After completion of the pre-shipment inspection, the unit will be locked, and no additional activity allowed on the vehicle prior to departure.

#### *Post-Shipment Inspection*

Conduct and document a post-shipment inspection in accordance with the Approved QCIP:

1. The inspection will be for each vehicle upon its arrival on the tracks at the City's facilities.
2. Document the results of this inspection and include them in the Vehicle History Book.

#### *Quality Audits*

Submit a comprehensive system of planned and periodic audits:

1. The audits will be performed by qualified personnel not having direct responsibilities in the areas audited.
2. Audit reports and follow-up action reports will be available to the City for review and approval no later than 10 working days after each audit.
3. Audits of subcontractors and suppliers will be made by the Contractor and may be witnessed by the City.
4. At a minimum, QA audits of subcontractors and suppliers will be made at the following times:
  - a. As a condition of the subcontract or purchase order, prior to start of work.
  - b. Within 30 calendar days of scheduling First Article Inspections or services being supplied by the subcontractor or supplier.
  - c. When the subcontractor or supplier manufacturing facility or manufacturing process has changed.
  - d. When re-audit is warranted due to unacceptable performance, such as nonconformances, schedule impact, or cost overruns.
5. The City reserves the right to conduct independent audits of the Contractor's Quality system, and that of its subcontractors and suppliers, for its effectiveness at any time.
6. At a minimum, QA audits of the Contractor may be made at the following times:
  - a. Prior to the start of production of the first vehicle shell.
  - b. Within 30 days prior to formal presentation of the first vehicle.
  - c. When the product manufacturing facility has changed.
  - d. When re-audit is warranted due to unacceptable performance, such as nonconformances, schedule impact, or cost overruns.

2.7.3 Open Items List

Throughout the production of the vehicles, develop, maintain, and submit an open items list (OIL) of discrepancies, and their status, associated with each vehicle.

1. The City will review the details of the OIL and furnish comments or concerns.
2. Correct or remedy all items on the OIL to the satisfaction of the City.

2.7.4 The City's Audit, Inspection, and Visual Documentation

*City's Inspection Activities*

The City may, at its discretion, perform its own QA/QC monitoring of work done under this Contract, including monitoring of the Contractor's or subcontractors' QA and QC activities.

1. Such activities do not reduce or alter the Contractor's QA and QC responsibilities, nor reduce or alter the Contractor's obligation to meet the requirements of the TS.
2. Following NTP, the City has the right of free access to facilities of the Contractor and subcontractors to inspect, examine, and test items during manufacture and shipment, and within a reasonable time after shipment.

*City's Visual Documentation*

The City has the right to document vehicle and vehicle component manufacturing activities, including tooling, fixtures, and similar by the following means:

1. Still photography
2. Motion media, with sound

*Contractor Provision of Facilities for the City's Use*

The Contractor will make available to the City's personnel in the Contractor's manufacturing facility:

1. A heated, cooled, and adequately lit private office with desk, chairs, and a worktable large enough to view full-sized drawings.
2. Ready access to modern toilet facilities.
3. A private telephone line, a fax line, and separate high-speed internet access.
4. Copies of all drawings, diagrams, schedules, changes, deviations, and QA records, upon request.
5. A combination copier/scanner/fax machine dedicated to City's use in the private office space.

2.8 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with this Section:

2-1 Management Plan:

1. Submit within 30 days of NTP.
2. Organization Chart for the Contractor's staff:
  - a. Personnel and responsibilities as listed in the Program Management Organization Chart section, above.
  - b. Show lines of both authority and communication.
3. Workflow Diagram:
  - a. Elements listed in the Workflow Diagram section, above.
  - b. Include company name, affiliation, principal contact and position, and the location at which the work will be performed.
4. CPM (Critical Path Method) Program Schedule:
  - a. Include, as a minimum, the following elements for each activity listed in the Program Schedule section, above:
    - i. Activity ID

- ii. Activity duration
- iii. Early start and early finish dates
- iv. Late start and late finish dates
- v. Activity float
5. Include a schedule narrative, describing the overall approach to meeting required milestones and including the elements listed in the Program Schedule section.

2-2 Monthly CPM Schedule Update:

1. Update and resubmit the CPM Program Schedule submitted with the Management Plan
2. Submit at least every month.
3. Submit at the same time as the Monthly Progress Report.
4. The schedule will comply with the requirements for the CPM schedule in the Management Plan.
5. Show actual achieved progress for each activity.

2-3 CPM Schedule – First Vehicle:

1. Separate, stand-alone schedule for the first vehicle
2. Comply with the requirements for the CPM schedule in the Management Plan.
3. Furnish more detail and show only those activities critical to the delivery of the first vehicle.

2-4 Monthly Progress Report:

1. Submit each month, starting with the first full month after issuance of NTP.
2. Submit the report for each month no later than the 5th day of the following month (e.g., 5th of July for the June report).
3. For work accomplished during the month:
  - a. Actual completion dates and start dates.
  - b. Updated reports, schedules, and other documents:
  - c. CDRL Report
  - d. Change Status Report
  - e. On-going or open engineering items
  - f. Status of correspondence
  - g. Dates and locations of program review meetings
  - h. Change Order log
  - i. Vehicle weight estimate
4. For the following month:
  - a. Estimated remaining durations for activities in progress.
  - b. Major work activities planned for the following month.
  - c. Estimated start dates
5. Quality breakdown and status, by system as necessary:
  - a. Contractor quality issues, status
  - b. Vendor quality issues, status
  - c. Activity related to the closure of discrepancies.
  - d. Projected closure dates for these items

2-5 Correspondence and Contract Deliverable Coding Scheme:

1. Submit within 30 days after NTP.
2. Furnish a coding scheme to identify correspondence and Contract deliverables.

2-6 CDRL Report:

1. Submit within 30 days after NTP.
2. Update and submit monthly.



3. Include the estimated submittal dates, and their status.

2-7 Contract Deliverables Status Report:

1. Submit monthly.
2. Include the following information:
  - a. Drawing and document numbers
  - b. Revision letter
  - c. Drawing title
  - d. Date submitted.
  - e. Transmittal document
  - f. Disposition
  - g. Document number identifying the disposition.

2-8 Meeting Minutes Format:

1. Submit the proposed format for minutes of meetings before the first meeting minutes are submitted.
2. Comply with requirements in the Meetings section, above.

2-9 Meeting Minutes:

1. Submit for each meeting between the Contractor and the City.
2. Submit within ten days after the meeting.
3. Comply with the Approved meeting minutes format.
4. Include reasonable projected closure dates for each action item.

2-10 Specifications Compliance Matrix (SCM):

1. At least 15 calendar days prior to the Specification Review Meeting, submit an SCM shell in the format that will be used for the completed SCM and monthly updates.
2. Submit the SCM populated during the Specification Review Meeting.
3. Submit monthly SCM updates.
4. Include the following in the SCM and monthly submittals:
  - a. A comprehensive list of Specification requirements extracted from the Specifications.
  - b. Documentation the Contractor intends to submit to demonstrate compliance with each Specification requirement, such as reports, analyses, system descriptions, manuals, drawings, inspection and test procedures, and test reports.
  - c. Approved documents that certify compliance with each requirement.
  - d. An indication for each requirement when it is compliant.

2-11 Construction Photographs:

1. Submit before delivery of the last vehicle.
2. Two sets of color, unmounted progress, and finished vehicle photographs, approximately 8-in by 10-in size.
3. Minimum 100 views of the vehicle during stages representative of its complete construction.
4. Record the date each picture was taken, the number of the vehicle pictured, and the location of the vehicle on the back of each print.
5. Insert photographs into a suitable album-type binder with transparent pockets.
6. The album will contain an index that identifies the photographs enclosed.
7. Provide photographs in standard, high-resolution electronic format on a shared network link, available for download by the City.



2-12 List of Final Drawings:

1. Submit within 90 days following shipment of the first vehicle.
2. Identify each drawing that will be submitted as part of the final drawings.
3. The list will identify each item required to be submitted by the Contractor in the Final Drawings CDRL.

2-13 Final Drawings:

1. Submit within 90 days following acceptance of the first vehicle.
2. Drawings will include those listed above in the Final Drawings section.
3. Drawings will be supplied on electronic media in the form Specified above for Contract Deliverables.
4. Update final drawings to as-built configuration and submit within 90 days after Acceptance of the last vehicle.

2-14 Modification and Configuration Control Manual:

1. Submit within 60 days after NTP.
2. Contractor-developed modification and configuration control plans and procedures.
3. Flow chart showing the process of configuration control.
4. Narrative describing the configuration control process.
5. Details and samples showing how drawing revisions are indicated.

2-15 ECR Form and Procedure:

1. Submit within 60 days after award of Contract.
2. Proposed standard form and procedure for controlling changes to Approved documents, drawings, and data.
3. The procedure will include each step required to maintain control of design changes.
4. The form will include spaces for the following:
  - a. A form tracking number
  - b. Date
  - c. The vehicle or part affected.
  - d. Quantity affected.
  - e. Serial numbers
  - f. Corrective and preventive actions
  - g. Other information appropriate for the proposed procedure
  - h. Contractor and City signature blocks for the change approval and acceptability of the implemented change

2-16 Vehicle History Books (VHB):

1. Submit format and content approval in advance of shipment/Acceptance of the first vehicle.
2. Final acceptance of the VHB format and content will be confirmed with review of the VHB for the first vehicle.
3. Material Specified in the Vehicle History Books section, above.
4. Submit a VHB for each vehicle when it is Accepted.

2-17 Draft Training Plan for Manufacturing Workers:

1. Instruction on correct use of all manufacturing tools
2. Procedures for addressing manufacturing issues.
3. Instruction on Specified standards of workmanship
4. Instruction regarding unacceptable practices.

5. Description of how workers will be tested at the completion of training to certify that they have understood and retained the instruction.

2-18 Control Samples:

1. Submit four samples for each required item.
2. Include validation forms for Contractor and City signature.
3. After approval, retain one sample and furnish one to the appropriate subcontractor or supplier.

2-19 QA Manager Qualifications:

1. Qualifications for the person proposed to be QA manager.
2. Resume demonstrating appropriate training and experience.

2-20 Quality Assurance Plan (QAP):

1. Submit within 60 days after NTP.
2. Required information as described in the Quality Assurance Plan (QAP) section, above.
3. Organization chart for the QA organization.
4. Organization chart for the Contractor's staff (see Management Plan CDRL)
5. Resumes of each member of the QA organization engaged in this Contract.
6. QA procedures listed in the Quality Assurance Plan (QAP) section, above.

2-21 FAI List:

1. Submit within 120 days of NTP.

2-22 FAI Packages:

1. Submit a package for each FAI a minimum of 30 days before the FAI.
2. Include the following as a minimum:
  - a. Agenda
  - b. Event location
  - c. Schedule of activity
  - d. All necessary logistics information, including point of contact.
  - e. Pertinent documentation and status reports, including the following:
    - f. Drawings
    - g. Engineering Changes
    - h. Modifications lists.
    - i. Complete open items list
    - j. Mill Certifications (Certificates of Conformance will not be allowed without approval from the City)
    - k. Status of required samples
    - l. Test procedures and reports
    - m. Contractor pre-FAI results
    - n. Software documentation, if applicable.
    - o. Inspection forms and data sheets for the FAI.

2-23 FAI Reports:

1. Submit a report for each FAI conducted within 15 working days.
2. The report must include pertinent information, including photographs.

2-24 Quality Control and Inspection Plan (QCIP):

1. Submit within 120 days after NTP.
2. Flow chart identifying major manufacturing and inspection points including source, receiving point, in-process, hold, witness, and final inspection points.

3. Include a list of all inspection and test procedures used in the manufacture and testing of the vehicle, including those performed at the Acceptance site.
4. Inspection forms:
  - a. Include a list of all forms used in the production or testing of the vehicles.
  - b. Include a blank copy of each form on the list.
5. Inspection Status:
  - a. Include the method used for identifying inspection status.
6. Control of Non-Conformance:
  - a. Include a written procedure for control of rejected (non-conforming) material in all the Contractor's facilities. The procedure must include a Material Review Board or Approved equal.
  - b. The procedures must address identification, segregation, and disposition of non-conforming material.
7. Sampling Procedures:
  - a. Include a list of parts and materials to be inspected by sampling and indicate the type of sampling to be used.
  - b. Indicate the standard on which sampling procedures are based.
8. Source/pre-shipment inspection for subcontractor and supplier product. Include the documentation/reports that must be captured.
9. Receiving Inspections:
  - a. Include written procedures for documenting how items are inspected at source and/or upon receipt to verify conformance to acceptance criteria of Specifications and drawings.
  - b. Include sample forms or documents for recording receiving inspection results.
10. In-Process Inspections:
  - c. Include written procedures and sample forms or documents for recording in-process inspection results.
  - d. Include inspection for conformance to current, Approved drawings.
  - e. Include a requirement to submit any corrective actions that must be Approved before implementation.
11. In addition to steps for initial inspections, include steps for inspection of repairs and corrections for conformance to drawings and the City-Approved rework procedures, as needed.
12. Hold-Point and Witness-Point Inspection:
  - f. Include a detailed procedure for each hold-point inspection listed in the Hold-Point and Witness-Point Inspection section, above.
  - g. Include sample forms or documents for recording hold point inspection results and discrepancies.
  - h. Include the approach applied to provide notification of a Hold or Witness point inspection to City's representatives.
13. Pre-Shipment Inspection:
  - i. Procedure and sample forms or documents to record this inspection.
  - j. Identify the documentation that must be captured and retained by the Contractor at a pre-shipment inspection.
14. Post-Shipment Inspection:
  - k. Procedure and sample forms or documents to record this inspection.
  - l. Include steps necessary to find any vehicle damage or evidence of anomalous conditions during shipping.
15. QC testing:

- 1                   m. Functional testing
- 2                   n. Subject to the City's approval, performing statistical analysis, tests, and other QC
- 3                   procedures when appropriate in the QA processes.
- 4           16. List and samples of all forms proposed to be used for the Contractor's QC activities.
- 5           17. Steps that the QA organization must take regarding suppliers, including supplier audits.

## Section 3 System Support

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### 3.1 Manuals and Catalogs

#### 3.1.1 Manual Schedule and Quantities

The Contractor will furnish manuals for use by vehicle operators and maintenance personnel in accordance with the requirements of this Section. Draft manuals must be sufficiently complete for the City to perform all maintenance and troubleshooting activities. Furnish drafts and final copies of the manuals in accordance with the following schedule:

<b>Manual and Catalog Delivery Requirements</b>			
<b>Manual Type</b>	<b>Deliver Two Sets of First Drafts No Later Than:</b>	<b>Deliver Final Manuals No Later Than:</b>	<b>Hard Copy Quantities of Final Manuals Per Vehicle</b>
Operator's Instruction and Troubleshooting Manual	30 months after NTP	41 months after NTP	10
Maintenance and Servicing Manual	30 months after NTP	41 months after NTP	2
Heavy Repair Manual	30 months after NTP	41 months after NTP	2
Illustrated Parts Catalog	30 months after NTP	41 months after NTP	1
Training Manuals	2 months before start of training	41 months after NTP	10
Special Tools and Diagnostic Equipment Manuals	30 months after NTP	41 months after NTP	1
Integrated Schematic Diagrams for Troubleshooting	30 months after NTP	41 months after NTP	3
Labor guide	30 months after NTP	41 months after NTP	1

Notes to Table, if additional vehicles are purchased, the Specified quantities per vehicle will also apply to additional vehicles.

#### 3.1.2 Manual General Requirements and Format

##### *General Requirements*

The Contractor will comply with the following requirements for each Specified manual:

- Organize the manual such that the vehicle is treated as an integrated system and not as a grouping of disassociated parts.
- Highlight safety precautions to be taken by operating and service personnel while operating vehicles and performing maintenance and servicing operations.
- Produce a manual specific to this Contract that accurately represents the completed as-built vehicle, including but not limited to Contract-specific maintenance instructions, parts, wiring schematics, wiring diagrams, and component physical layouts.

Following the issue of each publication, furnish revised pages covering any changes, whether required by change of design or procedures or due to error. Keep these revisions current (revise minimum every 6 months) during the warranty period.

#### *Hard Copy Format*

Professionally produce each Specified manual, complying, with the following requirements:

1. Furnish as a bound book with cover or in a heavy duty, locking, D-ring-type three-ring binder.
2. Divide and tabulate into logical sections and subsections.
3. Include a table of contents at the front of the manual.
4. Print on quality paper meeting the following requirements:
  - a. Tear-resistant
  - b. Waterproof
  - c. Grease, chemical, and stain resistant
  - d. Polyester based synthetic, such as Revlar, by Relyco, or paper with similar qualities, as Approved.
  - e. Minimum 5 mil thickness

#### *Soft Copy Format*

Submit each Specified manual on electronic media in portable document format (PDF). Comply with the following requirements when creating PDF version of each manual:

1. Create searchable, zoomable PDF directly from native format, not by scanning hard copy documents.
2. Create with sufficient resolution to allow zooming of graphics without loss of quality or resolution.
3. Size PDF the same as hard copy version to allow the City to easily print new hard copy versions from electronic media without resizing PDFs.
4. Create a hierarchy of bookmarks, with each major section as a top-level bookmark, and subsections as bookmark subheadings. Bookmarks will match the structure of the table of contents and include the headings and subheadings in the same hierarchical structure.

Revise electronic media versions in accordance with hard copy manual revisions.

#### *Content*

See the Contract Deliverables Requirements section, below, for details of each manual to be submitted.

### **3.2 Special Tools and Diagnostic Equipment**

#### **3.2.1 General**

The Contractor will furnish all special tools necessary to perform the required maintenance, as defined in the Contractor's maintenance manuals. Furnish all equipment Specified in this Section for comprehensive in-service maintenance and testing of vehicles. All tools and test equipment will be delivered prior to any training.

#### **3.2.2 Delivery Schedule**

The Contractor will comply with the following delivery requirements:

1. Deliver tools and test equipment at the same time as final copies of the Special Tools and Test Equipment Manuals Specified above.
2. If not furnished before scheduled maintenance training, furnish minimum one complete set of special tools and test equipment necessary to service, maintain, and overhaul each system for use in the training program, such as the following:

- a. Jigs
- b. Fixtures
- c. Meters
- d. Gauges
- e. Vacuum pumps
- f. Temperature sensing devices

### 3.2.3 Special Tools

Special tools include, but are not limited to the following tools and equipment that are not commonly available from commercial tool suppliers and are necessary to maintain, repair, overhaul, assemble, and disassemble the vehicle or subsystems:

1. Jigs
2. Fixtures
3. Gauges
4. Equipment
5. Hand tools
6. Power tools

At a minimum, furnish the following special tools:

1. Tools to activate tamper-proof fasteners and access panels.
2. Vehicle jacking adapters.
3. Door System: Gauges and jigs required for door installation and adjustments.
4. HVAC System:
  - a. Vacuum pump
  - b. Refrigeration recovery and charging test manifold.
  - c. Holding fixture
  - d. Leak tester, electronic
5. Propulsion System: Non-standard wrenches and gauges
6. Truck Assembly:
  - a. Tools for gearbox and coupling disassembly and re-assembly.
  - b. Journal-bearing puller
  - c. Truck assembly stand
  - d. Truck alignment jigs
  - e. Wheel tire removal and installation tools
7. Friction Brake System:
  - a. Caliper assembly tools
  - b. Actuator assembly tools
  - c. System bleeding & filtering equipment
  - d. Accumulator servicing gauge and fittings

### 3.2.4 Portable Test Units (PTUs)

PTUs (laptop computers) for on-board diagnostics are Specified in Section 7 Electronic Controls, Software, and MDS. The Contractor will comply with the following additional requirements:

1. Furnish one PTU per vehicle furnished.
2. Furnish with each unit all connectors, cables, and adapters necessary to communicate with on-board systems from the PTU.



3.2.5 Testability and Accessibility

The Contractor will comply with the following:

1. Provide serial connectors on each individual system to facilitate testing.
2. See instrumentation requirements in Section 18 Vehicle and Systems Testing, and ensure coordination between equipment design and testing requirements.
3. Test and data ports will be directly accessible without removal of equipment. No special tools or adapters will be required for access.

3.3 Training

3.3.1 General

The following requirements apply to all types of training described in this section:

1. The number of training hours and duration and quantities of staff to be trained Specified in this Section are the City's estimates only. The City will be the sole judge of the adequacy of the training plan offered.
2. Work closely with the City's staff as training materials are being developed to ensure City standards are being met with respect to course organization, content, and overall quality of training materials.
3. All training materials, such as training aids and lesson plans, will become the property of the City at the completion of the training program.
4. The City reserves the right to video tape training activities.

3.3.2 Training Program Description

The Contractor will comply with the following general requirements:

1. Location: At the City's facilities
2. Type of training: Classroom and hands-on.
3. Training categories:
  - a. Operator training
  - b. Maintenance training
  - c. Trainees: Instructors, Supervisors, Vehicle Operators, Mechanics, and Technicians, as selected by the City.
4. Training materials: Furnish the following as a minimum:
  - a. Specified training manuals
  - b. Other training aids as required to impart the essential knowledge to trainees.
  - c. Accurate and up-to-date reference materials
5. Testing: Design and conduct written and practical tests at suitable points in each course to determine the extent to which trainees have retained the course material and can apply the information.

3.3.3 Operator Training

The Contractor will comply with the following requirements for operator training:

1. Scope: Include basic vehicle operation and how to detect and resolve in-service problems and emergencies.
2. Initial training:
  - a. Within 10 days after delivery of the first vehicle, train COP's trainer and five operators.
  - b. This group will come from the core team of operators for the vehicle test program.

c. Furnish a vehicle for this purpose and ensure that all applicable systems are properly operating.

3. Additional training: Train a total of 20 operators, including those trained in the initial training.

#### 3.3.4 Maintenance Training

##### *Schedule and Duration*

The Contractor will furnish the following maintenance training:

1. Initial training: Before delivery of the first vehicle, complete training for one group of up to 10 technicians.

2. Additional training: After delivery of the first vehicle, train an additional 10 technicians.

3. Refresher training: Conduct one year after delivery of the last vehicle.

Time period:

1. Conduct the initial and additional training over a period of maximum 52 weeks.

2. Conduct the refresher training over a period of maximum 52 weeks.

Training hours:

1. Initial and additional training: Furnish minimum 760 instructor training hours.

2. Refresher training: Furnish minimum 240 instructor training hours, 120 classroom and 120 hands-on hours.

3. The City may shift these training hours from one training period to another.

##### *Description*

The Contractor will comply with the following requirements for maintenance training:

1. Scope: Include all systems and sub-systems provided under this Contract.

2. Maintenance types: Include preventive, corrective, and overhaul of components and/or assemblies.

3. Minimum maintenance training outline:

a. Introduction to the equipment, including terminology, identification of major components and their location on the vehicle.

b. Detailed theory of operation

c. Preventative maintenance:

i. Lubrication schedules

ii. Adjustments

iii. Tolerance limits

iv. Inspection criteria

v. Recommendation for test frequency

vi. Methods for testing, including instruments required.

d. Troubleshooting:

i. Problem symptoms

ii. Troubleshooting techniques

iii. Repair procedures

e. Removal and replacement of parts and components from the vehicle

f. Disassembly and reassembly for the purpose of component familiarity and any special processes

g. Instruction in the use of all special tools and processes

h. Overhaul of components and assemblies

4. Depth of training:
  - a. Include sufficient detail such that trainees can successfully perform all maintenance and overhaul tasks presented.
  - b. Give trainees the opportunity to perform the more complex maintenance functions on the vehicle and in the Shop.
  - c. Troubleshooting:
    - i. Instruct trainees in how to troubleshoot systems using appropriate subsystem test devices to locate and remedy faults.
    - ii. Artificially introduce faults into equipment as needed to furnish adequate troubleshooting training.
5. Field instruction: Include both on-vehicle demonstrations and demonstrations of basic overhaul procedures using equipment in the Shop.

*Specific Content*

The Contractor will furnish in-depth instruction addressing the following systems and components as a minimum:

1. Air conditioning and heating systems, including their controls.
2. AC auxiliary power system
3. Low-voltage dc power system, including battery.
4. Braking system, including controls
5. Communications system
6. Network controls
7. Train signal and control system
8. Monitoring and diagnostic system
9. Lighting controls
10. Propulsion system, including traction motors and controls.
11. Trucks, including bearings, bearing surfaces, gear units, frame, suspensions, and shock absorbers.
12. Door and bridgeplate operators and controls
13. Removal, replacement, and adjustment of vehicle body materials and equipment, such as the following:
  - a. Glazing
  - b. Seats
  - c. Doors
  - d. Underfloor equipment
  - e. Trucks
14. Removal, replacement, and adjustment, where applicable, of vehicle electrical equipment, such as the following:
  - a. Windshield wipers
  - b. Heaters
  - c. Circuit breakers
  - d. Switches and indicators
  - e. Light fixtures
15. Re-railing procedures

### 3.4 Spare Parts

The Contractor will furnish the spare parts listed in Contract Documents:

1. Based on the submitted recommended spare parts list, actual items and quantities may be adjusted after Contract award by amendment.
2. Individually package and label vehicle sets of spare parts and consumables with part numbers.
3. Part numbers must be the same as those indicated in the Specified Parts Catalog.

### 3.5 Technical Support Personnel

The Contractor will comply with the following requirements for technical support personnel:

1. Language: Fluent in English.
2. Availability: Any of three eight-hour shifts, as may be required by the City.
3. Purpose:
  - a. Assist during inspection, operation, testing, modification programs, and adjustment of vehicles both before and after Acceptance by the City.
  - b. Assist in training that may be required, in addition to the training Specified above, both before and after Acceptance by the City.
4. Field Service Engineer:
  - a. Quantity: Minimum one.
  - b. Location: At the City's facilities.
  - c. Qualifications: Knowledgeable in each of the vehicle's systems to the level of competent troubleshooting.
  - d. Availability: Full time.
  - e. Time period: One month before arrival of the first vehicle until two years after acceptance of the last vehicle.
5. Suppliers: Ensure 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 vehicle and equipment malfunctions.
6. Additional on-site technical assistance: If requested by the City, furnish as follows:
  - a. Delivery of first vehicle to Final Acceptance of last vehicle: Within 48 hours from receipt of request.
  - b. Warranty Period: Within 72 hours from receipt of request.

### 3.6 Firmware/Software Updates

As firmware and software updates are made to components and systems provided on vehicles, notify the City for the life of the vehicle.

### 3.7 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance:

#### 3-1 Operator's Instruction and Troubleshooting Manual:

1. The manual will contain all information needed for optimum operation of the vehicle.
2. Include general vehicle familiarization material, such as the following:
  - a. Description of location, function and operation of controls, gauges, indicators, and switches
  - b. Discussion of the trucks, couplers, propulsion, brakes, doors, bridgeplates, lights, HVAC control, and other features of the vehicle which the operator may not be able to control or adjust, but of which the operator should have some basic knowledge.
  - c. Safe practices and procedures

- d. Emergency procedures
- e. Trouble symptoms and diagnosis methods
- f. Operator corrective action
3. The manual will be logically organized with systems and elements considered in descending order of importance.
4. Ensure that all statements are clear, positive, and accurate, with no possibility of incorrect implications or inferences.
5. Size: 5 inches by 7 inches

3-2 Maintenance and Servicing Manual:

1. This manual will contain all necessary maintenance information for use by the City's maintenance staff for:
  - a. Preventive maintenance inspections
  - b. On-vehicle running maintenance and adjustment
  - c. In-service trouble diagnosis of each system
2. Include safe practices and procedures.
3. Include such data as troubleshooting guides, equipment specifications, and references to the Integrated Schematic Diagrams and Software Functional Description with error code troubleshooting assistance.
4. Include intervals of preventive and required maintenance. List the preventive and required maintenance on a chart that defines the intervals and type of maintenance for the first 10-year period of the vehicle.
5. Include forms required for each type of inspection or required maintenance. Each form will include tasks to be performed and required parts to be used in the inspection or task.
6. Include a detailed analysis and theory of operation for each component of the vehicle so that maintenance staff can effectively service, inspect, maintain, adjust, troubleshoot, repair, replace, and overhaul each component.
7. Include the list of recommended cleaning agents submitted under Section 16, Materials and Workmanship.
8. Include the maintenance information for paints and coatings submitted under Section 16.
9. Size: 8-1/2 inches by 11 inches.

3-3 Heavy Repair Manual (HRM):

1. This manual will contain the maintenance procedures performed at the Heavy Repair level.
2. Heavy Repair Maintenance is maintenance which requires holding a vehicle out of service due to the longer time required to complete the work and includes maintenance tasks scheduled for 3-year or greater intervals that are associated with vehicle and equipment overhaul.
3. The opening section of the HRM will be a table of Heavy Repair tasks, organized by interval, then by subsystem. The table will refer to subsections of the HRM where procedures for each task may be found.
4. The manual will be written from a vehicle subsystem and component perspective:
  - a. Each subsystem section will begin by illustrating the location of components within the subsystem.
  - b. Functional descriptions will accompany the illustrations to facilitate servicing, repair, overhaul, adjustment, inspection, and test.
  - c. Detail the function of each significant component and circuit within each assembly, rather than furnishing descriptions of subsystem functions within the integrated vehicle system.

5. Furnish maintenance procedures, including inspection, service, test, troubleshooting, adjustment, removal, repair, replacement, and overhaul, as applicable for this specific vehicle or its systems, equipment, or parts.
6. Assembly procedures will each include pertinent assembly criteria, such as clearances, backlash dimensions, torque values, recommended tools, required supplies, necessary follow-on tasks (if applicable), and similar data.
7. Procedures will include detailed instructions for troubleshooting all anticipated failure modes, including the use of necessary special tools, PTUs, and Bench Testers.
8. Furnish a listing of all tools required to perform maintenance on the vehicles and apparatus, including both special and commercially available tools.
9. Include safe practices and procedures.

3-4 Illustrated Parts Catalog:

1. This catalog will identify each component on the vehicle by part number down to the Lowest Level Replaceable Unit (LLRU). The LLRU is defined as the lowest level of component assembly that consists of a separate, individually fabricated part.
2. Enumerate and describe each component with its related parts for the entire vehicle.
3. Incorporate drawings showing exploded views and cutaways of subassemblies and components to permit identification of all parts down to LLRUs.
4. Identify each part with the Contractor's part number and next higher assembly. Include the supplier's part number if different from the Contractor's number.
5. Parts common to different components, such as bolts and nuts, will bear the same Contractor's number in all components with reference to the other components in which they are found.
6. In addition to identifying each component by the Contractor's number, identify commercially available items such as common fastenings, fuses, lamps, fittings, bearings, and relays by standard hardware nomenclature adequate to allow the City to purchase these items through commercial channels.
7. Size: 8-1/2 inches by 11 inches.

3-5 Training Manuals:

1. This manual will contain material to aid trainees who receive the required training, as Specified in the "Training" section.
2. Manuals and other training materials to be used by the Contractor during training will be furnished to the City two months before training is conducted.
3. The manuals will be complete, and contain an adequate supply of high quality, professionally prepared material of professional quality.
4. Include the final training plan, after approval of the draft training plan.
5. Size: 8-1/2 inches by 11 inches.

3-6 Special Tools and Diagnostic Equipment Manuals:

1. Submit manuals for each special device identified in the Special Tools and Test Equipment section.
2. Include setup and testing procedures for each special tool and test device.
3. In a separate section, include all information needed for periodic inspection and servicing requirements of the test equipment, including lubrication, inspection, and adjustment of all apparatus.
4. Size: 8-1/2 inches by 11 inches.

3-7 Integrated Schematic Diagrams for Troubleshooting:

1. Submit diagrams detailing all electrical, electronic, pneumatic and/or hydraulic systems in schematic fashion. These diagrams will be separate from the schematics and wiring diagrams in the maintenance manuals.
2. These schematics will be comprehensive, thoroughly detailed, include all components and include the following:
  - a. Electrical systems
  - b. Electronic systems
  - c. Pneumatic and/or hydraulic systems, wiring, and piping on the vehicles
3. Diagrams will reflect the City's vehicle as built and include all circuits on the vehicle.
4. At a minimum, include the following on the schematics:
  - a. Zone gradations around the perimeter of each sheet for location references.
  - b. Alpha-numeric designations for all components. The designations will be logical and clearly distinguish between different component types, such as CBxxx for circuit breakers.
  - c. All contacts or connections for relays, contactors, connectors, and other devices with multiple contacts or connections, even if unused.
  - d. Numerical designations for all circuit wiring, with logical groupings for power sources, return circuits, and similar.
  - e. Wire sizes and circuit voltages, piping sizes and system pressures, and similar.
  - f. Industry standard device symbols and nomenclature for piping, hydraulic, and pneumatics diagrams, such as defined by ANSI or similar organizations.
5. Number pages numerically and consecutively.
6. In addition to the required quantity of hard copies, submit two copies in an electronic format that is readable and searchable on a PTU screen and formatted to print on 11-inch x 17-inch paper.
7. Hard Copy Size: 11 inches by 17 inches.

3-8 Labor Guide:

1. Submit a guide for use by the City to determine vehicle maintenance and repair time.
2. Include standard times for recommended preventative maintenance tasks.
3. Include standard repair times and replacement times for all major components and the associated sub-assemblies.

3-9 Draft Training Plan:

1. Include information detailing the types of training and the number of hours required to train the City's staff.

3-10 Required Spare Parts:

1. For components that are listed in the Contract as required spare parts but are not applicable to the Contractor's specific design, indicate "not required."
2. Include part numbers.

3-11 Recommended Spare Parts:

1. Include spare parts recommended by the Contractor that are in addition to those Specified.
2. Include part numbers.

## Section 4 Design and Performance Criteria

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## 4.1 General

### 4.1.1 Scope

This Section describes the operating environment in which the vehicle must perform, establishing general design criteria and system performance; related and other requirements may appear in other sections of the TS.

### 4.1.2 Service Proven Design

Base the Vehicle and its systems on “service proven” designs, as defined in Section 1 General topics and definitions. Derivations from, or extensions of proven designs are permitted solely at the discretion of the City. The City will assess changes to service proven designs according to, among other factors, the risks to the success of the Project.

### 4.1.3 Service Life

Base service life on the vehicle operating environment, subject to the maintenance intervals Specified in this Section, the Contractor's recommended maintenance practices, and normal industry accepted operating procedures. Comply with the following service life requirements:

1. Vehicles: Minimum 30 years. Annual average mileage, estimated to be 40,000 km (25,000 mi) per vehicle.
2. Vehicle body, truck, and drive train structures: Minimum 30 years without the need for structural repairs.

## 4.2 Operating Environment

### 4.2.1 General

The vehicle will perform as Specified in the City operating environment.

1. The vehicle will operate on the existing and planned future alignment, shared with existing vehicles.
2. The vehicle will be functionally compatible with the existing signal systems, and structurally compatible with the existing streetcars.

### 4.2.2 Climatic Conditions

#### *General*

Consult official data sources for current versions of these and other relevant data.

1. Actual temperatures and conditions local to the vehicle along the alignment, including those within, underneath, and above the vehicle, may be much more severe than the historical climatic conditions below.
2. The vehicle will accommodate the environmental extremes on the alignment.

#### *Historical Climate Data*

Select historical climate data for the Portland area are presented below:

1. Ambient air temperature extremes, external to the vehicle:
  - a. Low: -20 degrees C (-4 degrees F)
  - b. High: 42 degrees C (107 degrees F)
2. Precipitation:
  - a. Maximum rainfall rate in 24 hours: 66 mm (2.6 in)
  - b. Maximum snowfall in 24 hours: 366 mm (14.4 in)
3. Icing conditions: Vehicles must be capable of operating under freezing rain and ice conditions without damage to equipment or reduction of useful service life.

4. Relative Humidity:
  - a. Minimum: 45%
  - b. Maximum: 100%
5. Wind Speed:
  - a. Maximum sustained: 56 km/h (35 mph)
  - b. Maximum gusting: 96 km/h (60 mph)

#### 4.2.3 Fordability

The vehicle will operate without impairment or damage in standing water of depths up to 75 mm (3 in).

#### 4.2.4 Alignment

##### *Description*

The vehicles will operate in City streets, in mixed traffic, with traffic congestion, traffic lights, bicycles, and pedestrians.

1. Vehicle speeds: See the Speed Requirements section, below.
2. Track bed cross section: Primarily level, with cross slopes of 2% between rails for drainage toward the center of the track.
3. Alignment plan and profile: Available from the City.

##### *Wireless Segments*

Operation on wireless segments will be in mixed auto traffic, subject to random and significant delays due to intersection conflicts, pedestrians in the streets, events, emergency responder activities, and similar.

1. The future Montgomery Park extension will be wireless.
  - a. The extension will be approximately 3.2 km (2 miles), round trip, with minimal grade.
  - b. The terminus will have a charging bar.
2. The City would like to be able to cross the Broadway bridge using the OESS.
3. The Vehicle must be able to operate anywhere on the City's alignment under OESS, so the vehicle can clear intersections, or to pass sections of deenergized OCS, under emergency operations.

##### *Wireless Operating Conditions*

Comply with the following operating conditions:

1. Stops in wireless segments:
  - a. Each traffic light: 20 seconds; assume the vehicle stops at all traffic lights.
  - b. Each station: 30 seconds.
2. Layover at each terminus: 10 minutes, during which time charging of the OESS is available from an OCS wire or charging bar.
3. Normal vehicle functions and performance in accordance with the Specifications, except as may be altered in this Section.
4. Reduced HVAC performance in passenger areas, as Specified below.
5. Worst case ambient conditions.
6. OESS at worst case life condition.

1 **Track Geometry**

Track Geometry	
Rail Types:	115 RE, Ri 52, Ri 59
Minimum horizontal curve radius:	20 m (65 ft)
Minimum vertical curve radius, crest:	250 m (820 ft)
Minimum vertical curve radius, sag:	250 m (820 ft)
Minimum frog number:	4
Nominal track gauge and tolerance, new:	1435 mm (4 ft 8.5 in) Sections of the alignment have a narrower gage 1429 mm.
Nominal track gauge and tolerance, maintenance:	1435 mm (4 ft 8.5 in) +/- 6mm (0.25 in)
Maximum track superelevation:	75 mm (3 in)
Maximum sustained gradient:	9% for 1000 ft, or the worst case on alignment drawings, whichever is greater
Reverse vertical curves:	Either a crest and a sag of 250 m (820 ft) separated by a tangent section of 7.5 m (25 ft), or a crest and sag of 350 m (1,148 ft) separated by no tangent track
Compound curves:	A 20 m (65 ft) horizontal curve superimposed on a 450 m (1,476 ft) vertical crest or sag.
Reverse horizontal curves	Refer to alignment drawings

2 **4.2.5 Station Platform Interface**

3 Comply with the following:

- 4 1. Platform Length: Less than the vehicle length.
- 5 2. Vehicle Width at Door Threshold: No less than vehicle-body width at floor level.
- 6 3. Vertical Motion Range: Floor height in the low floor section 355 mm, (14 in) at AW0, with
- 7 maximum deflection of 89 mm (3.5 in) under maximum passenger load.
- 8 4. Station Platform Height:
- 9 a. Front section of the stop: worst case, 175 mm (6.9 in) above top of rail, ramping to
- 10 accessible door platform height.
- 11 b. Accessible door section of the stop: 250 mm (9.8 in) above top of rail; ADA compliance is
- 12 achieved via Bridgeplate, see Section 9 Passenger Doors

13 **4.3 Vehicle Description**

14 **4.3.1 Vehicle Type and Characteristics**

15 The vehicle will be an articulated, modern urban streetcar with contemporary styling. The vehicle will have

16 the following characteristics:

- 17 1. Body sections: Minimum three, each separated by an articulated joint.
- 18 2. 100% low floor vehicles: Low floor section will extend from cab wall to cab wall.
- 19 3. Bi-directional: Provide a fully functional cab at each end with operating control and performance
- 20 equal from both cabs.
- 21 4. Single-unit operation: Include provisions for towing a non-operable vehicle.
- 22 5. Heated and air conditioned: Consistent with the Portland environment and the TS.
- 23 6. The vehicle design shall incorporate an onboard energy storage system, battery drive system,
- 24 which shall provide capability for wireless operation in accordance with the TS.

7. Powered trucks: At least two-thirds of the trucks will be powered. Provide motoring, dynamic braking, and spin protection for all wheels of powered trucks.
8. All trucks: Provide friction disc braking and slide protection for all wheels of all trucks. Provide track braking on all trucks.

#### 4.3.2 Vehicle Configuration Requirements

##### *Doorways*

Quantity of doors per side: Minimum two double-wide doors; alternative arrangements maybe proposed to the City for review and Approval.

##### *Seating*

Arrange seating laterally 2 x 1 abreast; alternative arrangements maybe proposed to the City for review and Approval.

#### 4.3.3 Mobility Impaired Accommodations

##### *General*

Mobility impaired accommodations will comply with 49 CFR 38, Subpart D.

##### *Mobility Aid Parking Areas*

Provide a minimum of two mobility aid parking areas, adjacent to the double-wide doorways with bridgeplates.

##### *Accessible On-Board Circulation Path (AOCP)*

The AOCP connects accessible features on the vehicle, including accessible doorways and mobility aid parking areas:

1. AOCP Clear Width: Minimum 32 inches.
2. Bridgeplates: Provide two, one on each side of the vehicle, at double-leaf doorways in the low floor section.
3. AOCP Route: Between each bridgeplate doorway and the Specified mobility aid parking areas.
4. Signage: If not all the doors give access to an AOCP route, provide the international symbol of accessibility on vehicle interior and exterior at each AOCP doorway.

##### *Vehicle Entryway Width*

The Contractor must comply with the following:

1. Vestibule: Vehicles where wind screens, modesty panels, or other partitions establish an entrance or “vestibule” area separate from the occupied passenger space:
  - a. Vestibule width: Minimum 44 inches over the most restrictive protrusion, where 90 degrees or similar turns are required immediately upon entering the vehicle.
  - b. Exception: If the vestibule is arranged to allow a free-flowing path into the passenger area or aisle leading to that area, then the most restrictive width of the vestibule near the door may be less than 44 inches, but in no case can the accessible on-board circulation path be less than 32 inches
2. No Vestibule: Vehicles that do not have physically defined separation between entrance areas and passenger occupied areas but require 90 degree or similar turn on to the Accessible On-board Circulation Path:
  - a. Clear path dimension: Minimum 44 inch wide across the vehicle free from panels or stanchions
  - b. Path configuration: Should be a straight line across the doorways on opposite sides of the vehicle.

- c. Exception: Entrances that are not on the Accessible On-Board Circulation Path or do not lead to a mobility aid parking area are not bound by this requirement

#### 4.4 Vehicle Weights and Dimensions

##### 4.4.1 General

Weights and dimensions will be as indicated below. Construction tolerances of dimensions will be as stated on the Contractor's drawings unless specifically stated in the TS.

##### 4.4.2 Weights

Vehicle weight is based on a ready-to-run vehicle, complete in all respects with all equipment, materials, and fluids.

The weight of each vehicle, including passengers at 70 kg (154 lbs.) each, will be defined as follows:

AW0	Empty vehicle operating weight, maximum of 1850 kg/m (1236 lbs./ft)
AW1	Full seated load (passengers plus operator), plus AW0
AW2	Standees at four persons per m <sup>2</sup> of suitable standing space per passenger, plus AW1
AW3	Standees at six persons per m <sup>2</sup> of suitable standing space per passenger, plus AW1
AW4	Standees at 6.6 persons per m <sup>2</sup> of suitable standing space per passenger, plus AW1

Notes to Table:

1. Suitable standing space will include areas of the aisles where it is possible for passengers to stand.
2. The ratings of vehicle equipment and systems will be based on the actual weight and passenger capacity of the vehicle.
3. Maximum axle weight at AW3: 12,500 kg/axle (27,558 lbs./axle)

##### 4.4.3 Weight Balance

Arrange equipment so that its weight is distributed to maximize adhesion and minimize the tendency to derail. Each vehicle will meet the following balancing requirements when complete with all necessary apparatus and for all Specified passenger loading conditions:

1. A-end and B-end trucks: The difference in vehicle weight supported by each truck at the rail will not exceed 900 kg (1984 lb) for all loading conditions from AW0 to AW3.
2. Center truck (if provided): The vehicle weight supported at the rail will be within the range of 25% to 40% of the total vehicle weight for all loading conditions from AW0 to AW3.
3. Lateral imbalance: At AW0 load, the difference in weight supported by each rail at each truck will not be greater than 340 kg (750 lbs.).



**4.4.4 Vehicle Body Dimensions**

Vehicle length: Allowed range, measured over anticlimbers	20 m to 21.5 m (65.6 ft to 70 ft)
Nominal vehicle width:	
Belt line:	2460 mm (97 in)
Door threshold:	2398 mm (94.4 in)
Height of roof equipment: Maximum (excluding pantograph) above TOR with new wheels at AW0, including roof shrouds	3600 mm (141.7 in)
Nominal low floor height above TOR:	355 mm (14 in)
Interior ceiling height: Minimum, including anything mounted on the ceiling in normal walking and standing areas	2184 mm (86 in)
Cab Interior ceiling height: Minimum	2000 mm (79 in)
Anti-climber height:	
Bottom to TOR	635 mm (25 in)

**4.4.5 Doorway and Door Dimensions**

Minimum side doorway clear opening width:	
Single-leaf door	813 mm (32 in)
Double-leaf door	1220 mm (48 in)
Minimum side doorway clear opening height:	1955 mm (77 in)
Location of accessible door from front bumper to front of accessible door:	
20.13 m (66 ft) vehicle	
Right hand platform stops	11,665 mm (459.25 in)
Left hand platform stops	7,165 mm (282 in)
21.5 m (70 ft) vehicle	
Right hand platform stops	13,035 mm (513 in)
Left hand platform stops	8,535 mm (336 in)
Bridgeplate maximum length past edge of threshold when fully extended:	380 mm (15 in)

**4.4.6 Pantograph Dimensions**

The pantograph location on the vehicle body, combined with pantograph head and carbon dimensions, will produce optimum operation and current collection under all conditions on the Portland alignment.

<b>Pantograph Dimensions</b>	
Maximum height above TOR in the lockdown position, new wheels, vehicle at AW0 passenger weight:	3,824 mm (151 in)
Pantograph to operate on contact wire within this height range, vehicle weight from AW0 to AW3, and with new to fully worn wheels	3,960 to 6,250 mm (156 to 246 in)
Maximum collector width over horns:	1,700 mm (67 in)
Minimum carbon shoe length:	1,050 mm (41 in)
Carbon spacing: Usually in the 12–14-inch range	300 to 350 mm (11.8 to 13.8 in)
Maximum lateral displacement from centerline of pantograph shoe at any operating height:	+/- 50 mm (2 in)
Two-Truck Design - Maximum longitudinal distance from truck centerline to center of pantograph shoe, locked down:	0 mm (0 in)

#### 4.4.7 Vehicle Clearance

##### *On the Portland Alignment*

Vehicles will operate in the Portland environment without physical interference with equipment and structures along the wayside. Dimensions will not exceed those shown for Dynamic Envelope and Curve Offsets, available from the City, under the worst-case combinations of the following:

1. Construction tolerances.
2. Wheel and rail wear.
3. Maximum possible body roll.
4. Suspension motions.
5. All other variables within the Contractor's control.

After Contract award, the City and Contractor will meet to clarify and finalize the vehicle dynamic envelope.

##### *In the Shop*

Verify clearance dimensions between existing overhead shop walkways at the level of vehicle roof.

##### *Under-Vehicle*

Vertical under-vehicle clearance is defined from top-of-rail with the maximum suspension deflection and vehicle body roll, minimum vertical curve radius, maximum track super-elevation, and fully worn wheels.

1. Vertical clearance:
  - a. Under floor: Minimum 90 mm (3.6 in)
  - b. Under truck: Minimum 50 mm (2 in)
  - c. Vertical clearances exclude track brakes, safety bars, and sanding nozzles.
2. Clearances between truck components and vehicle body: As Specified in TS 15.2.4.

4.4.8 Wheel Dimensions

Nominal Diameter, new:	590 mm to 660 mm (23 in to 26 in)
Wear on diameter, at condemning limit:	No less than 50 mm (2 in)
Wheel Profile:	Per Wheel-to-Rail Interface Study
Back-to-Back Dimension:	Per Wheel-to-Rail Interface Study

4.5 Wheel-to-Rail Interface

4.5.1 General

The vehicle truck design and wheels will be compatible with the chosen rail sections and track design. The combined design of the truck, wheels, and rail will optimize the wheel-to-rail interface for the following:

1. Minimum wheel and rail wear.
2. Minimum propensity to derail.
3. Wheel/rail noise reduction.
4. Ride quality enhancement.

4.5.2 Wheel-to-Rail Interface Study (WRIS)

Use the existing wheel profile and verify that the truck design provides stable truck operation on the indicated track work.

4.6 Supply Voltages

4.6.1 Primary Line Voltage

*General*

Vehicle equipment operated directly from the primary input source will not suffer damage or reduction of required service life under any continuous primary input voltage from zero up to, and including, the maximum values defined below.

*Traction Power Substation Supply*

The vehicle primary input power will be from an OCS supplied by dc substations:

1. Substation voltage: 750 Vdc at no-load.
2. Substation regulation: 6%.
3. Rectification:
  - a. Mainline: 12-pulse

*Line-Voltage Range*

Comply with the following:

1. Equipment operating directly from OCS line voltage:
  - a. Will not suffer damage or reduction of required service life under any continuous line voltage from zero up to, and including, the highest non-permanent voltage value as defined in IEC 60850 under 750 V nominal category.
  - b. Will not shut down or disconnect from the source if necessary to protect against damage for line voltages outside the range between 525 V and 925 Vdc.
  - c. Equipment will automatically restore operation upon removal of the condition.

Existing alignment:

1. Adjust control parameters via software to not exceed the voltage or current limitations of the existing infrastructure and vehicles. See TS 13.6.2, for maximum braking voltage limitation.
2. These parameters will be resettable to IEC 60850 compliant values at any time by the City.

#### *Performance Upon Loss of Primary Power*

Loss of primary power will not cause an abrupt change in vehicle performance:

1. In power mode: Change to coast or a minimum brake.
2. In brake mode: Remain in same brake mode at same brake rate.
3. Other systems: Shut down in a controlled manner, without spurious behavior or damage.

#### **4.6.2 Transients and Abnormal Electrical Conditions**

The design will protect equipment on the vehicle from the following:

1. Damage or continued shutdown caused by random interruptions of the OCS power due to isolation gaps, pantograph bounce, or other conditions.
2. Transients and voltage surges typical of rail transit, and as Specified in IEC 60850 for line voltage-connected equipment, and IEC 61287 for all other equipment.

### **4.7 Performance Requirements**

#### **4.7.1 General**

Specified performance will be independent of wheel wear, climatic conditions, and vehicle weights, unless otherwise indicated in the Contract Documents.

#### **4.7.2 Load Compensation**

Provide an independent passenger load measuring system for each truck:

1. The propulsion and brake systems will compensate for passenger load to meet Specified vehicle performance requirements; load distribution and compensation will be per truck.
2. The system will be active at standstill and with open doors only. Load values will be stored once the doors are closed, and the vehicle starts moving.
3. Sensors and associated circuits will be continuously or periodically checked to verify they are functioning properly.
4. If independent control logic units are provided as part of load compensation, they will comply with Section 7 Electronic Controls, Software, and MDS.

#### **4.7.3 Speed Requirements**

The vehicle and its equipment will be designed to operate at the following speeds:

1. Vehicle design speed: Minimum 57 km/h (35 mph).
  - a. Equipment design speed, with fully worn wheels: Minimum 57 km/h (35 mph)
2. Maximum operating speed:
  - a. 48 km/h (30 mph), irrespective of civil speed limits on the existing alignment.
  - b. The maximum operating speed may be automatically limited by the vehicle under certain Specified conditions.
3. Overspeed set point:
  - a. Forward: 57 km/h (35 mph), initially set at 48 km/h (30 mph)
  - b. Reverse: 10 km/h (6 mph)

See Section 13 Propulsion System, for overspeed protection.

#### 4.7.4 Propulsion and Braking Design Criteria

Propulsion and braking equipment will interface to produce the Specified performance values. The basis for performance calculations, designs and evaluation will be as follows:

1. Acceleration, braking and jerk rates will be based on level tangent dry track in still air except when otherwise noted.
2. Initial acceleration rates will be as required by this Section over a 525 Vdc to 925 Vdc range at the OCS.
3. Braking rates will be independent of the OCS voltage:
  - a. Performance in dynamic braking will be available at all line voltages down to, and including, 0 V, assuming line voltage is present at initiation of braking.
  - b. Performance in friction braking modes will be available at all line voltages down to, and including, 0 V.
  - c. Friction braking will automatically supplement dynamic braking, on a per-truck basis, whenever dynamic braking is not providing the requested braking effort.
4. Performance capabilities will be achieved over the Specified full range of the following:
  - a. Wheel wear
  - b. Ambient temperatures
  - c. Low voltage power supply voltage

#### 4.7.5 Acceleration Requirements

##### OCS

When operating from the OCS at nominal line voltage and higher, the vehicle will achieve the acceleration rate below with the MC at maximum power position at all vehicle weights from AW0 to AW2.

1. Acceleration rate at MC Max Power:  $1.34 \text{ m/s}^2$ , +/- 5%, from 0 to 32 km/h (20 mph).
2. Time to reach 40 km/h (25 mph) from 0 km/h: Less than 10 seconds.
3. Time to reach 70 km/h (43 mph) from 0 km/h: Less than 25 seconds.

Reduced acceleration requirements:

1. Weights greater than AW2: Acceleration may be reduced in direct proportion to the ratio of AW2 weight/actual vehicle weight.
2. OCS line voltages between nominal and 650 Vdc: Vehicle will achieve the Specified acceleration, except that the speed to which the acceleration is maintained may be reduced in direct proportion to line voltage/nominal voltage.
3. OCS line voltages between 650 and 525 Vdc:
  - a. Current limiting parameters Adjustable
  - b. Initial setting: 5 A/V, where "V" is the difference between 650 V and actual line voltage.
  - c. Final setting: Optimize this value during commissioning.

##### Wireless

When operating under OESS, the vehicle will achieve the acceleration rate below with the MC at maximum power position at all vehicle weights from AW0 to AW2.

1. Acceleration rate at MC Max Power:  $1.34 \text{ m/s}^2$ , +/- 5%, from 0 to 15 km/h (9 mph).
2. Time to reach 32 km/h (20 mph) from 0 km/h: Less than 10 seconds.
3. Time to reach 48 km/h (30 mph) from 0 km/h: Less than 20 seconds.

For vehicle weights greater than AW2, the Acceleration may be reduced in direct proportion to the ratio of AW2 weight/actual vehicle weight.

#### 4.7.6 Braking Requirements

##### *General*

Vehicle braking will be performed by dynamic braking, friction disk braking, and track brakes. Adhesion may be augmented by the application of sand, as Specified. The instantaneous and average brake rates will be as indicated below for vehicle weights from AW0 to AW3. Above AW3, brake efforts may be fixed at no less than the AW3 levels.

##### *Service Brake*

The Contractor must comply with the following:

1. Composition: SB will use dynamic and friction disk braking. At all vehicle weights, SB will be 100% dynamic braking down to the dynamic brake fade point.
2. Braking rate: MC MSB position, SB will produce the following braking rates from any entry speed to zero:
  - a. Average braking rate:
    - i. All dynamic brakes functional:  $1.34 \text{ m/s}^2$ , +/- 5%
    - ii. One dynamic brake unit inoperative:  $1.34 \text{ m/s}^2$ , +/- 10%
    - iii. 100% friction braking:  $1.34 \text{ m/s}^2$ , +/- 20%
  - b. 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.

##### *Maximum Brake*

The Contractor must comply with the following:

1. Composition: Maximum brake (MB) will use dynamic, track brake, and friction braking to achieve the Specified performance. MB will maximize the use of dynamic braking, filling in with friction braking only as necessary. Slide protection will be active.
2. Braking rate: At MB position on the MC, MB will produce the following braking rates from any entry speed to zero:
  - a. Average braking rate:
    - i. All dynamic brakes functional:  $2.25 \text{ m/s}^2 +10\%$ , -0%
    - ii. One dynamic brake unit inoperative:  $2.25 \text{ m/s}^2$ , +15%, -0%
      1. 1 stop, then speed restriction may be implemented, as Approved.
    - iii. With 100% friction braking:  $2.25 \text{ m/s}^2$ , +20%, -0%
      1. 1 stop, then speed restriction may be implemented, as Approved.
  - b. Instantaneous braking rate: Less than  $3.5 \text{ m/s}^2$

##### *Emergency Brake*

The Contractor must comply with the following:

1. Operator control: Provide an Emergency Brake Switch as Specified in Section 5 Operator's Cab.
2. Composition: Emergency braking (EB) will use a combination of friction disc brakes, track brakes, dynamic brakes, and the application of sand. Friction brake effort will be independent of dynamic brake effort:
  - a. AW1 and below: Minimum EB rate will use only friction disc brakes, track brakes, and application of sand.
  - b. Above AW1: Dynamic brakes may supplement friction disc brakes, track brakes, and application of sand to achieve minimum EB rate.
3. Braking rate: When EB is commanded, EB will produce the following braking rate from any entry speed to zero:

- a. Average braking rate:  $2.25 \text{ m/s}^2$ , +20%, -0%
- b. Instantaneous braking rate: will not exceed  $3.5 \text{ m/s}^2$ .
4. Function of systems during EB:
  - a. Spin-slide system: Cut out during EB.
  - b. Jerk limiting: Will not be applied to EB.
  - c. Other vehicle systems: Must not inhibit EB.
  - d. Interlock with vehicle speed:
    - i. EB command: Irretrievable to the no-motion detection speed
    - ii. Track brake release: At no-motion detection speed
    - iii. Sanding termination: At no-motion detection speed
5. EB is a safety system:
  - a. Control line: Double-wire double-break as follows:
    - i. Separate positive and negative control wires with duplicate switching contacts for each control function in the positive and negative control lines.
    - ii. Both positive and negative supply leads to the EB relay will be switched by the cab console emergency brake switch, and interlock relays.
  - b. Vital circuits: Treat EB control circuits, including wiring, as vital, with maximum isolation maintained from possible sources of false energization.
  - c. Failsafe: Arrange EB circuits in a failsafe manner, such that control lines must be energized to sustain a permissive condition.

#### *Dynamic Brake Failure*

In the event of dynamic brake failure, comply with the following:

1. Friction disk brakes will automatically produce the necessary braking efforts to achieve the requested braking rate.
2. After the initial stop with a dynamic brake failure, the system will automatically reduce vehicle maximum operating speed as a function of vehicle weight, as Approved by the City, as necessary to conform to friction brake thermal limitations.

#### *Parking Brake*

Provide parking brakes capable of holding a vehicle as follows:

1. Weight: Up to AW4.
2. Grade: Maximum 9%, or worst case on alignment drawings, whichever is greater.
3. Duration: Indefinitely.

#### *4.7.7 Automatic Initiation of Brakes*

Provide an ATS device and related controls to interface with MSB or EB circuit. Details of interface with wayside will be furnished by the City; current system is furnished by Siemens.

#### *4.7.8 Wheel Spin/Slide Detection and Correction*

Provide a wheel spin/slide system complying with the following:

1. Performance:
  - a. The system will detect and correct wheel spins and slides on all wheels of the vehicle, both in acceleration and braking.
  - b. Spin/slide protection will be active in all motoring and braking modes except for emergency braking.
2. Safety:

- a. Design the system for safe operation such that a spin/slide system failure will not prevent the application of braking at any level less than desired, in any braking mode.
- b. Include a safety supervision algorithm to override the brake release on a per truck basis if a slide condition is determined to be excessive, subject to the City's approval.
3. Detection:
  - a. The system will detect both individual and synchronous slides or spins by evaluation of axle or wheel speed differences and axle/wheel acceleration/decelerations.
  - b. The system will use the speed information from all axles (including stub axles) of the vehicle.
  - c. The system will detect a locked axle or loss of speed sensor.
  - d. The system will modify the deceleration detection level during track brake applications.
4. Correction:
  - a. Spin/slide correction will use modern methods of tractive effort modulation that are in proportion to the magnitude of the detected spin or slide.
  - b. Sanding will be applied automatically during correction of major spins and slides.
  - c. Sanding will be cancelled at no-motion or if the spin/slide condition is corrected.
  - d. Removal of effort will not be jerk limited during spin/slide corrections.
  - e. The correction system will function as Specified independent of wheel diameter differences.
5. Efficiency:
  - a. Minimum 90% at all adhesion levels down to and including 5%, as measured by an inertial accelerometer on rails with artificially reduced adhesion.
  - b. Calculate efficiency as the ratio of actual acceleration to achievable acceleration, using an Approved calculation method.
  - c. Take measurements only during periods of actual spin/slide activity when wheels are spinning or sliding.

#### 4.7.9 System Response Times

Response time for any change in master controller position within a power or brake mode: Maximum 150 ms, to the resultant tractive effort change, as measured by dv/dt of axle speed.

#### 4.7.10 Jerk Limits

The Contractor will comply with the following:

1. Rate of change in acceleration (jerk): Actively controlled at  $2.0 \text{ m/s}^3 \pm 5\%$ , or other agreed value.
2. Jerk limiting applies:
  - a. To all normal power and service braking applications.
  - b. During all requested changes in power and brake efforts within the same mode, when rate of change request is greater than the limit.
3. Jerk limiting does not apply:
  - a. During emergency brake or manual track brake applications.
  - b. During spin/slide correction.
  - c. During power removal due to loss of primary line voltage.
4. Where the rate of change request is less than the jerk limit: The system will follow the command signal rate of change within Specified accuracy limits.
5. Jerk limiting adjustments:
  - a. For direct mode change between Power and Brake via master controller, jerk limiting of power removal will be canceled when the master controller reaches any brake position.



- b. For overweight vehicles, such as an AW3 vehicle with AW2 effort limit, the effort application rate will be increased to achieve nominal jerk limit.

#### 4.7.11 Mode Change Dead Times (MCDT)

The Contractor will comply with the following:

1. MCDT: Less than 600 ms for the following direct mode changes:
  - a. Power to Brake, from point of jerk limit cancellation (above)
  - b. Coast to Brake
  - c. Coast to Power
2. MCDT for Brake to Power:
  - a. Braking fully dynamic: 300 ms
  - b. Friction brakes involved: 400 ms.
  - c. If traction motors must be magnetized: Less than 1 second, as Approved by the City.
3. MCDT for EB: 400 ms or less, regardless of original mode.
4. Measurement of MCDT: From the time that the control line(s) change(s) state, until the vehicle has achieved 10% of the requested acceleration or deceleration.

#### 4.7.12 No-Motion Detection System

Provide a no-motion detection system complying with the following:

1. Range: System will detect vehicle motion down to, and including, 1 km/h (0.6 mph).
2. Safe signal: System will transmit a signal to indicate no-motion state, for other vehicle systems that require such information.
3. Redundancy: System will monitor all axles and include at least two independent circuits to generate the no-motion state.

#### 4.7.13 Speed Sensing

Provide and integrate speed sensing devices for all systems that require speed information, and as Specified:

1. Systems may share speed information if buffering and isolation between signals is provided, and only as Approved.
2. Integrate systems' requirements to minimize the types of sensors.
3. Select sensor types and installation methods such that mechanical adjustments are not required for installation or replacement.
4. Incorporate speed sensors into truck or gearbox designs, as appropriate:
  - a. Speed sensors will not be shared among systems, except as Approved.
5. Speed sensing devices will meet the requirements of Section 13 Propulsion System.

#### 4.7.14 Rollback Prevention

Design the propulsion and braking systems with sufficiently precise controls to prevent the vehicle from rolling in a direction opposite to that selected by the reverser on any Specified grade:

1. Accelerating from a stop:
  - a. Design systems to limit vehicle rollback until motor torque is sufficient to hold or move the vehicle.
  - b. Maximum rollback distance (AW3 vehicle): ~~75~~ 150 mm (~~3~~ 6 in).
2. Moving MC from motoring, to coast, or to brake:
  - a. Design systems to detect and prevent rollback either by maintaining motor torque to hold the vehicle at zero speed, or by applying friction brakes upon detection of reverse motion.

- b. Maximum rollback distance (AW3 vehicle): ~~75~~ 150 mm (3 6 in).
- c. Maximum speed during rollback (AW3 vehicle): 1.6 km/h (1 mph).

#### 4.7.15 Duty Cycle

The vehicle will operate on the intended alignment, under worst case ambient conditions, without exceeding the thermal ratings of equipment.

##### *Normal Duty*

The vehicle will be capable of operating continuously over the Specified alignment, in all directions, at AW3 passenger loading, on the following duty cycle:

- 1. Full power acceleration to the civil speed for each track segment.
- 2. Maintaining that speed until brake.
- 3. Full-service deceleration to a stop.
- 4. Eight-second dwell time at each station.
- 5. Two-minute layover at each end of the line.

##### *Abnormal Duty*

The Contractor will comply with the following:

- 1. An operating vehicle will have the capacity to tow or push an inoperative vehicle as follows:
  - a. Operating vehicle:
    - i. Full acceleration and braking tractive effort.
    - ii. AW0 weight
  - b. Inoperative vehicle:
    - i. Brakes released (not functional)
    - ii. AW3 weight
  - c. Operating vehicle performs the following:
    - i. Tows or pushes inoperative vehicle to the next available unloading location.
    - ii. Moves empty vehicle to Shop via worst case (most severe duty cycle) routing.
- 2. Dynamic braking on a vehicle or truck inoperative:
  - a. A maximum operating speed restriction may be imposed, as Approved by the City.
  - b. Vehicle will have the capacity to perform the following:
    - i. Travel to the next station at the restricted speed with AW2 load weight.
    - ii. Travel from that station to the Shop at the restricted speed with AW0 load weight.

#### 4.7.16 System Redundancy and Recovery

The Contractor will comply with the following:

- 1. Design the vehicle such that it can continue to operate under failure conditions:
  - a. Provide devices and establish procedures to disable the failed system and allow the remaining systems to continue operation.
  - b. Performance may be limited, except where specifically indicated otherwise.
- 2. The following systems will be physically and functionally redundant and share no components except where specifically permitted:
  - a. Propulsion
  - b. Friction braking
  - c. HVAC
  - d. AC and dc power sources
  - e. OESS; alternative arrangement maybe proposed for review and Approval.

Specific requirements for each system are Specified elsewhere in the TS.

## 4.8 Noise and Vibration Limits

### 4.8.1 General

Unless otherwise noted in the Contract Documents, the Specified noise limits apply to equipment that operates on a regular basis and does not apply to equipment that operates infrequently, such as a circuit breaker or pneumatic pressure relief device. Perform sound measurements as Specified in Section 18 Vehicle and Systems Testing.

### 4.8.2 Pure Tones

The maximum allowable noise levels Specified below will be reduced by at least 3 dB under the following circumstances:

1. Significant pure tones in the range from 250 Hz to 8,000 Hz are present in the noise.
2. Pure tone noise is considered significant in this context if anyone-third octave band sound pressure level is 3 dB, or more, higher than the arithmetic average of the two adjacent bands containing no pure tones.

### 4.8.3 Interior Noise Limits

Interior Noise Limits		
Limit	Location	Conditions
68 dBA	Interior	Vehicle stationary, windows and doors closed, air conditioning equipment operating in full cool, and all auxiliary equipment operating simultaneously under normal operating conditions.
65 dBA	Cab, at seated operator's ear height	Vehicle stationary, windows and doors closed, and air conditioning equipment operating in cooling mode.
75 dBA	Interior	Vehicle operating on the Portland alignment, on smooth rail, at any speed up to 56 km/h (35 mph), and under any acceleration or deceleration condition.
48 dBA	300 mm (12 in) from any lighting fixture	Fixtures installed and energized at rated voltage and frequency.

### 4.8.4 Wayside Noise Limits

Wayside Noise Limits	
Limit	Conditions
70 dBA	Vehicle stationary and empty, air-conditioning equipment operating in full cool, and all auxiliary equipment operating simultaneously under normal conditions.
75 dBA	Vehicle operating on the Portland alignment, on smooth rail, at any speed up to 56 km/h (35 mph), under any acceleration or deceleration condition.

See Section 18 Vehicle and Systems Testing, for detailed noise testing parameters.

#### 4.8.5 Vibration Limits

Comply with the following:

Interior Vibration Limits	
Frequency	Vibration Limit
Below 1.4 Hz	Maximum deflection (peak-to-peak): 2.5 mm (3/32 in)
1.4 Hz to 20 Hz	Peak acceleration: 0.1 m/s <sup>2</sup>
Above 20 Hz	Peak velocity: 0.75 mm/s

Vehicle equipment operation will not cause visible or audible vibrations:

1. Anywhere on the vehicle floor, walls, ceiling panels, or seat frames
2. At any Specified operating speed
3. Under any acceleration or braking condition except emergency braking

#### 4.8.6 Effects of Vibration on Vehicle Equipment

The Contractor will comply with the following:

1. Equipment will operate without damage or degradation of performance when subjected to vibration and impacts encountered during normal service.
2. Equipment will comply with IEC 61373, including functional and durability requirements.

### 4.9 Ride Quality

Design vehicle with ride quality according to ISO 2631 as applicable to the rail vehicle design:

1. Rms acceleration values: Maximum 0.32 m/s<sup>2</sup> for each measurement point for operators and passengers, seated or standing.
2. Vibration total value (root sum of squares summation): Maximum 0.5 m/s<sup>2</sup> for each when calculated for each measurement point.
3. Evaluate acceleration data over the range of 0.5 Hz to 80 Hz. Where appropriate, use frequency weighting Wb instead of Wk.

### 4.10 Electromagnetic Interference (EMI) and Compatibility (EMC)

#### 4.10.1 General

The vehicle, its systems, and its components will not cause EMI that results in malfunctions of the following:

1. Onboard equipment and systems.
2. Existing vehicles on the City alignment.
3. Existing and new wayside equipment, including the following:
  - a. Signaling system
  - b. Train to wayside communications
  - c. GPS/AVL system
  - d. Traffic signal controllers

Limit vehicle emissions as defined below and verify by test as Specified in Section 18 Vehicle and Systems Testing.

#### 4.10.2 Design and Implementation

The Contractor will comply with the following:

1. Limit and apportion individual equipment emissions as necessary to limit point-source emissions and to achieve defined vehicle limits.
2. To contain EMI emissions, wherever possible, suppress transients at their source.
3. Employ design techniques, construction methods, and whatever equipment is required to prevent interference caused by internal sources from affecting the proper operation of vehicle and external systems:
  - a. Coordinate frequencies, EMI levels, and susceptibility levels.
  - b. Provide necessary on-board grounding, balancing, filtering, shielding, modulating techniques, and isolation to meet the requirements of this Section.
  - c. Employ electrostatic and magnetic shielding methods to minimize the effect of stray signals and transient voltages on interconnecting cables.
  - d. Physically separate power and signal cables.

#### 4.10.3 Individual Subsystems

##### *General EMC Compliance*

Each individual subsystem containing electronics will comply with all applicable requirements of EN 50121-3-2 and will be tested for compliance in an EMC testing laboratory, in accordance with Section 15, Testing.

Electronic components and assemblies classified as intentional radiators in accordance with 47 CFR 15.3, Definitions, will comply with provisions of 47 CFR 15 or 47 CFR 90, as applicable for specific devices and their operating frequencies.

Irrespective of qualification test results, Contractor will be responsible to resolve EMC issues arising from operation of equipment in service as provided in 47 CFR 15.5, General conditions of operation.

##### *Conductive and Inductive Emissions*

Each OCS-powered subsystem will comply with conductive emissions limits into high-voltage supply, as apportioned by the Contractor, to meet vehicle-level allocations per the Conductive Emission Limits section, below.

Each individual unit of power equipment will meet the limits indicated below for vehicle-level inductive emission limits into the loop formed by the vehicle and running rails.

#### 4.10.4 Vehicle-Level

##### *Radiated Emission Limits*

Vehicle radiated emissions will not exceed the limits defined by the standards indicated in the table below, when measured in accordance with Section 18 Vehicle and Systems Testing.

Radiated Emission Limits	
Frequency	Limit
9 kHz to 150 kHz	EN 50121-3-1, Annex C, Emission values for lower frequency range
150 kHz to 1 GHz:	EN 50121-3-1
1 GHz to 6 GHz	EN 50121-3-2, Table 3, Emission - Enclosure port

##### *Conductive Emission Limits*

Conductive emissions will have a current limit (amperes rms) defined as follows, when measured in accordance with Section 18 :

Conductive Emission Limits	
Frequency	Limit
30 Hz to 40 Hz:	10 A maximum
40 Hz to 120 Hz:	1 A maximum
120 Hz to 320 Hz:	10 A maximum
320 Hz to 600 Hz:	2 A maximum
600 Hz to 7 kHz:	Limit follows a smooth curve through 2 A at 600 Hz, 0.08 A at 2 kHz, 0.016 A at 4 kHz and 0.0046 A at 7 kHz
7 kHz to 31 kHz:	4.6 mA
31 kHz to 120 kHz:	0.5 mA

#### Inductive Emission Limits

The inductive emissions will be limited as follows, when tested in accordance with Section 15:

Inductive Emission Limits	
Frequency	Limit
20 Hz to 20 kHz:	20 mV rms, rail-to-rail maximum
20 kHz to 31 kHz:	Linear decrease from 20 mV rms to 1 mV rms
31 kHz to 120 kHz:	1 mV rms maximum

### 4.11 Vehicle Safety

#### 4.11.1 General

Design and construct the vehicle to be safe to passengers, persons nearby, and the City's employees and contractors, both under normal operating conditions, and in the event of equipment failure:

1. Perform the required safety analyses and apply safety design requirements, following the City's PTASP.
2. Ensure that all systems' safety aspects have been considered for each individual system, and for systems integrated to complete the vehicle design.
3. Ensure that the vehicle meets the requirements of NFPA 130.
4. Terms used have the following meanings:
  - a. Device: Includes any component, subsystem, or system, whether electrical, mechanical, pneumatic, or hydraulic.
  - b. Failure: Includes both the initial device failure and consequential device failures caused by the initial failure.
  - c. Hazard: A real or potential condition that can cause injury, death, or damage to or loss of equipment or property.
  - d. Permissive: Potential system response that results in a less safe condition such as proceed versus stop, a higher speed versus a lower speed, acceleration versus deceleration, brakes released versus brakes applied, or no actuation of alarm versus actuation of alarm.
  - e. Restrictive: Potential system response that results in a safer condition such as stop versus proceed, a lower speed versus a higher speed, deceleration versus acceleration, brakes applied versus brakes released, or actuation of alarm versus no actuation of alarm.

4.11.2 Vehicle Safety Analyses

*Hazard Listing*

Identify all failure-induced and normal operating (non-failure condition) hazards. In addition to those hazards identified by the Contractor, the following hazards will be included in the hazard listing and will be considered hazards:

1. Emergency brake fails to apply when requested.
2. SBs fail to apply when requested.
3. Propulsion fails to cease when requested.
4. No-motion detection system indicates no-motion when the vehicle is moving.
5. The door opens spontaneously when not commanded.
6. The door opens on the wrong side of the vehicle.
7. Door closes on an obstacle and indicates door closed and locked to control system.
8. Door interlocks erroneously indicate door is closed and locked.
9. Excessive currents or overheated equipment cause fire.
10. Vehicle moves in the wrong direction.

*Hazard Analyses*

Perform hazard analyses on each hazard in the hazard listing:

1. Analyses will demonstrate that the vehicle conforms to the requirements of the TS and that all identified hazards are either eliminated or reduced to levels of risk in accordance with the City's PTASP.
2. Adjust or amend hazard analyses as the vehicle design and construction progresses.
3. Select the analysis methods as appropriate for the system under evaluation and the hazard severity, subject to approval by the City. Demonstrate, by test, the validity of any portion of analyses if requested by the City.
4. Use standard failure and safety analysis methods and publish failure rates for components wherever possible.
5. For each hazard in the hazard listing, submit design documentation. If the design is modified to mitigate a hazard, submit construction documentation.
6. 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 the City's approval.

*Mitigation of Hazards*

Resolve failure-induced and normal operating (non-failure condition) hazards such that the likelihood of injury or damage is remote or improbable:

1. Employ high quality components, proven systems, redundancy, checking devices, and other techniques to resolve hazards.
2. Design and construct vehicle equipment and systems to revert to safe modes under failure conditions.
3. Apply design principles in the Safety Design Principles section, below, to vehicle systems, the failure of which could result in injury to a person or damage to equipment.
4. Prevent unsafe conditions resulting from human error:
  - a. No sequence of operations, or the simultaneous activation of any controls, will result in unsafe conditions.
  - b. Where conflicting commands, such as simultaneous power and brake, are requested, the more restrictive will result.

- c. Arrange maintenance of safety-related equipment such that the effects of errors are minimized. Employ methods such as limitation of adjustment ranges, unalterable software, non-interchangeable parts, and visible wear indicators.

#### 4.11.3 Vehicle Safety Design

##### *Safety Under Normal Operating and Maintenance Conditions*

The Contractor will comply with the following:

1. Protect passengers and operators from hazards:
  - a. Eliminate tripping hazards, sharp points, and edges, lethal or injurious voltages, toxic materials, abrupt or unexpected accelerations, or similar hazards.
  - b. Enhance visibility of step edges, windscreens, controls, and other objects with which the passengers and operators must interface via appropriate selections of location, illumination levels, colors, graphics, and surface finishes.
  - c. Clearly identify normal and emergency equipment and controls that the passengers or operators may operate, and where required, provide operating procedures in both printed and graphic formats.
2. Protect maintenance and operating staff from hazards:
  - a. Manuals and training materials: Clearly identify hazardous materials and equipment and indicate their proper handling, storage, and disposal.
  - b. Maintenance procedures: Clearly identify hazards and provide instructions to reduce or eliminate hazards during the procedure.
  - c. High voltage: Reduce exposure of maintenance personnel to lethal or injurious voltages through compartmentalization, interlocks, and similar measures.
  - d. Cutting hazards: Equipment will be free from sharp points and edges.
  - e. Signage: Clearly label equipment containing hazardous materials, lethal or injurious voltages, or other risks on both the outside and inside of the equipment.

##### *Safety Design Principles*

Incorporate the following design principles into vehicle systems affecting safety:

1. Service proven: Use only components with high reliability and predictable failure modes that have been proven in conditions similar to the projected service.
2. Vehicle environment: Systems will function safely under all combinations of supply voltages, fluid pressures, shock, vibration, dirt accumulation, and the City environment.
3. Devices:
  - a. Use 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.
  - b. The failure of a single device will not result in a permissive condition.
  - c. An undetected failure of any device will not permit a subsequent device failure to result in a permissive condition.
4. Circuits:
  - a. Assume electronic circuits can fail in permissive modes.
  - b. Base systems on closed circuit principles in which energized circuits result in permissive conditions, while interrupted or de-energized circuits result in restrictive conditions.
  - c. Vital circuits not wholly within the system apparatus enclosure will be double-wire, double-break, except for connections to non-vital circuits, which may be single-wire, single-break.



- 
- d. A component or wire becoming grounded will not cause a permissive condition. Keep safety circuits free of any combination of grounds that could permit a flow of current equal to, or more than, 75% of the release value of any safety device in the circuit.
  - e. Select circuit impedances, signal encoding, shielding, layout, and isolation to reduce the effects of interference to the extent that safety is maintained under all conditions.
5. Channels:
    - a. Provide independent channels with independent checking of each.
    - b. All channels will indicate a permissive state for the controlled system to achieve a permissive state.
    - c. Failure in any channel will not affect any other channel, or force the system into a permissive state, unless other actions are required by other parts of the TS.
    - d. Differences in state between channels will be alarmed and will force a restrictive state on the system.
6. Signals:
    - a. Commands that result in permissive conditions will be propagated by a minimum of two independent signals.
    - b. For a controlled system to achieve a permissive state, all signals will indicate a permissive state. The lack of one or more output signal(s) will be interpreted as a restrictive command.
    - c. Variable-level signals:
      - i. Arranging systems such that zero signal level results in the most restrictive condition.
      - ii. A minimum enabling signal, independent from the variable-control signal, will be present before the control signal can modulate the system to a more permissive level.
7. Overcurrent protection:
    - a. Circuit breakers and fuses will be guaranteed by the manufacturer to successfully interrupt rated currents.
    - b. Select circuit breakers and fuses such that the maximum circuit fault currents cannot exceed the manufacturer's guaranteed ratings.
8. Software: Considered unsafe unless verified as safe by an Approved method. Approved methods will comply with the requirements of IEEE 1483 or EN 50128.
  9. Structural: Systems that rely on structural integrity for safety will have sufficient safety factors such that failures are not possible within the life of the vehicle under all possible normal conditions.
10. Mechanical:
    - a. Systems that apply force to achieve safe states will not depend upon the application of fluid pressure or electrical energy, unless specifically Approved by the City.
    - b. Locks, catches, and similar devices affecting safety will be either self-engaging without application of power or, if engaged by application of power, will remain fully and safely engaged in the absence of power.
11. Wear:
    - a. Systems and devices subject to wear will not wear to permissive states within a period equal to a minimum of three times the recommended and Approved overhaul period under the worst-case combination of duty cycle, environment, and all other influences.
    - b. Clearly indicate such systems and devices as SAFETY CRITICAL in the maintenance manuals.

12. Identification: Clearly identify safety related systems, and devices within those systems, as SAFETY CRITICAL in operation and maintenance manuals, procedures, and training materials.

13. False indications:

- a. Failures in equipment that result in an indication of danger, whether actual danger exists, will be considered to have occurred in a safe manner.
- b. A failure that results in an indication of safety when, in fact, a dangerous condition may exist, will not be considered safe.

#### *Fire and Life Safety Design*

The Contractor will comply with the following:

1. Design vehicle components, subsystems, and systems per NFPA 130 for the following:
  - a. 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.
  - b. Protection of system elements from damage by fire or explosion
2. Whenever practical, locate equipment outside the passenger compartment, unless Specified otherwise, to isolate potential ignition sources from combustible materials.
3. Design the articulation, floor, sides, and roof to retard propagation of an underfloor or roof fire to the vehicle interior. Provide firestops at floor and roof penetrations.

#### *4.11.4 Safety Certification Support*

The Federal Transit Administration (FTA) requires a certification program to address safety and security. A Safety Certification process will be implemented by the City, per the City's PTASP, to certify the delivered vehicles:

1. Comply with and support the requirements of the Safety Certification process.
2. Participate in the Safety Certification process and furnish supporting documentation to facilitate required audits of the Safety Certification documentation, as required, by the Department of Transportation and the FTA.
4. The Conditional Acceptance and final determination of readiness of delivered vehicles for revenue service is contingent upon completion of Safety Certification.

#### *4.12 Reliability*

##### *4.12.1 General*

This section includes the reliability demonstration and MDBF requirements. Additional reliability requirements for specific equipment may appear elsewhere in the TS.

##### *4.12.2 Reliability Demonstration*

Demonstrate vehicle reliability during the Demonstration Period, using the Approved Reliability Demonstration Plan (see CDRL section, below):

1. Demonstration Period: Demonstrate reliability in actual revenue service during the warranty period.
2. MDBF: During the reliability demonstration, record all vehicle failures and establish the numerical reliability values (MDBF) for each system.
3. Redesign: Systems that fail to meet reliability goals during the demonstration period will be re-designed and retrofitted by the Contractor, at the Contractor's expense, before the end of the warranty period.

**4.12.3 Mean Distance Between Failures (MDBF)**

Vehicle systems will meet the Mean Distance Between Failures (MDBF) requirements listed below:

1. Assumption: Maintenance, preventive and corrective, is performed as recommended by the Contractor.
2. Mean distance: MDBF is based on actual vehicle mileage.
3. Failures: Unscheduled maintenance activities resulting from equipment failures, whether occurring in revenue service or not.
4. Equipment furnished by the Contractor will be considered as belonging to one of the systems listed below:

<b>MDBF Requirements</b>	
<b>System</b>	<b>MDBF (miles per vehicle)</b>
Vehicle Body & Appointments, including seating, windows, cab equipment	50,000
Propulsion, Dynamic Brake & Controls including gear case	30,000
Friction Braking, including track brake and sanders	20,000
Communications and passenger information	20,000
Passenger Doors, Bridgeplates & Controls	15,000
Lighting Fixtures and Power Supplies	100,000
Electrical, including the vehicle network and cab controls, and apparatus which are not included in other systems. Excludes equipment internal to other systems.	20,000
HVAC	30,000
Trucks & Suspension	50,000
OESS	50,000

**4.13 Maintainability**

**4.13.1 General**

The vehicle will incorporate design standards that minimize Mean Time to Repair (MTTR) and costs throughout its intended useful life.

4.13.2 MTTR Requirements

The quantitative MTTR requirements for the vehicle will consist of the following subsystem requirements:

System Element	MTTR (hours)
Vehicle Body & Appointments	2.13
Propulsion, Dynamic Brake & Controls	1.77
Friction Braking	1.94
Electrical	1.50
HVAC	2.12
Communications (except communications front end)	0.82
Passenger Doors & Controls	0.84
Lighting	0.50
Couplers & Draft Gear	1.50
Trucks & Suspension	1.57
Total	14.7

Notes to Table:

1. The MTTR for each element will be derived from Predicted Mean Time to Repair (PMTTR) analyses as required.
2. The City may approve subsystem MTTRs that take more time than Specified, if the average for any system element is not changed significantly and total MTTR hours for the vehicle are not exceeded.

4.13.3 Scheduled and Preventive Maintenance

Maintenance includes the tasks necessary to service the vehicle, to defer or prevent failures, and to maximize equipment life:

1. Scheduled maintenance tasks will be defined in the Maintenance and Servicing Manual and will be no more frequent or take more time than Specified in the Service Levels Schedule, below.
2. The Contractor's Reliability Demonstration and Maintainability Demonstration will assume the service levels Specified in the Service Levels Schedule, below, with no augmentation.

Service Levels Schedule	
Cycle (Operating Miles)	Scheduled Maintenance Person (In Hours)
1,000	6
10,000	8
20,000	24
30,000	36
150,000	50
300,000	1200 (First Major Overhaul)

Notes to Table:

1. An exception is made for HVAC filter maintenance, which may occur at 5,000-mile intervals, or greater.
2. Scheduled activities during the 10,000-mile cycle will be limited to inspection, filter cleaning or replacement, and replacement of consumables.

3. Ensure that maintenance requirements for vehicle equipment have been established through the operating and maintenance training and manual publication. The City will verify that this schedule can be achieved three months after Final Acceptance of the first vehicle.

#### 4.13.4 Maintainability Demonstration

As part of the training program for maintenance personnel, verify that durations of maintenance tasks fall within the times established by the Scheduled Maintenance Plan (see CDRLs, below):

1. Demonstrate the following and record the duration of each task:
  - a. Selected servicing, scheduled and preventive maintenance, troubleshooting, change-out of components, corrective maintenance, and use of special tools, where special emphasis, instruction, or proficiency is needed.
  - b. Vehicle movement under disabling conditions.

#### 4.14 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 19, Program Control and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

#### 4-1 Vehicle system functional description

#### 4-2 Individual system SFDs

#### 4-3 Vehicle Curve Capabilities:

1. Evidence that the vehicle can operate within Specified limits on the Specified horizontal and vertical curve radii.

#### 4-4 General Arrangement Drawings:

1. Plan, profile, and front elevation drawings of the vehicle exterior, showing visible features, with dimensions.
2. Plan view of seating arrangement, including seat dimensions, and spacing, aisle widths, accessible on-board circulation path, mobility aid parking areas, bicycle areas, and doorway dimensions.
3. Longitudinal section drawings of the vehicle, showing seating arrangements, stanchions, interior steps, cab, and similar features.
4. Plan view drawing of roof equipment, with dimensions.
5. Plan view drawing of under-floor equipment, including trucks, with dimensions.

#### 4-5 Vehicle Detail Dimensions:

1. Detail drawings of vehicle and systems:
  - a. Show compliance with Specified Vehicle Weights and Dimensions.
  - b. Include the location of center of gravity, with vertical, lateral, and longitudinal coordinates.

#### 4-6 Weight Plan and Calculations:

1. Plan view of the vehicle showing standing space.
2. Calculations for each of the weights AW0 through AW4.

4-7 Vehicle Excursions:

1. Drawings showing dynamic vertical and horizontal excursions of the vehicle under normal and worst-case conditions of truck and suspension motions and vehicle body roll on tangent track:
  - a. Show vehicle clearance dimensions with maximum suspension deflection and maximum body roll.
  - b. Identify the location of the roll center(s).
2. Tables showing excursions as under 1, above, with representative curve radii, including the minimum Specified curve radius.

4-8 WRIS Plan, Schedule, and Report:

1. Narrative of how the Wheel Rail Interface study will be carried out, including the following:
  - a. Study procedures
  - b. Personnel involved.
  - c. How the various parties will be coordinated.
  - d. Schedule for conducting the study.
2. Narrative of how the study was carried out.
3. Data collected.
4. Demonstration of compatibility among the following:
  - a. Chosen rail sections.
  - b. Track design
  - c. Vehicle truck design
  - d. Wheels
5. Details of how these are optimized for long term wheel and rail wear, minimum propensity to derail, wheel/rail noise reduction, and ride quality enhancement.

4-9 Load Compensation Design Package

4-10 Emergency Brake System Design Package

4-11 Spin/Slide System Design Package:

1. Slide control safety supervision algorithm

4-12 No-Motion Detection Design Package

4-13 Propulsion, OESS and Braking System Performance:

1. Tractive effort curves and line current for motoring from zero to the vehicle design speed, as indicated in Section 2, at AW0, AW1, and AW2, for line voltages of 525, 625, 750, and 900 Vdc. The charts will include the factors needed to convert effort to torque and speed to rpm.
2. Braking performance curves and brake line-current, including emergency braking, from the vehicle design speed to zero, at AW0, AW1, AW2, AW3, and AW4 showing apportionment between dynamic, friction braking, and track brakes for 900 Vdc and 750 Vdc. The charts will include the factors needed to convert effort to torque and speed to rpm.
3. Speed/time/distance curves for motoring and braking at 525 Vdc and 750 Vdc and at AW0, AW1, AW2, AW3, and AW4.

4-14 EMI/EMC Design Package:

1. Description of the design approach used to ensure that Specified EMC and EMI requirements are met, and that proper emphasis is placed on the control of interference, interface design, and FCC requirements.
2. List of vehicle-borne EMI sources.
3. List of vehicle-borne equipment potentially susceptible to this interference.

- 1        4. Failure conditions, proposed techniques, and methods for resolution of potential EMC problems.

2    4-15 Vehicle Safety Design Package:

- 3        1. Plans, documents, and analyses demonstrating that the vehicle is safe, and complies with this  
4            Section, and other safety requirements in the TS.  
5        2. At a minimum, include the following:  
6            a. A system safety plan, delineating the steps and processes that will be used by the  
7               Contractor to ensure vehicle safety.  
8            b. A hazard listing, as described in this Section.  
9            c. Failure analyses, both top-down and bottom-up, as appropriate, and as Approved,  
10               demonstrating that the hazards identified will not occur.  
11            d. Other analyses, drawings, material property data sheets, or other information  
12               appropriate for demonstrating safety.

13    4-16 Mitigation of Hazards Design Documentation:

- 14        1. Changes that were made to the design to mitigate hazards identified during the Vehicle Safety  
15            Analysis.

16    4-17 Mitigation of Hazards Construction Documentation:

- 17        1. Evidence that design changes made to mitigate hazards were implemented during construction,  
18            as applicable.

19    4-18 Predicted Reliability Design Package:

- 20        1. Predicted reliability of each system, with supporting data.

21    4-19 Reliability Demonstration Plan:

- 22        1. Submit before the start of revenue service.  
23        2. Methods of collecting failure data, analysis of failures, and assignment of failures to the  
24            appropriate system, corrective action processes, and similar processes.  
25        3. Processes by which corrective actions are applied to systems that fail to meet reliability goals.

26    4-20 Predicted MTTR:

- 27        1. Predicted MTTR of indicated systems, with supporting data.

28    4-21 Scheduled Maintenance Plan:

- 29        1. Schedules and activities for the vehicle's corrective and preventive maintenance recommended  
30            by the Contractor and its equipment suppliers.  
31        2. Include the following:  
32            a. Outline of each maintenance task  
33            b. Time schedules  
34            c. Recommended tools  
35            d. Personnel and skill levels required.  
36            e. Periodic updates as required.  
37        3. Verification that actual durations of Specified maintenance tasks demonstrated during training  
38            fell within the times established.

## Section 5 Operator’s Cab

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## 5.1 General

### 5.1.1 Scope

This Section includes controls located in or originating from the operator's cab at each end of the vehicle. The cab area will contain all controls, displays, and appurtenances necessary for normal and abnormal vehicle operation.

Design and furnish the cab as Specified in Section 6 Interior and Exterior Appointments.

### 5.1.2 Controls and Indicators

The Contractor will comply with the following:

1. Locate all controls and indicators necessary for vehicle operation in the cab.
2. Provide status and fault indicators for all systems.
3. Provide Specified controls and indicators in both cabs; cabs will be identical.

## 5.2 Cab Console

### 5.2.1 Cab Console Design

Design Cab Console such that operator has good visibility of controls and labels.

### 5.2.2 Cab Console Layout

The Contractor will comply with the following:

1. Unless otherwise Specified or permitted in the Contract Documents, locate controls and indicators on the Cab Console directly in front of the operator's seat.
2. Arrange controls in an ergonomic manner based on the relative frequency and criticality of each task, the size range of operators as Specified in Section 6 Interior and Exterior Appointments, and the design principles of The Measure of Man and Woman: Human Factors in Design ("Measure of Man and Woman").
3. Arrange controls according to frequency of use, design to avoid unintentional activation, and locate to minimize reach and to reduce operator strain and fatigue.

## 5.3 Master Controller Group

### 5.3.1 General

The MC group consists of a MC key switch, Reverser switch, and MC. Alternative arrangements with functionality like that described below may be considered by the City.

### 5.3.2 Master Controller Key Switch

Provide a two-position MC key switch to select cab status. Interlock the MC key switch with the MC and Reverser switch, as described in the Reverser Switch and Master Controller sections, below. Provide the following functionality:

1. MC key moved to On position:
  - a. The Cab Console, cab controls and displays, hotel load systems, and all other vehicle systems activate and function in their normal operating modes.
  - b. Systems already energized remain energized without interruption.
  - c. Doors remain in last commanded state (OPEN, CLOSED, or RELEASED)
  - d. Cab Console controls and indicators in the other end of the vehicle are disabled, except as Specified otherwise.
  - e. The MC key will not be removable in this position.

- f. Keying more than one MC key switch On in a vehicle will be detected by software and considered an invalid command, and the additional cab will not be activated. Annunciate the attempt to activate an additional cab on the TOD in both cabs.
- g. During vehicle startup, no system shall be erroneously activated; example Track Brakes activate due to EB and no-motion circuits not being energized.
2. MC key moved to Off position (both cabs OFF):
  - a. Hotel Load timer activates (see description of operation below).
  - b. The Cab Console and other cab controls de-activate and are non-functional, except the following remain active:
    - i. Emergency Brake pushbutton
    - ii. Battery charging
    - iii. Systems maintained by the Hotel Load timer.
  - c. Doors remain in the last commanded state (OPEN, CLOSED, or RELEASED)
  - d. The MC key will be removable in this switch position.

Additional MC key switch and cab interlock controls are detailed within this Section.

### 5.3.3 Reverser Switch

Provide a three-position Reverser switch with these positions: Reverse, Neutral, Forward.

1. Interlock MC key switch and Reverser switch as follows:
  - a. Reverser switch cannot be moved from the Off position unless the associated MC key switch is in the On position.
  - b. MC key switch cannot be moved from On position unless Reverser switch is in the Off position.
2. Electrical Interlocking:
  - a. Vehicle operation will not be possible unless the Reverser switch in controlling cab is in either Forward or Reverse position.
  - b. Reverser switch and MC: MC handle must be in MSB position to move Reverser switch out of either Forward or Reverse position.
  - c. Initiate MSB if forward and reverse commands are given simultaneously, record error state by MDS, and indicate error on TOD.

### 5.3.4 Master Controller

#### General

Provide a MC to allow manual selection of braking and motoring efforts. The MC will be arranged to move linearly fore and aft; motoring in the forward direction and braking towards the rear (that is, towards the operator).

#### Ergonomics

The handle will be shaped, located, and oriented to minimize strain and fatigue on the operator, matching existing fleet. Locate the MC for left hand operation.

#### Handle Positions

There will be distinct tactile positions in the handle travel, indicated by stops or detents, as indicated below:

Function	Position/Tactile Indication
Maximum Brake (MB):	Stop (rearmost position)
MSB (MSB):	Detent

Coast:	Detent
Maximum Power:	Stop (forward-most position)

Notes to Table:

- Between Maximum Power and MSB, braking and power efforts will be linearly proportional to handle position.
- The MC will stow in the MSB position when the cab is inactive.

#### Deadman

The MC handle will incorporate a Deadman feature with associated circuitry, to perform as follows:

- The MC handle shall rotate in a counterclockwise direction to engage the Deadman, the movement will be reviewed and Approved by the City.
- Release of the Deadman at any MC position other than MSB or MB:
  - Initiate an audible alarm.
  - After a two-second time delay apply MSB.
- If Deadman is picked up during the alarm and before MSB is initiated, the dead man timer will be reset, and the alarm cancelled.
- Once a Deadman-initiated MSB is applied, MSB will remain applied and cannot be released by the MC until the vehicle has achieved no-motion and the MC is placed into a MSB or MB position.
- MC handle in MSB or MB position: Deadman function will be disabled.

The circuit and timing function will be a safe function as defined in Section 4 .

## 5.4 Cab Console Switches

### 5.4.1 General

Comply with the following requirements for switches:

- Type: Heavy-duty industrial grade, IP65 rated in conformance with IEC 60529.
- Illuminated Type: Backlighting by LEDs.
- Identification: Provide a durable and permanent label for each control switch.

### 5.4.2 Summary of Control Functions with Basic Switch Types

Provide control functions on the Cab Console as shown in the following table. Typical switch and control types are presented, although the Contractor may propose alternative designs, including via TOD touch screen, if similar functionality is provided. Additional control functions with special requirements are described separately.

<b>Summary of Control Functions with Basic Switch Types</b>	
<b>Control Function</b>	<b>Type Code (see key below)</b>
Master Controller Group	See Master Controller Group Section, above
Left Door Close	MPB (illuminates green)
Left Door Open	MPB (illuminates red)
Left Door Release	MPB (illuminates yellow)
Right Door Close	MPB (illuminates green)
Right Door Open	MPB (illuminates red)
Right Door Release	MPB (illuminates yellow)
Wiper, Off/Intermittent/Low/High	4R
Wiper Delay Adjust	Rotary Potentiometer
Windshield Washer, On/Off	MPB
Headlight, High/Low	LPB or MPB (illuminates for high beams)
Turn Signal, Left/Off/Right	2PJSS
Hazard Lights, On/Off	LPB or MPB (illuminates yellow)
Cab Ceiling Light (general Illumination) On/Off	LPB or MPB (illuminates while active)
Cab-Console-Mounted Light, dimmer	Rotary Potentiometer
Cab Console lights and indicators dimmer	Rotary Potentiometer
Indicator Lamp Test	MPB (illuminates while active)
Horn, On/Off (automobile warning)	MPB
Bell, On/Off (pedestrian warning)	MPB (illuminates while active)
PA	MPB (illuminates while active)
Cab-to-Cab Intercom	MPB (illuminates while active)
Passenger Emergency Intercom acknowledge/pick up call on hold	MPB (illuminates while active)
Windshield Heating (embedded heater)	MPB (illuminates while active)
Cab Heater Off/Fan/Low Heat/High Heat	4R
Track Brake, On/Off	MPB (illuminates while active)
Emergency Brake	See switch description below
HSCB (Propulsion) Reset	MPB
Pantograph Up/Down	3MTRC or MPB (illuminates while active)
Auxiliaries On/Off	See switch description below
TWC Control Module	See Section 8.15
Left Bridgeplate Retract/Extend	MPB (illuminates while extended)
Right Bridgeplate Retract/Extend	MPB (illuminates while extended)
Wireless Operation	MPB (illuminates while active)

1

<b>Type Code Key</b>	
LPB	Pushbutton with latching circuitry (push on, push off)
MPB	Momentary pushbutton
3MTRC	Three-position momentary toggle switch, spring return to center
2PJSS	Two-position joystick selector switch
4R	Four-position rotary
Rotary Potentiometer	Continuously adjustable control

2

Notes to Tables Above:

1. If the Cab Console and other cab lights do not have integrated dimming functionality, dedicated LED PWM supplies will be provided and controlled by the dimmer potentiometers.
2. Provide the indicated latching functions using electrical circuitry or software. Mechanically latching switches are prohibited, except for the emergency brake switch described below.
3. Pushbutton switches will be flush or recessed to prevent inadvertent operation.
4. Illuminated switches will show the state of the controlled circuit, not the state of the switch.
5. The Indicator Lamp Test will illuminate all discrete indicators on the console.

#### 5.4.3 Emergency Brake Switch

The Contractor will comply with the following:

1. Type: Heavy duty, industrial grade self-latching pushbutton gang switch with a large, red mushroom-shaped twist or lift to unlatch actuating head.
2. Location: Cab Console in each cab.
3. Configuration: The switch mechanism will 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.
4. Strength: The actuation mechanism will be sufficiently robust such that striking the mushroom head will ensure breaking the circuit even with welded contacts.
5. Function: will be functional in all cabs, regardless of cab active status. See additional control requirements below.
6. Release: Twist to unlatch an activated (latched) EB pushbutton.
7. Circuits: The active cab will energize the only power and return circuits for control of all emergency brake equipment in the vehicle.

#### 5.4.4 Special Switch-Layout Requirements

Comply with the following layout requirements for specific switches:

1. Passenger Doors: Position controls for safe actuation, with the right-side door controls on the right side of the Cab Console, and the left-side door controls on the left side of the Cab Console.
2. Pantograph Up/Down: Locate near HSCB reset and away from commonly used controls.

### 5.5 Foot Switches

Provide a footswitch for manual operation of the sander system. The switch will be of the momentary, spring-loaded type.

### 5.6 Cab Console Indication and Annunciation

#### 5.6.1 General

Comply with the following requirements for indicators:

1. Type: LED, heavy-duty industrial grade devices, IP65 rated in conformance with IEC 60529.
2. Activation: Indicators will illuminate only in the active cab.
3. Identification: Provide a durable and permanent label for each indicator, on the indicator itself, wherever possible.

#### 5.6.2 Cab Console Indication and Annunciation

Provide indications in the cab as shown in the table below. Indicating switches (illuminate to show state of circuit) are shown above in the Cab Console Switches section:

Indication/Annunciation	Symbol/ Action	Activation Description
Left turn signal	Left-facing arrow/ flashing	Flashes when corresponding turn signal is active
Right turn signal	Right facing arrow/ flashing	Flashes when corresponding turn signal is active
Odometer		See below
Passenger Stop Request	Visual and audible	Illuminated when request is made. Audible alert one first activation
Interior Manual Door Release (Passenger Emergency Switch)	Visual and audible	Illuminated when active
Door Open or Unlocked	Visual and audible	Illuminated when active
Door Cutout	Visual	Illuminated when active
Overhead Heat high-limit temperature indication	Visual	Illuminated when active
Tripped or Open HSCB	Visual	Illuminated when active
Passenger Bridgeplate Request	Visual and audible	Illuminated when request is made. Audible alert one first activation
Bridgeplate Extended	Visual and audible	Illuminated when active
Bridgeplate Cutout	Visual	Illuminated when active
Wireless-operation Mode	Visual	Illuminated when active

#### Notes to Table:

- Some of these annunciations may be part of the TOD, if Approved by the City.

## 5.7 Other Displays and Control Groups on the Cab Console

### 5.7.1 Train Operator Display (TOD)

The TOD will be part of the Monitoring and Diagnostic System (MDS) Specified in Section 7 Electronic Controls, Software, and MDS.

Provide a TOD in the cab complying with the following requirements:

- Location: Near the center of the Cab Console, in a location free of glare and reflections under all natural and artificial lighting conditions.
- Purpose: Display information useful to the operator when the vehicle is in motion or during a normal station stop, including all status indications. Provide vehicle control functions, as Approved, via the touch screen interface.
- Odometer: The propulsion system will transmit distance information to the MDS that will display the odometer mileage for the vehicle on the TOD, or on a dedicated display. An alternative source for the distance information to the odometer may be presented during design review.

### Wireless operation

- Wayside transition command received.
- Wireless operation mode.
- OESS State of Charge: Indicate each OESS capacity as a percentage of maximum capacity.
- OESS Conditions Warnings: Flashing and colors, indicating OESS faults, SoC at unacceptable levels, and similar abnormal conditions.
- OESS HSCB Open/Closed if one is provided separate from the propulsion HSCB.

6. OESS SoC Low Level Visual and Audible Alarm: Include in the audible alarms that are acknowledged by the sealed Audible Alert Bypass switch located in the Bypass Control Panel.

#### 5.7.2 Surveillance Display Screen

Provide a display screen in each cab for viewing interior or exterior surveillance cameras; additional details see Section 6.10.8 Surveillance Display Screen.

1. Arrange display to be viewed easily by seated and standing operators.

#### 5.7.3 Speedometer

Provide a speedometer display:

1. Size: Minimum diameter 120 mm (5 in).
2. Range: 0 to 50 mph, spanning approximately 270 degrees of the face, with speed indicated in miles per hour and kilometers per hour.
3. Illumination: Evenly illuminated over the entire display, with a dimmer control.
4. Color of indicator and face: Select for maximum visibility, as Approved by the City.
5. Accuracy: +/- 2.5% of actual vehicle speed or better.

Provide a dedicated speed sensor, or a speed processed by one of the vehicle systems, and automatically compensate speed signal for actual wheel diameter.

#### 5.7.4 Discrete Indicator Group

Provide a minimum of 12 LED indicators that duplicate selected status indications shown on the TOD. Indicators will give sufficient information to the operator to allow safe operation of vehicle in service with a non-functioning TOD.

At a minimum, the group must continuously display the following indications:

1. Door Closed
2. Bridgeplate retracted.
3. Brake Released
4. Bypass Active
5. Wireless-operation mode

#### 5.7.5 Radio and Communications Group

Provide space for future installation of vehicle radio chargers, for handheld radios, located on the right side of Cab Console, close enough to allow the operator easy access.

Provide a separate APIS Control Panel to the left of the radio charger. APIS control may be incorporated into TOD with the City's approval.

#### 5.7.6 TWC Group

Provide a TWC Cab Control Panel in each cab. TWC status information will be shown on the Operating Status Screen of the TOD.

### 5.8 Cab Console Functional Descriptions

#### 5.8.1 Scope

This section includes specific functionality that originates in the cab. Other cab functionality, and functional descriptions for systems that require a response from the operator, such as passenger emergency intercom and passenger stop request, are described in other sections of the TS.



## 5.8.2 Door and Bridgeplate Controls

Provide door and bridgeplate operator controls as Specified in Section 9 Passenger Doors.

## 5.8.3 Public Address (PA) System

Provide the following:

1. The operator will be able to select where operator PA announcements are broadcast:
  - a. Interior, exterior or both.
2. Operator-initiated PA messages will override, passenger information system messages, and door system messages generated from the APIS.

## 5.8.4 Initiation of APIS Announcements

Provide with the following:

1. APIS announcements will be initiated by the operator entering a route ID number, which will determine which message sequence, and special features are to be used by the system.
2. The present location of the vehicle in the route's station sequence may also be entered if vehicle location is not known at initiation.
3. Once initiated, the system will be automatic, as Specified.
4. System initiation will also establish the settings for the end destination signs in each cab and side destination signs in the vehicle.
5. The system will give a positive indication to the operator when all signs in the vehicle are connected and functioning.

## 5.9 Other Cab Controls

### 5.9.1 General

For devices located off the Cab Console, comply with requirements for Cab Console switches and indicators in the sections above.

### 5.9.2 Bypass/Aux Switch Control Panel

Provide a Bypass Control Panel mounted under Cab Console on right side of operator. At a minimum, include the following switches, bypass controls, and switch types in the Bypass/Aux Switch Control Panel:

Control	Type
Auxiliaries Switch, Off/On	3MRC
Audible Alert Bypass	MPB or Rotary, sealed
No Motion Bypass	MPB or Rotary, sealed
Door Interlock Bypass	MPB or Rotary, sealed
Pantograph-Down Bypass	MPB or Rotary, sealed
Friction Brake Applied Bypass	MPB or Rotary, sealed
Propulsion cutout	Sealed rotary
Tow mode	MPB or Rotary, sealed
Hill climb	MPB or Rotary, sealed
OESS load shed	MPB or Rotary, sealed
OESS cutout	Sealed rotary
<b>Type code key</b>	
MPB	Momentary pushbutton (illuminates while active)
3MRC	Three-position momentary rotary, return to center

The sealed bypass switches listed above will function as described below:

1. Seal: Breakable by the operator without the need for tools.
2. Bypass Active indication: Will illuminate if any bypass switch is activated and will flash if more than one bypass is active.
3. MPB: Illuminates when bypass is active
4. Bypass circuitry will be Type I circuits, except as Approved by the City.
5. Availability: Bypass switches will be enabled only if the MC key switch is ON in the same cab as the bypass switches.
6. Automatic Reset: When MC key switch is switched Off, all bypassed systems will return to normal function and remain so when that cab's MC key switch is returned to On position.
7. Audible Alert Bypass: Acknowledges and cancels the following audible alarms:
  - a. Emergency door operating device activated.
  - b. Friction brake or dynamic brake fault
  - c. OESS SoC low level audible alarm
8. No-Motion Bypass: This switch will bypass the local no-motion detection circuits, which prevent door operation.
9. Door Interlock Bypass: This switch will bypass the summary door interlock circuit, which prevents propulsion in the event of an open door (see also Section 6, Passenger Doors).
10. Pantograph-Down Bypass: Bypasses the pantograph-down interlock, which prevents wireless-operation unless the pantograph is down and allows battery drive operation to be initiated with the manual Battery Drive Mode switch.
11. Friction brake applied bypass: Allows propulsion to move the vehicle when there is a brake applied indication.
12. Propulsion cutout: Allows propulsion unit to be cutout.
13. Tow mode: If need, will increase tractive effort for AWO vehicle.
14. Hill Climb mode: Will increase tractive effort for maximum 2 minutes, user adjustable.

#### 5.9.3 Wireless-Operation Switch

Provide the following:

1. Purpose: To permit manual control of wireless operation by the vehicle operator, if automatic operation malfunctions, or wireless operation is required at other locations.
2. Location: Cab Console, adjacent to the Pantograph Up/Down switch(es).
3. Function:
  - a. Active always when a cab is keyed on.
  - b. Initiates and terminates off-wire operation, including lowering and raising of the pantograph.
  - c. Manages vehicle equipment loads and pantograph currents during on- and off-wire transitions, using controls and interlocks as Specified above for automatic operation.

#### 5.9.4 Wireless-Operation load shedding switch

Provide with the following:

1. Purpose: To allow manual load shedding for situations where the vehicle is expected to be stuck in a wireless segment for an extended period with passengers on board, such as a serious car accident or traffic jam.

2. Type: Momentary pushbutton, sealed. See general requirements for bypass switches in Section 5, Operator’s Cab, and Controls. Alternative arrangements maybe proposed for review and Approval by the City.

3. Location: Bypass control panel.

4. Function: Initiates a pre-defined load shedding scheme as Approved by the City.

#### 5.9.5 OEES cutout Switch:

Provide the following:

1. Purpose: Isolate an OEES unit from vehicle circuits, permitting continued operation with the remaining OEES(s).

2. Type: Sealed rotary or toggle switches, one per OEES unit

3. Location: Off the console with other cab cutout switches

#### 5.9.6 Hotel Load Timer

Provide a user-programmable timer that controls the hotel load system and functions in conjunction with the Auxiliary On/Off switch, below:

1. Enabled: Only when no cab is active.

2. Activated: Whenever MC key switch is switched Off, or if Auxiliary On/Off switch is switched to On.

3. Hotel load systems: HVAC, cab heat, interior lights, exterior lights, passenger door controls.

4. Timer setting: Adjustable from 1 to 60 minutes in 1-minute increments, initially set to 20 minutes.

5. Upon activation:

- a. Resets timer to full value, and turns On all hotel load systems, into their normal operating states.

- b. If hotel load systems are already ON when the timer is activated, maintains those systems in their ON state without interruption.

6. End of the timer setting: Shuts down hotel load systems and activates HVAC layover mode, as Specified.

7. Delayed Off: When Auxiliary On/Off switch is placed in Off position, and the Hotel Load timer has not expired, set the timer for 1 minute. The Delayed Off time setting will be user settable to any value less than the timer setting, including zero.

#### 5.9.7 Auxiliary On/Off Switch

Provide an Auxiliary On/Off switch in each cab that functions in conjunction with the Hotel Load timer, above:

1. Switch type: Momentary, three-position, return to neutral center.

2. Enabled: Only when no cab is active.

3. On position: Activates the Hotel Load timer.

4. Off position:

- a. Sets the Hotel Load timer to the Delayed Off setting.

- b. Coordinate between Auxiliary Off command and other vehicle systems as necessary for HVAC shut down procedures.

5. Activating a cab will return auxiliaries control to the active cab.

6. Exterior Auxiliary On/Off function: See Crew Door-Switch.

5.9.8 Sander Control

Provide the following:

1. Automatic: System will apply sand in response to emergency brake applications and spin/slide activities.
2. Manual: System will apply sand in response to operation of the Manual Sander switch by the operator. Manual operation of the sanders via the switch will not be canceled below the no-motion detection point.

5.10 Automatic Controls

5.10.1 Interior Lighting Control

Lighting in the passenger compartment will be ON whenever either cab is ON. It will remain active with both cabs OFF when controlled by the Hotel Load timer or the Auxiliary On/Off.

5.10.2 Exterior Lighting Control

With an active cab and Reverser Switch in Neutral, or the Hotel Load timer is active:

1. Red marker lights at both ends of vehicle are illuminated.
2. Amber marker lights on the sides of vehicle are illuminated.
3. Taillights on the front and rear ends of vehicle are illuminated.

With a cab active, Reverser Switch in Forward or Reverse, as determined by the forward and reverse directional control lines:

1. Amber marker lights on the front end of vehicle are only illuminated.
2. Red marker lights on the rear end of vehicle are only illuminated.
3. Amber marker lights on front sides and midpoint of vehicle only are illuminated.
4. Red marker lights on rear sides of vehicle only are illuminated.
5. Headlights only at the front of vehicle are illuminated.
6. Taillights only at rear of vehicle are illuminated.

Stop lights will be illuminated at the rear of the vehicle whenever a direction has been selected and any brake mode has been selected, including manual track brake application.

5.10.3 HVAC Control

Provide HVAC control as follows:

1. Passenger compartment:
  - a. HVAC system will activate automatically whenever the MC key switch in either cab is placed in the On position.
  - b. HVAC system will remain active when both cabs are OFF until the Hotel Load timer expires or when activated by the HVAC layover mode.
2. Operator’s cab:
  - a. Cab air comfort controls will activate automatically when a Cab Console is activated and deactivate after a time delay when the Cab Console is deactivated. See Hotel Load timer section, above.

5.10.4 Parking Brake Control

Parking brake will be applied automatically when reversers in each cab are both in the Neutral position.

## 5.11 Control Configurations and Interlocks

### 5.11.1 General

Control of the vehicle will be via control signals, as Specified in Section 7 Electronic Controls, Software, and MDS. Unless otherwise indicated in the Contract Documents or Approved by the City, all control signals, interlocks, and other vehicle controls will operate from the low-voltage power supply.

### 5.11.2 Cab Interlock

Interlock cab controls using control lines and associated circuitry such that no more than one cab can take control of a vehicle at the same time; interlocking will be accomplished by relay logic.

### 5.11.3 Direction Control

Direction signals will be given by a pair of control lines, designated Forward and Reverse:

1. Direction signals will originate at the controlling cab's Reverser Switch, or as Approved.
2. Arrange associated circuitry such that one control line must be energized while the other must be de-energized for correct operation.
3. Energization or de-energization of both control lines at the same time will inhibit propulsion and display a fault on the TOD.

### 5.11.4 Track Brake Control

Provide a track brake switch for operator control of track braking:

1. Location: Cab Console in each cab.
2. Switch type: See switch requirements above.
3. Switch function:
  - a. Activate all track brakes on the vehicle.
  - b. Will not inhibit propulsion.

### 5.11.5 Hazard Lights

Provide a hazard light switch to cause turn signals to function as hazard lights:

1. Location: Cab Console in each cab.
2. Switch type: See switch requirements above.
3. Activation: Switch will always be enabled in all cabs.
4. Switch activated: All turn signals in the vehicle flash.
5. Deactivation: Lights will remain flashing until the switch is turned Off, regardless of cab activation.

Hazard light indicator: Illuminates and flashes only in the cab with the activated switch.

## 5.12 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

- 1 5-1 Master Controller Group Design Package
- 2 5-2 Cab Controls Design Package:
- 3     1. Manufacturer’s literature and detail drawings for each type of switch and indicator, and for
- 4         displays and devices not submitted under other sections.
- 5     2. List names of switches and indicators for which each submitted type will be used.
- 6     3. Drawings of all controls, indicators, and labels with components identified.
- 7 5-3 Control Configuration and Interlocks Design Package

## Section 6 Interior and Exterior Appointments

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## 6.1 Scope

This Section describes interior finishing, including liners, insulation, floor covering, seats, and windows; layout and design of the operator's cab and Cab Console; exterior finishing; and other such features and appurtenances.

## 6.2 Interior Finishing

### 6.2.1 Materials

Provide the following types of materials:

1. High-durability, low-maintenance, as Specified or as Approved by the City.
2. Conforming to flammability, smoke emission, and toxicity requirements as specified.
3. Color will extend all the way through materials except FRP and melamine (where FRP and melamine are Specified).

### 6.2.2 Design and Workmanship

Provide the following:

1. The vehicle interior will be free of sharp corners or edges.
2. Surfaces will be free from tooling marks, gaps, distortions, and other visible defects.
3. Surfaces will be rigid and supported to prevent sagging, drumming, and vibration.
4. Gaps between fittings that are not rigid will be wide enough to prevent injury when one or more fittings moves or provide rigid spacers to prevent the gap from closing.
5. Like components will be interchangeable with like locations, and between vehicles. Panels, linings, masks, trim, and other interior finishing materials will be manufactured to finished dimensions and installed without modifications, except where specifically Approved by the City.

### 6.2.3 Interior Linings

#### Walls

Provide the following:

1. Side Wall Material:
  - a. Balanced melamine, FR Grade, minimum thickness 3.2 mm (0.125 in)
  - b. Thermoplastic sheet
  - c. FRP
  - d. Aluminum sheet with a melamine cover
2. Side Wall Joints:
  - a. Maximum one joint per wainscot section between side entrance doors and in each passenger compartment level.
  - b. Hide joint from view with seats, where appropriate.
3. End walls, bulkheads, and door pocket panels: Cored construction, **alternative design maybe proposed**, to be Approved by the City.
4. Window masks: Provide at vehicle-body windows, including windshields:
  - a. Slope masks to eliminate dirt collecting areas.
  - b. Support and cover joints with moldings.
  - c. As an alternative, if glued-in windows are not selected, wide glazing strips may be used which extend to and engage the lining panels.
5. Moldings: Colors of moldings on exposed surfaces will be compatible with the colors of the other materials in the vehicle.

*Ceiling*

Ceiling between air diffuser-light fixture assemblies:

1. Material: Melamine-faced panels with an aluminum honeycomb core, minimum thickness 10 mm (3/8 in); or other materials and thicknesses if Approved by the City during design review.
2. Ceiling panels: Individually removable. Provide trim caps between panels. Alternative designs maybe proposed for review and approval by the City.
3. Joints:
  - a. Transverse joints: Space no closer than 1220 mm (4 ft).
  - b. Longitudinal joints: Not permitted.
4. Support: Ceiling panels may be supported by the air-distributor/light-fixture assemblies and by hinges welded to the roof structure. Hinges will be no greater than 1015 mm (40 in) apart.

Ceiling Cove Area (outboard of light fixtures):

1. Material:
  - a. Melamine-faced aluminum, minimum thickness 2.0 mm (0.08 in).
  - b. Molded fiberglass reinforced composite
  - c. Alternative materials maybe proposed for review and Approval by the City.
2. Alternatively, panels may be formed by extensions of the window masks, or maybe flat diagonal sections, using the above materials.

*Support and Installation of Interior Linings*

Mechanically fasten interior linings to their supporting surfaces:

1. Fasteners will not be exposed to passengers unless specifically Approved.
2. Alternatives that bond the interior panel to the exterior wall as a unitized replaceable assembly may be considered.
3. The mounting will accommodate dynamics of vehicle movement without transmitting stress to the liners; unless not possible by design restriction, as Approved.
4. Provide minimum 25 mm (1 in) radius cove at intersecting adjacent surfaces.
5. Provide "anti-squeak" tape between all linings or panels and any structure to which they are attached or with which they come into contact.

*Access Panels*

Provide access panels in the vehicle interior lining where required, as Approved by the City; intended purpose access equipment or maintenance items. Comply with the following:

1. Interchangeability: Manufacture panels, hardware, and their interface to the vehicle body with sufficient tolerances to allow exchange of panels of like size anywhere in the vehicle.
2. Material: Matching the surrounding lining.
3. Latches: Quick-release fasteners, as Specified.
4. Ceiling Access: Panels and grilles will be hinged and equipped with safety catches.
5. Equipment Enclosures: See Equipment Enclosures section, below.

*Equipment Supports*

Support equipment directly from the vehicle structure or via hangers welded to the vehicle structure. Ceiling panels and wall linings will not be used to support equipment or equipment lockers.

#### 6.2.4 Interior Finishes

Comply with the Interior and Exterior Design Package and the following:

1. Interior metals: Painted, with the following exceptions:
  - a. Exposed stainless steel (except for floor covering): Provide an Approved brushed finish with grain direction arranged to be consistent with the decorative scheme. Paint only as required by the Approved Interior Design Package.
  - b. Aluminum: For interior applications not exposed to passengers, aluminum may be unpainted, but if unpainted must be anodized.
2. Powder Coat: Powder coat may be applied only to items that can be removed for recoating.
3. Durability: Color and finish will be fade-resistant and will not change appearance or run when exposed to interior lighting, sunlight, or chemicals typically used to clean vehicles.
4. Graffiti Resistance: Walls and ceilings will be graffiti resistant to ASTM D6578/D6578M, using cleaning agents agreed by the City, with a pass rating of 5, minimum.
5. Gloss: Interior surfaces will have a low-glare finish with a glossometer reading between 4 and 15, per ASTM D523, machine direction, using a 60-degree glossometer, or as outlined in the Approved Initial Interior and Exterior Design Package.

#### 6.2.5 Articulation

Comply with the following:

1. Design and construct flooring, walls, and other moving components such that their movement creates no audible noise under all conditions.
2. Design and size gaps between articulation section and interior panels to prevent injury. Gaps in the articulation portion of the passenger compartment will not increase or decrease in width, to be hazardous to persons, under any conditions.

### 6.3 Insulation

#### 6.3.1 Acoustical Insulation

Provide sound and vibration-damping insulation:

1. Material:
  - a. Resistant to dilute acids, alkalis, greases, gasolines, aliphatic oils, and vermin.
  - b. Compliant with flammability, smoke emission, and toxicity requirements in as specified.
2. Location:
  - a. Provide on 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).
  - b. Provide on articulation close off panels and bellows.
3. Installation: Clean and prime surfaces before installation in accordance with Section 19 Materials and Workmanship.

The City may consider alternatives such as sandwich insulation between interior panels and the exterior wall as a unitized replaceable assembly.

#### 6.3.2 Thermal Insulation

Provide thermal insulation:

1. Material:
  - a. Fiberglass: Manufactured from long, textile-type glass fibers drawn from a calcium borosilicate mixture to an average diameter of 9 microns.
  - b. Bonding agent: Thermosetting phenolic resin not exceeding 15% by weight.

- c. High-temperature limit: Minimum 230 degrees C (446 degrees F).
- d. Alternatives that sandwich insulation between interior panels and the exterior wall as a unitized replaceable assembly may be considered.
- e. Material will not:
  - i. Mold, rot, or sustain vermin.
  - ii. Corrode metals.
  - iii. Settle because of vehicle vibration
  - iv. Have an odor or be capable of absorbing odors.
- 2. Location: Insulate roof, sides, and ends of the vehicle, including inside faces of posts and structural members.
- 3. Density:
  - a. Fill the entire volume of the available cavity.
  - b. Select density of fiberglass insulation consistent with vehicle-body transmission heat loss/gain.
- 4. Installation:
  - a. Roof: Retain insulation using stainless steel wires or strips.
  - b. Side and end-walls: Retain insulation using spears or other ft method. Take steps to ensure that sharp, pointed ends are not a hazard to personnel or maintenance equipment.
  - c. Floor: Insulate with two layers of equal thickness of fiberglass separated by a vapor barrier. Place this insulation in the structural floor between the transverse floor beams and fill the entire volume of the available cavity. Floor insulation will be compatible with the material used at each insulated location in the vehicle structure.

#### 6.3.3 Urethane Foam Prohibited

The use of urethane foam insulation is prohibited.

### 6.4 Floor Covering

#### 6.4.1 General

Provide floor covering and accessories that result in a durable, watertight, textured covering for the floor panels and other vehicle structures. Floor color and pattern will be determined by the City during design review.

#### 6.4.2 Floor Material

Comply with the following requirements for floor covering material:

- 1. Rubber material:
  - a. Water and chemical resistant.
  - b. Fully homogeneous throughout, meeting requirements of ASTM F1344.
  - c. Rubber flooring will bend around a 20 mm (0.8 in) diameter mandrel without breaking, cracking, crazing, or showing any change in color.
  - d. Flammability, smoke emission, and toxicity: In accordance with Section 19 Materials and Workmanship.
- 2. Static coefficient of friction: Minimum 0.6 measured in accordance with ASTM D2047, using leather and rubber shoe materials meeting these requirements:
  - a. Leather shoe material: Federal Specification KK-L-165C
  - b. Rubber shoe material: ASTM D1630

**6.4.3 Specific Applications**

Provide the type of floor material indicated below for the Specified locations:

1. Seat areas: Smooth rubber sheets.
2. Aisles and other walking areas: Ribbed or non-slip grit surface, as Approved.
3. Mobility aid parking areas: Smooth rubber sheets with an integral non-slip grit surface.
4. Stairs:
  - a. Provide each step with a safety nosing resistant to chipping, peeling, and other forms of preliminary failure.
  - b. Nosing will extend the full width of the step and contrast visually from the stair tread and riser covering by 70%, as determined by the following formula:  
$$\text{Contrast (\%)} = [(B1-B2)/B1] * 100$$

Where  
B1 = Light reflectance value of brighter area  
B2 = Light reflectance value of darker area

**6.4.4 Cove and Trim Moldings**

Comply with the following for cove molding used for floor covering:

1. Material: Brushed finish stainless steel.
2. Size: Minimum size consistent with maintenance access to dirt in the corners.
3. Corners, Splices, Terminations: Formed pieces that rigidly connect to the cove pieces.
4. Application: Provide between floor covering and vertical surfaces at which, or behind which, the floor covering terminates, such as side walls, end walls, equipment boxes, and floor heaters, including those in the operator's cab.

Trim molding: Provide stainless steel or aluminum molding around the periphery of the floor covering at exposed removable floor access panels and at the edge of the articulation section.

**6.4.5 Floor and Molding Installation**

Prepare and install floor as follows:

1. Preparation:
  - a. Before installing the floor covering, fill voids, indentations, fastener heads, and separations between floor panels with an Approved flame-retardant leveling compound.
  - b. The floor will be made smooth and flat within 1.6 mm (0.063 in) measured within any 915 mm (36 in) distance in any direction.
2. Installation: Securely bond floor covering to the floor structure with a waterproof adhesive as recommended by the floor-covering supplier.
3. Seams: Transverse seams will not be used. All seams will be longitudinal.

Install molding as follows:

1. Form a watertight seal with the floor covering and the vertical surface.
2. Alternate:
  - a. Where the floor covering meets walls, curve floor covering upward onto walls, providing support in the curve. Radius will not be less than recommended by the floor covering manufacturer.
  - b. Terminate floor covering with an edge sealant or other method Approved by the City.

**6.4.6 Quality Criteria and Repair Methods**

Comply with the following quality criteria and repair methods, where permitted, for rubber flooring:

1. Thin-skinned blister: A blister that, when finger-pushed, will collapse upon itself. Thin-skinned blisters larger or more frequent than the indicated maximum size and population will be repaired as indicated:
  - a. Maximum Size: 0.75 mm (0.03 in) height, 0.500 mm<sup>2</sup> (0.0008 in<sup>2</sup>) area with longest dimension of 50 mm (2 in).
  - b. Maximum Population: 3 blisters in a 300 mm by 300 mm (11.8 in by 11.8 in) area. There will be only one other blister within 1 m (39 in) of this area.
  - c. Repair Method: Using a hypodermic needle, apply just enough Loctite 420 or Bostik 1685 to bring to a flush surface.
2. Thick-skinned blister: A blister that, when finger-pushed, will collapse and then return to its original condition. Thick-skinned blisters larger or more frequent than the indicated maximum size and population are not permitted and may not be repaired:
  - a. Maximum Size: 0.75 mm (0.03 in) height, 0.500 mm<sup>2</sup> (0.0008 in<sup>2</sup>) area with longest dimension of 50 mm (2 in).
  - b. Maximum Population: 3 blisters in a 300 mm by 300 mm (11.8 in by 11.8 in) area. There will be only one other blister within 1 m (39 in) of this area.
3. Lump: A blister without a void, consisting of solid material. Lumps larger or more frequent than the indicated maximum size and population are not permitted and may not be repaired:
  - a. Maximum Size: 0.75 mm (0.03 in) height, 0.500 mm<sup>2</sup> (0.0008 in<sup>2</sup>) area with longest dimension of 50 mm (2 in).
  - b. Maximum Population: Three lumps in a 300 mm by 300 mm (11.8 in by 11.8 in) area. There will be only one other lump within 1 m (39 in) of this area.
4. Hole: A defect that is 100% through the material. No holes are permitted, regardless of size or population. Repair of holes is not permitted.
5. Thin area: A defect where the sheet is below thickness locally. Thin areas of the indicated maximum size and population are permitted but will be repaired as indicated. Thin areas larger or more frequent than the indicated maximums are not permitted and may not be repaired:
  - a. Maximum Size: 0.75 mm deep at the lowest point, 2000 mm<sup>2</sup> (3.1 in<sup>2</sup>) with the longest dimension of 125 mm (5 in).
  - b. Maximum Population: One thin area in a 1 m by 1 m (39 in by 39 in) area, and there will not be another thin area within 1 m (39 in) of this area.
  - c. Repair Method: Rub with #00 steel wool to blend this area into the normal thickness material and then buff to a normal surface finish.

**6.4.7 Door Thresholds**

Provide a threshold at each doorway:

1. Material: Extruded aluminum or cast or machined stainless steel.
2. Anti-skid treatment: Provide on top surface, integral to the threshold.
3. Drainage: If the threshold includes longitudinal slots, such as for door tracks, provide drainage to the outside of the vehicle.
4. Installation:
  - a. Fasten threshold to vehicle structure with stainless steel fasteners.
  - b. Provide sealant underneath and around the full periphery of the threshold.
  - c. Fully seal the interface between threshold and mating floor covering.



5. The threshold may be integral to the bridgeplate assembly.

## 6.5 Passenger Seats

### 6.5.1 Description

Provide passenger seats meeting the following requirements:

1. Type: Heavy-duty, transit-grade.
2. Color: To be determined by the City during design review.
3. Seat back pans: Sculptured to give knee room.
4. Manufacturer's logos or markings: Not visible to passengers.

### 6.5.2 Design Criteria

Incorporate the following requirements in passenger seat design:

1. Standards: Comply with Section 49 CFR 571.222 or APTA-PR-CS-S-016-99-Rev, except that seats will be subjected to a 5g, 250 ms crash pulse rather than the 8g requirement for commuter rail. Alternative European standards maybe proposed for review and Approval by the City.
2. Comfort and Safety: Use recognized ergonomic and human factors principles to ensure a comfortable and safe ride for short distance local patronage:
  - a. Design: Molded one-piece type or backs rigidly attached to each other.
  - b. Pinching: Design gaps between seats and walls or windows or back-to-back seats to prevent injury when the seat moves.
3. Seat Replacement:
  - a. Secure seats with a maximum of six mounting bolts per seat for easy removal and reinstallation.
  - b. Hide mounting bolts where exposed to passenger view using inconspicuous snap-in covers.
4. Aisle width:
  - a. Minimum 635 mm (25 in) between seats on opposite sides of the vehicle. Alternative designs maybe proposed for review and Approval by the City.
  - b. See Section 4 Design and Performance Criteria, for special requirements related to width of Accessible Onboard Circulation Paths for access to mobility aid parking areas.

### 6.5.3 Materials

Materials will be consistent with intended use and performance requirements:

1. Application considerations: Passenger safety, comfort, and durability; maintainability; and compliance with flammability, smoke emission, and toxicity requirements in Section 16.
2. Visible structural materials:
  - a. Brushed stainless steel, with 180 grit, horizontal finish.
  - b. Formed synthetic frames, such as FRP or thermoplastics, may be considered but must comply with material requirements and flammability, smoke emission, and toxicity requirements.
3. Non-visible internal structures: Powder-coated steel or stainless steel.

### 6.5.4 Dimensions

Comply with the following dimensions for passenger seats:

1. Total seat cushion depth: Minimum 431 mm (17 in), measured from the seat's forward edge to the forward surface of the seat-back.

2. Seat spacing (knee-to-back seats): Minimum 740 mm (29 in), measured from the same point on each seat.
3. Legroom (longitudinal clear distance tangent to the seat bottom cushion): Minimum 660 mm (26 in), measured from the front of the seat-backrest-cushion to the back of the next seat-back-shell.
4. Individual seat width: 445 to 483 mm (17.5 to 19 in), which may be achieved using spacers placed between individual seats.

## 6.6 Mobility Aid Parking Areas

Comply with the following:

1. Quantity: Provide in each vehicle as Specified in Section 4 Design and Performance Criteria.
2. Orientation: Design parking areas to locate the mobility aid longitudinally (end facing) in the vehicle.
3. Clear Floor Space: Provide area compliant with 49 CFR 38, Subpart D, for each mobility aid parking area.
4. Maneuvering Circle: Provide area compliant with 49 CFR 38, Subpart D, for each mobility aid parking area.

## 6.7 Interior Equipment

### 6.7.1 Stanchions, Handrails, and Grab Rails

Provide stanchions, handrails, grab rails, grab handles, handholds, and related fittings complying with the following requirements:

1. Regulations: Comply with 49 CFR 38, Subpart D.
2. Material: Stainless steel with an Approved circumferential finish. Surfaces will be smooth and free of sharp edges that might injure passengers.
3. Dimensions:
  - a. Diameter: 32 to 38 mm (1.25 to 1.5 in).
  - b. Knuckle Clearance: Minimum 38 mm (1.5 in).
4. Placement:
  - a. Standing passenger positions: Provide stanchions within 760 mm (30 in) of possible standees, but in locations that do not interfere with access by mobility devices. Provide handholds where stanchions are not possible.
  - b. Boarding area: Provide stanchions to define the boarding area.
    - i. Location: At each passenger door location.
    - ii. Accessible Boarding: At locations where a stanchion may interfere with accessible boarding, it may be reduced in size or eliminated with the City's approval.
  - c. Transverse seats: Provide grab handles or grab rails, and at every other seat row provide stanchions, alternating from one side of the aisle to the other.
5. Mounting:
  - a. Fasteners: Tamper-resistant stainless steel.
  - b. Orientation: Select and locate attachment points, including seat attachments, such that there is no visual divergence from vertical or horizontal, as appropriate, from all viewpoints.
  - c. Stanchions:
    - i. Rigidly mount to the floor, wall support structure, or seat grab rails.
    - ii. At the upper end, mount stanchion only to vehicle structure.
    - iii. Mount such that no rattling or noise is produced during operation.

- iv. Design such that stanchions give no support for the ceiling, roof, or any other component, and make no contribution to vehicle-body structural design.
- 6. Grab rails: Design without the need for lateral supports.
  - a. Strength: will withstand applied loads of 1330 N (300 lbs.) in any direction without permanent deformation and without transient deformation that would pinch or injure.
- 7. Mobility aid area:
  - a. Provide at least one horizontal handrail positioned 685 mm (27 in) above the floor.
  - b. Provide stanchions, handrails, or other safety devices to allow safe use of this area by standees when no mobility aids are present.

#### 6.7.2 Fare Validation Equipment

##### *General*

Install City provided farecard readers.

Existing system: Init.

Ticket Validators: Four

##### *Fare Validation Equipment*

- 1. Location/Quantity: Located adjacent to doors, or at other Approved locations.
- 2. ADA: Install farecard readers to be ADA accessible, complying with ADA requirements.
- 3. Signage: Provide fare-information and operating-instruction decals.
- 4. Stanchions: Provide for mounting farecard readers to prevent passengers from using the equipment as a leaning post.
- 5. Horizontal passenger assist: Provide between boarding passengers and farecard readers in compliance with 49 CFR 38.77.
- 6. Strength: Installed equipment will withstand applied loads of 1330 N (300 lbs.) in any direction.
- 7. Power/Network Connections:
  - a. Provide electrical power from a dedicated circuit breaker located in the electrical locker to each farecard readers.
  - b. Provide Ethernet connection to each farecard readers from the vehicle network controller.
  - c. Hide all cabling in the stanchion, or via other Approved methods.

##### *Fare Collection Equipment Testing*

Test farecard readers before delivery of the vehicle, in accordance with Section 15, Testing.

#### 6.8 Keys and Locks

Comply with the following:

- 1. Provide keys operable in new vehicles.
- 2. Provide the following three types of keys for access to various vehicle equipment or controls:
  - a. Master Controller Key: Seven-pin tumbler tubular key or Crew Key, alternative keys maybe proposed for review and Approval.
  - b. Crew Key
  - c. Maintenance Key
- 3. Keys and locksets will be readily obtainable from U.S. domestic sources.
- 4. Keys and locksets will be assigned as shown in the Key Assignment Table, below, or as agreed during design review. Other locks and keys may be required that are not listed, and they will fall into one of these two categories:
  - a. Crew Key: Access panels or controls intended for operator access or operation.

- b. Maintenance Key: Access panels or controls intended for maintenance access or operation only.

Key Assignment Table	
Name	What the key operates/opens
Master Controller Key	Master Controller key switch
Crew Key	Crew door switch
	Exterior manual door release
	Manual door release mechanism reset device
	Cab via the cab door
	Operator's storage locker
	All Circuit breaker dead front panels
	Access panels to under-seat equipment requiring operator access
Maintenance Key	Side skirt (for removal)
	Electrical lockers
	All equipment covers
	All access panels

## 6.9 Windows

### 6.9.1 General

Provide only glazing products that are readily available in the U.S. from U.S. suppliers, in the sizes and thicknesses provided on the delivered vehicles.

### 6.9.2 Type and Performance

Comply with the following:

1. Type: Single-glazed, fixed.
2. Glazing: Laminated, tempered safety glass.
3. Standard: Test in accordance with ANSI Z26.1 or Approved equivalent standard:
  - a. "Motor vehicle" applies to the vehicles in this Contract, notwithstanding that vehicles of this type operated only on a rail line are excluded by the standard.
  - b. Apply requirements in the standard applicable to buses with comparable types of glazing.
4. Identification: In accordance with ANSI Z26.1, and other appropriate designation.
5. Solar Heat Gain Coefficient (SHGC): As defined by the National Fenestration Rating Council and Specified in this Section.
6. Visible light transmittance: As defined by the National Fenestration Rating Council and Specified in this Section.
7. Distortion: In accordance with ANSI Z26.1 Optical Deviation and Visibility Distortion tests. Test specimens must comply with requirements for both optical deviation and visibility distortion to meet this requirement.
8. Glazing treatments: Permanent, within the glazing and/or in the center membrane. Surface films are not permitted.
9. UV blockage: Minimum 99% for both UVA and UVB.
10. Corners and edges: Ground smooth with edges seamed in accordance with SAE J673, Edge No. 4.

**6.9.3 Installation**

Mount glazing directly to the vehicle structure with service proven bonding methods:

1. Sealant: Commercial product suitable for exposure to carwash, cleaning solvents, UV, and temperature range and other climatic conditions Specified.
2. Installation:
  - a. Prepare glazing according to the sealant manufacturer's instructions.
  - b. Finish where visible to a smooth surface flush with surrounding surfaces, with no gaps or blemishes.
3. Removal: Design joint and provide sealant that allow removal with standard hot- or vibrating-knife bonded-window tools.

**6.9.4 Cab Windshield**

Provide a windshield in each cab:

1. Tinting: None.
2. Parallel luminous transmittance: Minimum 0.70, visible light at normal incidence.
3. Solar heat blocking: Lowest SHGC rating consistent with minimum 0.70 transmittance, using the most technologically advanced low emissivity products.
4. Embedded electrical defrosting: As Specified.
5. Design/Installation: will minimize external glare, and reflections from inside the vehicle when the vehicle is operated at night with the passenger interior lighting in use.
6. The upper portion of the windshield may cover the end destination sign. Tinting is allowed in that area to cover the surrounding area, if required.

**6.9.5 Cab Side Windows**

Provide side windows in each cab:

1. Type: Emergency egress
2. Window type: Horizontal sliding, with latch.
3. Tinting: None.
4. Parallel luminous transmittance: Minimum 0.70, visible light at normal incidence.
5. Solar heat blocking: Maximum 0.4 SHGC.
6. Window frame: Satin finished anodized aluminum, opening, with a latch operable from inside the cab only; weather stripped; reinforced for hard usage; designed to eliminate rattling in all positions.

**6.9.6 Passenger Section Side and Door Windows**

Provide side and door windows in the passenger section:

1. Tinting: None.
2. Solar heat blocking: Maximum 0.4 SHGC.
3. Visible light transmittance: Minimum 0.75. Lower light transmittance may be considered if SHGC values of less than 0.4 can be attained.
4. Protection: Provide an Approved vandal-resistant window film on window interiors.

**6.10 Operator's Cab**

**6.10.1 General**

Provide a full-width, fully enclosed operator's cab at each end of the vehicle.

6.10.2 Size Range of Operators

Design cab for use by an operator in the size range of the fifth-percentile female to the ninety-fifth-percentile male of the general population as defined by *The Measure of Man and Woman: Human Factors in Design* (“*Measure of Man and Woman*”).

6.10.3 Cab Layout

Design cab layout to meet the following criteria:

1. Comply with the design principles of *Measure of Man and Woman*.
2. Operator's forward view will not be obstructed while standing or sitting.
3. The cab will be free of sharp edges, protruding objects, safety hazards and floor obstructions.
4. Areas in which paper and other debris can accumulate are not permitted.
5. Ensure that height to underside of console is sufficient to accommodate largest Specified operator, and distance to controls accommodates smallest Specified operator.
6. Coordinate seat dimensions, console height, clearances, and footswitch locations and dimensions to comply with design requirements.

6.10.4 Visibility Requirements

Design cab to allow maximum possible field of view in all directions and minimize reflection in windows, taking into consideration cab layout and design of windshield, corner posts, cab liner color, and cab side windows.

Provide the following operator view as a minimum, allowing for all possible operator seat adjustment positions and an operator within the Specified size range:

1. Upward view of minimum 20 degrees.
2. Downward view sufficient to see a 1.0 m (3 ft-3 in) tall person standing 0.5 m (1 ft-8 in) from the front-most surface of the vehicle without the need to bend at the waist.
3. Ability to locate coupler head directly or indirectly while at the same time accessing controls during coupling operation (standing is permitted for this activity).

6.10.5 Cab Partition

Provide a full width, transverse partition for the rear wall of the cab enclosure:

1. Material: Melamine faced plymetal, of balanced construction, or Approved equal. Aluminum or other materials may be proposed in place of plymetal, subject to the City's review and approval.
2. Thickness: 13 mm (1/2 in).
3. Attachment: Fasten securely to vehicle roof structure, floor, and vehicle-body side structure, not to ceiling panels or side-lining panels.

6.10.6 Cab Door

Comply with the following:

1. Provide a hinged or sliding door in the cab partition:
  - a. Material: Same as cab partition. Aluminum honeycomb material or Approved equal may be proposed, subject to the City's review and approval.
  - b. Matching: Cut from cab partition panel to maintain proper color and pattern match.
  - c. Hinge (if provided): Full length, stainless steel, piano-type.
  - d. Door swing (if hinged): Into the passenger compartment. Provide a rattle-free latching device to retain against the cab partition.

- e. Tamper-proof construction: Design and construct doors and frames such that passengers cannot gain access when door is locked.
2. Provide door latching and locking hardware as follows:
  - a. Material: Nickel-bronze or stainless steel.
  - b. Inside Cab: Rapid door lock release mechanism that allows the operator to quickly find it under poor lighting conditions and allows the door to be opened without the use of a key.
  - c. Operation: Door will automatically latch and lock when closed.
  - d. Key: Lock will be unlockable from passenger side with a key.
3. Provide a grille in the lower portion of door for ventilation: Louvered, sight tight.
4. Provide kick plates along the bottom portion of door on inside and outside face:
  - a. Material: Stainless steel
  - b. Dimensions: Minimum 0.76 mm (1/32 in) thick and 200 mm (8 in) high
5. Provide a sash window to allow operator to look into passenger compartment:
  - a. Location: Align bottom edge of window with bottom edge of side windows
  - b. Glass: Minimum 6.4 mm (1/4 in) thick laminated safety glass
  - c. Frame: Aluminum. Fully support frame with cab door panel on all sides
  - d. Tinting: Adequate to prevent glare on the windshield from passenger area lighting at night
  - e. Operation: Vertically sliding
  - f. Latch: Spring latch in the up (closed) position, operable only from within the cab
  - g. Protection: Provide an Approved vandal-resistant window film on surface of window facing passenger compartment
  - h. Window curtains: Designed to block light from entering a cab from passenger compartment.

#### 6.10.7 Cab Console

##### *Cab Console Design*

Design the Cab Console to accommodate all controls and indicators Specified in Section 5 Operator's Cab, and others as needed per the Contractor's design:

1. Slope console surfaces toward the Operator at angles suitable for the layout requirements of Section 5.
2. Design materials and orient surfaces to avoid glare on the windshield interior or any other adverse visual distraction.
3. Design size and shape taking into consideration the layout of controls and indicators Specified in Section 5.
4. Permit easy operator access to both cab side-windows.
5. Design so that liquid spilled on the surface will not pool or collect and will not damage or interfere with operation of the components or back panel wiring.

##### *Cab Console Material and Finish*

Comply with the following material and finish requirements:

1. Console Cabinet Material:
  - a. Melamine faced aluminum, integrally colored.
  - b. Fiberglass reinforced polyester resin.
  - c. Thermoplastic sheet.
  - d. Alternative materials maybe proposed for review and Approval by the City.
2. Console Cabinet Color: Match adjacent cab lining materials.



3. Operating Face Material:

- a. Anodized aluminum: Corrosion resistant, cigarette burn resistant; or
- b. Melamine faced aluminum: Integrally colored.

4. Operating Face Finish:

- a. Black, non-reflective, non-glare.
- b. Cleanable with soap and water solution.

*Cab Console Construction*

Comply with the following:

1. Maintenance Access:

- a. Provide a piano-type hinge along the lower edge of the console face panel to facilitate replacing switches or repairing wiring.
  - b. Provide wire dress and slack that allows full horizontal opening without wire strain.
2. Fasteners: will not be visible on the console face.

*Master Controller Area of Cab Console*

Comply with the following:

- 1. Location: On the cab console to the left of operator's seat.
- 2. Armrest: Upholstered, padded, ergonomically designed for comfort during long periods of use.

*Operator's Handhold*

Provide a formed tubular handle attached to the front edge of the Cab Console to give support for operators:

- 1. Material: Stainless steel.
- 2. Strength: Handle, attachment method, and console structure will withstand repeated use by the 95% percentile male without loosening or damage to the console over the life of the vehicle.

**6.10.8 Cab Furnishings and Equipment**

*Cab Flooring*

Subfloor: Same as provided in the passenger section.

Floor covering: Smooth surface, same as used under the passenger seating.

*Operator Seat*

Provide an operator's seat in each cab meeting the following requirements, located on the vehicle's longitudinal centerline, as Approved:

- 1. Design principles: Comply with *Measure of Man and Woman*.
- 2. Size: Design for the Specified size range of operators (see Size Range of Operators section, above).
- 3. Foot space: Adequate to accommodate the operator's feet.
- 4. Footrest: Adjustable for use by smaller operators.
- 5. Seat frame: Corrosion-resistant tubular construction, designed for hard vehicular usage.
- 6. Seat and back cushion: Low-smoke foam; the seat cushion will be minimum 100 mm (4 in) thick.
- 7. Seat covering: Transportation-grade fabric-backed vinyl that breathes to minimize perspiration buildup and operator discomfort.
- 8. Armrests (both sides of seat): Flip-up type.
- 9. Seat adjustments, with controls easily operable from a seated position:
  - a. Vertical, forward, and backward directions.
  - b. Seat back angle.



- c. Seat back lumbar support.
  - d. Swivel: Minimum plus or minus 30 degrees from the forward-facing position, with a lock that engages automatically in the forward-facing position and prevents further turning.
10. Attachment: Through the flooring into the underlying vehicle structure and designed to withstand normal usage without failure or loosening over the life of the vehicle.

#### *Air Comfort System*

Provide each cab with operator-controlled heating and cooling, as Specified.

Provide cab windshield and side window defrosting and demisting as Specified.

#### *Sunscreens*

Provide motorized sunscreens as needed to aid the operator in all external light conditions, including simultaneous front and side sunlight:

1. Screens will be service proven in a similar transit application with respect to material, mounting, and adjustment.
2. The sunscreen material will not neutralize the color of traffic control signals.
3. Consider the following design factors:
  - a. Window size and arrangement
  - b. Operator position
  - c. Color
  - d. Light blockage ratio
4. Controls will be located on the operator's console.

#### *Windshield Wiper and Washer*

Provide a windshield wiper(s) for each cab windshield:

1. Wiper drives, mechanisms, blades, and controls will be an integrated system, presently in use in similar applications.
2. Wiper blades and rubbers are considered consumables, and must be commercially available in the U.S.
3. Wipers will sweep a minimum of 80% of the width and 60% of the height of the total windshield area over one complete cycle.
4. Wiper controls will include variable speed and interval operation to suit a wide range of rainfall conditions.
5. When not active, wipers will automatically park at a secure and unobtrusive location.

Provide fluid-dispensing windshield washers:

1. Washer nozzle: Attached to each wiper blade such that it moves with the blade.
2. Washer fluid reservoir:
  - a. Readily accessible for refilling from vehicle exterior.
  - b. Minimum usable capacity 8 liters (2 gallons).

#### *Interior Mirror*

Provide one or more adjustable interior mirrors in each cab:

1. Locate so the operator can view the passenger compartment.
2. Mirror: Distortion-free glass with minimum 360 cm<sup>2</sup> (56 in<sup>2</sup>) reflecting area
3. Frame: Covered edges

*Surveillance Display Screen*

Provide color display screens, one in each cab. The screens will be able to display all Surveillance cameras as selected by the operator.

1. Operator Controls: Provide for user-adjustable contrast, brightness.
  - a. When the vehicle has reached no-motion the operator will have the ability to select different surveillance cameras.
  - b. When a vehicle door is Released or Open, the respective exterior side-view Surveillance cameras will be selected.
  - c. When both sides of the vehicle's doors are Released or Open, the active cabs side-view camera for each side of the vehicle will be selected.
  - d. Ability to select side-view cameras and have displayed with no-motion de-activated. To be used in the event a side-view mirror has been damaged, this action will create a fault and be logged by the event recorder, as Approved by the City.
2. Maintenance Controls:
  - a. Screen view, select camera(s), or black screen to view when no-motion de-activated.
  - b. Maximum number of selectable cameras by operator.
3. Type: LCD TFT, LED backlit
4. Reflection/glare mitigation: Provide a shroud to prevent washout during bright conditions, and a filter or coating, if necessary; filter or coating will not reduce clarity or brightness.
5. Size: Minimum 200 mm (8 in), diagonally
6. Resolution and Aspect Ratio: Match the display screen's camera and recorded video.
7. Operating Environment: Ensure that display functions in all environments, including an enclosed unconditioned cab in worst-case ambient conditions.
8. Location: Cab, viewable by seated operator, as approved by the City.

Maintainability: The LCD panel will be user-replaceable, and of a common design and format available from multiple sources in the U.S.

*Convenience Outlets*

Provide one duplex convenience outlet in each cab:

1. Location: As Approved by the City.
2. Receptacle: Ground fault circuit interrupter (GFCI) protected, rated 120 Vac, 20 A.
3. Circuits: Provide a dedicated circuit breaker for each outlet.

*Operator's Tools*

Provide mounts for operator's tools:

1. Location: A-end operator's cab, as Approved by the City.
2. Tools:
  - a. Switch iron, furnished by the City.
  - b. Pantograph crank, provided by Contractor.

*Fire Extinguisher*

Provide fire extinguishers:

1. Type: Marine, with a minimum rating of 4-A:30-B:C, UL listed
2. Capacity: 4.5 kg (10 lb.)
3. Quantity: Two total
4. Location: Mount one in each operator's cab, accessible to the operator

5. Mounting: Use a marine-type mounting bracket

6. Signage: Clearly marked

#### 6.10.9 Operator's Appurtenances

##### *Coat Hook*

Provide a coat hook of Approved design in each cab on the cab rear partition:

1. Hook: Folding, flush, nickel-bronze

2. Strap: Provide to restrain hanging items

##### *Waste Receptacle*

Provide a detachable waste receptacle in each cab:

1. Location: Within reach of operator when seated

2. Material: Stainless steel

3. Design: Leak-proof, designed to accommodate commercially available trash-receptacle liners

4. Capacity: Approximately 8 liters (2 gallons)

5. Mounting: Secured to prevent rattling when the vehicle is operating

##### *Cup Holder*

Provide a cup holder in each cab:

1. Location: Within reach of the operator, but not over the console

2. Size: Designed to hold a 700 ml (24oz) beverage cup or container

#### 6.11 Exterior Finishing

##### 6.11.1 Exterior Finishes

Comply with Exterior Design Package and the following requirements:

1. Steel and aluminum: Paint as Specified.

2. FRP: Paint as Specified if paint is required by the Exterior Design Package.

3. Stainless Steel:

a. Exposed to view: Approved brushed finish or paint, as required by the Exterior Design Package.

b. Not exposed to view: Paint not required

##### 6.11.2 Paint Colors and Gloss

The color difference between Approved color samples and production components will have a delta  $E_{cmc}$  of 1 or less. Provide paint colors, gloss, and finish as follows:

1. Exterior sides and ends of the vehicle, and roof shrouds:

a. Colors: At least two, as Approved in the Initial Interior and Exterior Design Package.

b. Gloss level: Minimum 85 as measured with a 60-degree glossometer.

c. Orange peel: Minimum level 6.

2. Trucks, traction motors, and gear reducers:

a. Color: Black

b. Gloss level: Semi-gloss

3. All other areas, including roof surfaces and equipment, underfloor surfaces and equipment, and other areas not exposed to view:

a. Color: Charcoal gray, or similar

b. Gloss level: Semi-gloss

6.11.3 Graphics

Where graphics are required as part of vehicle exterior finishing, comply with the Approved Exterior Design Package.

6.11.4 Exterior Side Mirrors

Provide side view mirrors on the left and right sides of each cab, arranged for maximum visibility by a seated operator.

- Mirrors will be electrically adjustable, enabling an operator to supervise the loading and unloading of passengers at all doorways
- Mirrors will include a blind spot mirror, enabling an operator to view the front lower edge of the carbody, so the operator can view clearance between the carbody and objects along the wayside, like parked cars and trucks.
- Mirrors will be electrically foldable, enabling an operator to pull the mirrors closer to the carbody to avoid an obstruction on the wayside, like a box truck parked within the mirror's envelope.
  - Mirrors will be manually foldable, forward and backwards inline with the carbody, without damage.
- Mirrors will have thermostatically controlled heaters for defogging.
- Cab controls, left and right:
  - Mirror adjustment
  - Mirror fold/unfold
  - Mirror defog

6.12 Rain Gutters and Water Drainage

Provide rain gutters or other devices to prevent water drainage over the sides of the main body sections and cab ends:

1. Provide concealed gutter-drainage conduits, which will empty below the floor line of the vehicle.
2. Size gutters and drainage conduits to prevent accumulated water from overloading the system:
  - a. During maximum rainfall rate for the Portland area, as Specified.
  - b. During vehicle acceleration and braking
  - c. On grades
3. Gutters: Separately form and attach or make integral with the roof structure via roof sheet corrugations or similar configurations.
4. Drainage conduits:
  - a. Construct with no sharp bends
  - b. Design for easy clean-out
  - c. Provide screens at water entry points.
  - d. Fully insulate where inside the vehicle-body structure to prevent condensation or leakage.
  - e. Do not run through equipment lockers except as reviewed and Approved by the City during design review.

## 6.13 Equipment Enclosures

### 6.13.1 General

#### *Standards*

Comply with the following standards as applicable to equipment enclosures:

1. NFPA 130, Chapter 8, Vehicles: Comply with requirements of sections on equipment arrangement, flammability and smoke emission, equipment lockers, electrical fire safety, and other sections with requirements applicable to equipment enclosures.
2. NEMA 250: Comply with Specified type requirements, except as Specified otherwise in this Section. Where conflicts exist, comply with this Section.

#### *Hardware*

Latches, hinges, and cover attachment hardware: Stainless steel.

#### *Labels and Warnings*

Provide labels and warning indicators as Specified.

#### *Paint*

Comply with the following:

1. Interiors of equipment enclosures will be primed and painted.
2. Exteriors and interiors of covers will be painted or finished as Specified.
3. Seals and cover hardware will not be painted.

#### *Location*

Comply with the following:

1. Locate enclosures for control and other critical equipment to ensure protection against environmental contamination and mechanical damage.
2. Locate and orient enclosures and covers such that:
  - a. Covers can be opened at least 90-degrees without interference with other equipment.
  - b. Enclosure openings and space in front of the enclosure allow access to all internal equipment, and allow inspection, repair, and replacement equipment without disassembly or removal of other equipment.
3. No high-voltage dc equipment enclosures may be installed inside the passenger compartment.

### 6.13.2 Exterior Equipment Enclosures

#### *Material and Construction*

Comply with the requirements of the General section, above, and the following requirements specific to exterior equipment enclosures, which include underfloor- and roof-mounted equipment enclosures:

1. Material:
  - a. HSLA steel or, where Approved, aluminum, FRP or stainless steel.
  - b. Enclosures constructed of steel or aluminum will have continuous welds or Approved spot welds with fillers along all seams.
2. Construction:
  - a. Watertight: When subjected to pressure wand cleaning and driving rain, except where equipment must be ventilated; NEMA Type 4.
  - b. Drainage: Provide for discharge of condensation and leakage due to damaged or deteriorated seals. Provide cotter keys or other Approved, simple drain clearing mechanisms.

- c. Stiffeners: Provide welded-in-place stiffeners for walls and covers of large boxes; comply with high-quality commercial practice.
  - d. Cover bearing surface: Provide a flat, NEMA-type formed lip as the bearing surface for the cover seal, minimum 3.2 mm (1/8 in) wide.
  - e. Gasket compression: When closed and latched, covers will bear on the frame or a hard stop to control gasket compression.
3. Vents:
- a. Provide where necessary.
  - b. Arrange to minimize water entry and deflect direct water spray.
  - c. Cover vents with stainless steel screens welded to the inside of the enclosure.
  - d. For underfloor enclosures, provide external shields or baffles to prevent directed water sources, such as from wheel splash, from entering the enclosure.

### *Seals and Gaskets*

#### Sealing System:

1. Material: Closed cell neoprene foam, minimum thickness 9.5 mm (3/8 in), resilient, watertight.
2. Attachment: Secure in a channel near the periphery of the cover.
3. Minimum life: 10 years.
4. Compression: The seal will be compressed maximum 50% with the cover securely fastened.
5. Testing: Sealing system will pass the water test for equipment enclosures.

RFI gasketing: Continuously conductive contact strip. Provide all equipment boxes and covers containing equipment that could produce RF, including auxiliary power supplies and traction inverters.

### *Covers*

Comply with the following requirements for exterior equipment enclosure covers:

1. Interchangeable: Provide doors, covers, and access panels that are interchangeable between boxes of the same size and type within a vehicle and between vehicles.
2. Hinged covers: Readily removable, if provided, without the use of tools.
3. Latching:
  - a. Latch Type: Quick-release type with no separable or non-retained parts.
  - b. Latch Clearance: For underfloor enclosures; arrange latches and latch catches so they do not protrude beyond the bottom or edge of the box or cover in latched position and do not violate vehicle dynamic clearance outline in unlatched position.
  - c. Seal Relaxation: Latch will compensate for seal relaxation considering the worst-case condition of hard contact between cover and box. In this extreme case, the latch will hold the cover firmly to the box without rattling.
  - d. Safety Catch: Spring-loaded. Provide at the center of each underfloor box cover. Design to retain cover within vehicle dynamic clearance envelope at all operating speeds up to vehicle design speed without cover latches engaged.
4. Hold-Open Mechanism: Provide on top-hinged underfloor covers and roof-mounted enclosure covers, internal to enclosure:
  - a. Cover Removal: Mechanism will not interfere with or impede easy removal or replacement of cover and will stay with the cover when the cover is removed.
  - b. Mechanism Removal: Easily removable from the cover for replacement.
  - c. Non-Shorting: When the cover is opened or closed, it will not be possible for the mechanism to short or ground internal electrical parts.

*Equipment Arrangement*

Comply with the following requirements for equipment arrangement inside exterior equipment enclosures:

1. Underfloor Equipment Access: Provide ready access from the side of vehicle, maintenance pits, and when vehicle is on lifts.
2. Roof-Mounted Equipment Access: Provide from top of enclosure, or other location Approved by the City.
3. Equipment Mounting: Attach equipment to standoffs or subplates welded to the box. Do not attach equipment directly to enclosure walls, top, or bottom using bolts or other fasteners.
4. Clearance: Provide sufficient clearance to protect internal equipment from damage due to minor impacts; minimum 13 mm (1/2 in), between exposed sides and covers of equipment enclosure and internal equipment.

*Ventilation*

Comply with the following requirements:

1. Arrange equipment for maximum ventilation of parts and minimum restriction of cooling air.
2. Divert high-temperature air exhausted from one piece of equipment away from the air intake of other pieces of equipment.
3. Where forced air ventilation is provided, provide a manometer test fitting in an accessible location on each equipment enclosure for measurement of pressurization.

**6.13.3 Interior Equipment Enclosures**

*General*

Comply with the requirements of the General section, above, and the requirements in this Section specific to interior equipment enclosures:

1. Use: Requires review and approval by the City during design review.
2. Construction: Fully enclosed with hinged and latched access covers. Visible enclosures and covers will match surrounding interior finish and colors, except as Specified in the Contract Documents.
3. Access covers: When closed and latched, prevent access to the enclosure at all locations around the cover periphery.
4. Environmental: Enclosures and covers will be dustproof. Enclosures in areas subject to water ingress, such as near doorways, in the cab, or under-seat, will be watertight on all faces potentially exposed to water ingress.
5. Access: Equipment will be readily accessible and will be removable through the access cover without removal or alteration of enclosure components.

*Under seat Type*

Where Approved by the City, equipment enclosures may be located under seats:

1. Construction: Stainless steel structural frame faced with sheets of rigidized stainless steel.
2. Access: By removal of the seat or through access panels in windscreens. Seat boxes will have a removable access cover.
3. Molding: Provide stainless steel cove molding where seat box meets floor covering.

#### Electrical Locker Type

Enclosures may be located in the cab, adjacent to the articulation, or in the ceiling cove area:

1. Construction: Rugged and secure, using panel materials, or constructed from formed sheet metal coated with an Approved thermosetting powder coating, as Specified in Section 19 Materials and Workmanship.
2. Access Cover:
  - a. Design to be rattle-free during vehicle operation.
  - b. Secure with quarter-turn locks, except as reviewed and Approved by the City during design review.
  - c. Secure with a key as Specified above in the Key Assignment Table.
  - d. Access panels may be used for covers if a full dead-front is provided.
3. Ceiling Cove Location:
  - a. Coordinate the design with the need to have card holders above the windows as required by this Section.
  - b. Hinge the panels at the top and secure at the bottom with key-operated latches, as Specified in the Key Assignment Table, above.
  - c. Provide “hold open” devices.

### 6.14 Signage

#### 6.14.1 General

Provide signage and graphics in each vehicle as Specified in this section. Text will be in English and one other language.

#### 6.14.2 Informational Text and Graphics

Provide signs and graphics throughout the vehicle to furnish passengers and operating personnel information regarding operation of the vehicle:

1. Regulations: Comply with 36 CFR 1191 Appendix D, Section 703, Signs (ADA requirements).
2. Operating personnel use only: Clearly label controls and devices with text.
3. For use by passengers: Label equipment both with text and graphical figures or icons in full compliance with ADA requirements, however infrequently the equipment may be used.
4. Passenger interactive devices: Provide identification and instructions, such as for door push buttons, stop request buttons, and passenger emergency stations.

Below is a table of typical signage. Signage for this vehicle will be similar, but as defined by the City after NTP:

Typical Signage	
Description	Location
Priority Seating (Handicapped)	Centered above location
Plate-Emergency Exit (Window)	On all emergency windows
Plate-Emergency Exit (Seat)	On all emergency window location
Push For Stop (Horizontal)	On light panel, center of window above tape
Fire Extinguisher	Fire extinguisher compartment
No Smoking/Eating/Radio (International)	Centered on bulkhead
Watch Your Step	Centered on all steps and doorways
Open Doors Manually	Next to manual door operation
Open Emergency Door	Interior, over emergency door handle



Typical Signage	
Door Number	Located above door
Passenger Stop Request Switch	Interior, at mobility aid location
International mobility aid	Per ADA requirements
Don't Forget Your Bike	At doorway
This Streetcar May Be Equipped With Audio Visual Recorders	Centered on bulkhead
Electrical component locations	All interior and exterior electrical compartments

#### 6.14.3 ADA Accommodation Graphics

Comply with the following requirements for ADA compliant graphics and signs:

1. International symbol of accessibility (ISA): Provide at each required mobility aid parking area and priority seating area. Located 48 inches to 60 inches above the floor or where most logical.
2. Priority Seating: Sign at each mobility aid parking area indicating that the primary use of the area is for mobility aids. Provide instructions for operating the flip-up seats, where provided.
3. Passenger Stop Request: Sign for the mobility aid parking area passenger stop request switch Specified in Section 9 Passenger Doors, with instructions for use.

Other ADA-required signage and information, as they apply to transit applications.

#### 6.14.4 CCTV Notice

Provide signage at each cab indicating that the vehicle has an active surveillance system, recording audio in the cab, details to be provided by the City.

#### 6.14.5 Vehicle Numbering

Provide clearly displayed numbering for each vehicle to aid operating personnel and passengers in reporting vehicle locations or incidents:

1. Number Graphics:
  - a. Material: Graphic film.
  - b. Number Font: Helvetica medium type style or Approved equal.
  - c. Number Height:
  - d. Interior: 75 mm (3 in)
  - e. Exterior: 100 mm (4 in)
  - f. Roof: 915 mm (36 in)
2. Numbering Scheme: Number vehicles sequentially using numbers with up to four digits, as Approved by the City, and in the vehicle interior, provide both vehicle number and end-identification letters (A or B).
3. Number Locations:
  - a. Interior:
    - i. Cab: Above left side cab window.
    - ii. Passenger compartment: Upper part of each cab and articulation bulkhead.
  - b. Exterior:
    - i. Both vehicle ends: Above the windshield.
    - ii. Both vehicle sides: Center section.
    - iii. Roof: Each end, oriented as Approved by the City.

6.14.6 Safety

Provide the following safety warnings and signage:

1. Safety warnings and advisories at doors, articulation sections, and access points to hazardous equipment.
2. Equipment enclosure labels with safety warnings for High Voltage, as appropriate.

6.15 City-Provided Routes, Schedules, and Advertising

Provide interior areas in each vehicle to accommodate City-provided material such as route maps, schedules, advertising, and similar materials that are changed periodically:

1. Size: 300 mm square to 600 mm square (12 in square to 24 in square). Exact dimensions will be defined by the City.
2. Locations: As defined by the City during interior design reviews, but typically on cab or interior walls.

6.16 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

6-1 Initial Interior and Exterior Design Package:

1. Submit within 60 days after NTP.
2. Initial submittals may be in the form of accurately colored renderings and models.
3. Include the following:
  - a. Interior and exterior color scheme
  - b. Finishing
  - c. General appearance
  - d. Seat cushion material and color/patterns
  - e. Seating arrangement
  - f. Samples of all finishing materials and the material specifications

6-2 Interior Design Package:

1. After approval of the Initial Interior and Exterior Design Package, submit a comprehensive interior design package.
2. Include everything related to the interior that was included in the Initial Interior and Exterior Design Package, but in final form.
3. Sample of each paint color (if paint is Approved for interior):
  - a. Apply the same number of coats of primer and final paint as Specified for the vehicle.
  - b. Use the same base material to which paint will be applied on the vehicle.
4. Corresponding CIE Lch tristimulus values for each paint sample, as measured using D65 (sunlight) light source.

6-3 Walls and Ceiling Design Package:

1. Materials specifications

- 
2. Thermoplastic (if used): Laboratory test certificates stating that thermoplastic sheet complies with standards and strength requirements Specified in Section 16, Materials and Workmanship.
  3. Application Instructions
  4. Drawings showing application locations.
- 6-4 Acoustical Insulation Design Package:
1. Data sheets demonstrating that Specified requirements are met.
- 6-5 Thermal Insulation Design Package:
1. Data sheets demonstrating that all Specified requirements are met.
  2. Details of method of retention for roof insulation and side and end wall insulation.
  3. Details of the vapor barrier required for the floor insulation.
- 6-6 Floor Covering Design Package:
1. Propose the material manufacturer and model.
- 6-7 Passenger Seat Design Package:
1. Details of seat materials, including sufficient information to verify compliance with the Specifications.
  2. Dimensioned drawings of seats and seat layout.
  3. Mounting details.
- 6-8 Mobility Aid Parking Area Design Package:
1. Dimensioned drawings for mobility aid parking areas showing required clearances.
- 6-9 Stanchions, Handrails, and Windscreens Design Package:
1. Stanchion and handrail spacing and placement.
  2. Details of finish.
- 6-10 Fare Collection Design Package:
1. Installation location, stanchion arrangement, and mechanical and power/network details.
- 6-11 Key Design Package:
1. Key Assignment Table like the table in this Section, with final key and lockset assignments.
  2. Samples
- 6-12 Windows Design Package:
1. Data sheets demonstrating that Specified requirements are met.
  2. Details of how windows are replaced.
  3. Details of U.S. suppliers.
  4. Windshield:
    - a. Details of embedded defrosting with sufficient information to demonstrate that the requirements of Section 7, Heating, Ventilating, and Air Conditioning, are satisfied.
    - b. Details of how external and internal glare are minimized for the cab windshield.
- 6-13 Operator's Cab Design Package:
1. General arrangement drawings of the cab, depicting all features required in the cab:
    - a. Plan, profile, and front elevation drawings of the interior, showing all visible features, with dimensions.
    - b. Plan and elevation views of Cab Console, including operator's seat and side windows.
    - c. Drawings showing operator's range of visibility out the windshield, and views through the mirrors.

- i. Include cab features affecting visibility, such as vehicle structure, sunscreens, shades, window masks, and display screens.
    - ii. Show the Specified size range of operators, while seated.
    - iii. Show the seated operator’s whole body accurately in relation to the console and cab seat, with height adjustment of the operator’s seat according to both head and knee height.
    - iv. Show the seated operator’s relationship to the Master Controller
    - v. Show the actual sitting position of the operator, to the extent possible
    - vi. Show the operator standing to confirm visibility of the coupler with left hand on the master controller, over the size range of operators.
  - d. Foot switch location.
  - e. Panelboard locations.
  - f. Convenience outlet locations.
2. Manufacturer’s literature or detailed drawings of the following, as appropriate:
  - a. Mounts for switch iron and pantograph crank.
  - b. Coat hook
  - c. Speedometer
3. Parts List

6-14 Windshield Wiper and Washer System Design Package:

1. Drawings showing the following:
  - a. Components of the windshield wiper and washer system
  - b. Windshield wipers in parked position
  - c. Area swept by the wipers.
  - d. Size and capacity of the washer fluid reservoir
  - e. Access to the washer fluid reservoir, and location of fill port
2. Narrative describing windshield-wiper controls.

6-15 Exterior Design Package:

1. Drawing showing the final exterior color scheme, with detailed drawings of graphics.
2. Sample of each paint color:
  - a. Apply same number of coats of primer and final paint as Specified for vehicle.
  - b. Use same base material to which paint will be applied on vehicle.
  - c. Roof: One sample with anti-skid paint and one without.
  - d. Trucks: Sample demonstrating that paint does not hide structural cracks.
3. Corresponding CIE Lch tristimulus values for each color sample.
4. Graphics:
  - a. Sample of each graphic, for small graphics, or a sample of each color, for large graphics.

6-16 Rain Gutters and Water Drainage Design Package:

1. Detail drawings showing material and dimensions.
2. Calculations confirm the size of gutters and drainage conduits is adequate for rainfall rate.

6-17 Equipment Enclosures Design Package:

1. Shop drawings and data sheets demonstrating that all Specified requirements are met.
2. Details of stiffeners for large boxes.

6-18 Signage Design Package:

1. Informational and safety graphics: Text and graphic layouts.
2. Vehicle numbering: Numbering locations, font, and size.

- 1        3. Route maps, schedules, and advertising: Frame materials, retention methods, colors, and related
- 2        features.

## Section 7 Electronic Controls, Software, and MDS

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**7.1 General**

**7.1.1 Scope**

This Section includes the following:

1. Requirements for the vehicle control system Specified in this and other sections.
2. Requirements for the vehicle network and monitoring and diagnostic system.
3. Requirements for software Specified in this and other sections.

**7.1.2 Electronic Control Equipment Configuration**

Comply with the following:

1. Segregate electronic control equipment both physically and electrically from power equipment.
2. Galvanically isolate control circuitry and control voltage sources from power circuitry and high voltage sources via transformers.
3. Provide dedicated power supplies for control systems that are transformer isolated and powered from the low-voltage dc system.

**7.2 Control Logic Units**

**7.2.1 General**

Comply with the following:

1. Each vehicle system will have dedicated network-connected controls to achieve all functionality Specified in this Section and other sections of the TS. Provide diagnostics and fault logging, connections, and firmware for PTUs.
2. The control logic units will include user-programmable operating characteristics. Control programs will be stored in field-updateable, non-volatile memory.
3. All connections to low-voltage dc circuits will have galvanic isolation.

**7.2.2 Vehicle Control Unit**

Provide a control unit, designated as the vehicle control unit (VCU):

1. Purpose: To manage all communication between vehicle systems, monitor system states, display required information on the TOD, and similar functions.
2. Alternate to VCU: May be proposed to the City, such as the propulsion system providing the VCU function.

**7.2.3 Monitoring and Fault Recording Capability**

Comply with the following:

1. Control logic units will have self-diagnostics, monitor status and faults of internal and external devices, and continuously monitor critical parameters (Local Diagnostic and Test System (LDTS)).
2. LDTSs will be integrated into the Monitoring and Diagnostic System (MDS) Specified below.
3. The control logic unit and related software and devices will be sufficiently responsive to detect and remedy erroneous or potentially damaging conditions such that equipment damage is prevented or minimized.



## 7.3 Control Signals

### 7.3.1 General

Comply with the following:

1. Critical vehicle systems will be controlled via discrete battery-level signals issued directly from the controlling cab, and propagated directly to the controlled systems without intervening electronic systems or other components that could cause false activation.
2. The status of control signals may be monitored by the vehicle network controllers Specified below. However, discrete control signals must predominate, and conflicts will be flagged as errors.

### 7.3.2 Required Discrete Control and Status Signals

Provide the following signals, at a minimum, configured as Type 1 interfaces as defined in IEEE 1475:

1. Cab or Vehicle activation status
2. Emergency brake control
3. Door Interlock (locked and closed) status.
4. Door Enable control.
5. Door Open control
6. No Motion status
7. Propulsion mode control
8. Brake mode control
9. Track brake control
10. Friction brake released status.
11. Forward mode control
12. Reverse mode control
13. Sanding control

### 7.3.3 Special Requirements for Door Control and Status

Configure door control and status signals in a separate left/right side of vehicle configuration.

## 7.4 Vehicle Data Network

### 7.4.1 General

All vehicle system control logic units will communicate with each other and the main VCU via data networks.

### 7.4.2 Network Standards

The vehicle networks will conform to TCN (Train Communication Network), in accordance with IEC 61375-

1. The following network types are permitted:

1. MVB (Multifunction Vehicle Bus): IEC 61375-3-1
2. CCN (CANOpen Consist Network): IEC 61375-3-3
3. ECN (Ethernet Consist Network): IEC 61375-3-4

The main vehicle network may be MVB, CCN, or ECN.

**7.4.3 Network System Redundancy**

Comply with the following:

Use a partial mesh topology and other techniques to minimize the effects of single-point network failures on the remaining system. Establish redundant links between managed switches and/or routers using Rapid Spanning Tree Protocol (IEEE 802.1D) or Shortest Path Bridging (IEEE 802.1Q) to achieve a convergence time of no more than 6 seconds after a link failure. Unmanaged switches that do not participate in RSTP or SPB will not be used to make redundant connections to managed switches or routers.

**7.4.4 Network Requirements**

Comply with the following:

1. The network system will use an open design that is either non-proprietary or available from multiple sources. Network components and transceivers will be available from multiple sources.
2. The network protocol will be structured with respect to ISO/IEC 7498. All layers other than the application layer will be transparent to the various vehicle system suppliers.
3. Communication related to real time control, such as propulsion control, will be prioritized to the extent that anomalies in system stability and operation are prevented.
4. Calculated peak and average traffic levels will not exceed 60% of the recommended peak and average traffic levels. Actual peak and average traffic levels measured under Section 18 Vehicle and Systems Testing, will not exceed 70% of the recommended peak and average traffic levels.
5. Protocols will include error detection and retransmission. Each node on the network will collect summary statistics regarding current and historical error rates and make that information available through the Monitoring and Diagnostic System Specified below.
6. Network wiring will be physically isolated from sources of EMI. Where redundant networks are employed, they will not be run in the same conduit, wireway, or other such routing path.
7. The main network will be fault tolerant, such that loss of connections to systems does not affect the connections of other systems to the network.
8. Safety relevant bus members, such as door controls and friction brake controls, will continue to operate safely, and as commanded by the operator, even if the network has failed.

**7.4.5 Vehicle Network Controller**

Each vehicle will include a Vehicle Network Controller (VNC) to manage the local vehicle network(s):

1. Data that does not need to pass between the various networks will be restricted from so doing.
2. The VNC may be considered as a functional entity and may be physically implemented within a more comprehensive equipment package.
3. The VNC will automatically identify the vehicle upon which it is installed.
4. The VNC will act as a router and will prevent local vehicle faults from interfering with vehicle operation.

**7.4.6 Time Synchronization**

The vehicle data network will be used to synchronize sub-system clocks within the vehicle with the official time signal, as received by the GPS system.

7.4.7 Wireless Access

The network will be accessible via the Wi-Fi IP Router, to allow protected access to the vehicle network for purposes such as downloading data when the vehicle is in the Yard or Shop.

7.5 Monitoring and Diagnostic System (MDS)

7.5.1 General

Comply with the following:

1. The MDS will be a physically distributed, functionally integrated system that monitors signals and events within the vehicle and within selected subsystems on the vehicle and stores the collected subsystem and vehicle data in non-volatile memory located within the selected subsystems and at a central data storage point on the vehicle.
2. Each vehicle system will include self-diagnostics, status, and fault monitoring, accessible locally via PTUs and via the MDS.

7.5.2 Diagnostic Systems

Provide each vehicle with a Central Diagnostic System (CDS) and each Specified individual subsystem with a Local Diagnostic and Test System (LDTs). The CDS will integrate the individual LDTs of the various subsystems and sensors on the vehicle.

Provide an LDTs to subsystems including, but not limited to, the following:

1. AC Auxiliary and Low-Voltage DC Power System
2. Propulsion System
3. Friction Brake System
4. Door and bridgeplate Control System
5. HVAC System
6. Communications System
7. CCTV System
8. Automatic Passenger Counting System
9. Diagnostic System
10. Event Recorder System
11. Network System

7.5.3 Fault Management

Comply with the following:

1. Provide diagnostic and failure reporting at levels of detail appropriate for the operating or maintenance function being supported.
2. Data points will be associated with fault attributes that can be changed by the City's personnel.
3. System faults will be time stamped and stored in memory.

4. Operating and maintenance functions that will be considered include the following:
  - a. Operating Failure Identification and Correction:
    - MDS will communicate information concerning failures affecting vehicle operation to the operator and other staff, where appropriate, of which they should be aware.
    - MDS will indicate if the failure is safety-related, affects operating procedures, and is correctable by the operator or other staff.
  - b. Status Assessment:
    - MDS will communicate sufficient information to enable maintenance personnel to assess operational readiness and suitability for service of each vehicle before entry into service.
  - c. Troubleshooting:
    - MDS will include detailed data to guide maintenance personnel using troubleshooting procedures to isolate and diagnose faults down to the lowest level possible.
    - This capability will be built into the vehicle borne MDS hardware and embedded software to the greatest extent practical; however, use of PTU will be permitted, subject to approval of the City.
  - d. Intelligent Failure Screening:
    - Each subsystem will have sufficient diagnostic intelligence to enable it to distinguish between actual subsystem failures and apparent failures caused by failure of another subsystem. For example, auxiliary inverter failures causing loss of three-phase power to an HVAC system will not be reported as an HVAC system failure.
    - Power-up and shut-down sequencing among subsystems will not generate failure messages.
  - e. Repeated instances of the same failure will be handled such that LDTs memory is not filled with multiple occurrences of the same failure.

#### 7.5.4 Interface with Shop

Comply with the following:

1. Equip the vehicle MDS with a Wi-Fi IP router to transmit MDS and other Specified data to the vehicle maintenance workstation in the Shop.
  - a. The MDS will automatically transmit fault data to the Shop when a vehicle enters the Yard or Shop.
  - b. Communication will be secure and encrypted to prevent unauthorized users from accessing the data or system.
2. Provide software for the storage, interpretation, and assessment of fault data transmitted to the vehicle maintenance workstation in the Shop.
  - a. Provide software and hardware compatible with the City's computer systems and associated access points to read and display vehicle health data from the onboard Wi-Fi when vehicles are in the Shop and Yard.
  - b. It will collect and analyze the data from the MDS and other Specified systems.

3. Coordinate with the City to ensure compatibility.

#### 7.5.5 Train Operator Display (TOD)

##### *General*

Provide a TOD, as part of the vehicle network, in each cab:

1. Activated cab: Automatically activated.
2. Non-activated cab: Possible to activate display manually.

##### *Display Requirements*

Comply with the following:

1. Type: LED back-lit LCD touch screen color display, ruggedized for industrial applications.
2. Screen size: Minimum 10 inch (diagonal measurement)
3. Resolution: Minimum 1024x768.
4. Brightness:
  - a. Easily readable under adverse lighting conditions including bright sunlight.
  - b. Provide both manual and automatic brightness adjustment.

##### *Controls*

Interface with the TOD will be by control buttons located directly below or by pressing the appropriate area on the screen.

Provide the following controls, as a minimum:

1. Fault Acknowledge
2. Screen Selection
3. Navigate through screens (menus)
4. Select specific items.
5. Screen Brightness

##### *Operating Status Screen*

Comply with the following:

1. Activation: Default screen upon power up and while the vehicle is in motion.
2. View:
  - a. Important information such as system status and conditions of each subsystem monitored.
  - b. Additional requirements are Specified within the TS.
3. Failures: Annunciate by highlighting the subsystem shown on the display in which a fault occurred.
4. Urgent items:
  - a. Will flash to catch the operator's attention.
  - b. Flashing will be canceled by the operator's activation of the Fault Acknowledge control.

*Additional Screens - Vehicle Stopped*

Comply with the following:

1. Activation: Possible if the vehicle is at standstill.
2. Additional screens available:
  - a. Fault screens to assist in failure reset or isolation.
  - b. Screens to show more detailed information.

*Maintenance Mode*

Activation: No restrictions on which screens may be activated.

**7.5.6 Portable Test Units (PTUs)**

*PTU Hardware*

Comply with the following:

1. PTU type: Laptop computer, Windows 10, or more current.
2. PTU connections:
  - a. Via Ethernet ports using M12 connectors.
  - b. Where other interfaces are Approved, provide all necessary interface adapters and interface software.

*PTU Software*

Comply with the following:

1. Provide laptop software that is not copy-protected, does not require external validating devices such as "dongles", and can be freely copied by the City onto the City's computers.
2. Design PTU software for future ease of upgrade and ease of migration to newer replacement computers during the life of the cars, at no cost to the City. This includes the possible use of open systems and tools.
3. For software requiring a license, furnish software licenses with a term at least as long as the service life of the vehicle, as Specified.
4. The Specified requirements for revisions to vehicle software in the Software Revisions section, below, apply also to PTU software.
5. Furnish back-up copies of all PTU software to the City.
6. Provide PTU software for each system requiring adjustment or diagnostics, including the following as a minimum:
  - a. Door and Bridgeplate system
  - b. HVAC
  - c. AC auxiliary and Low-voltage dc power system
  - d. Propulsion
  - e. Friction brake
  - f. Communication systems, including PA, intercom, APIS, CCTV, GPS, Event Recorder, APC, AVL, TWC, and operator interface.

g. Vehicle network

h. Monitoring and diagnostic system

#### *PTU Connection Points*

Comply with the following:

1. Centralized diagnostic port: Provide to connect a PTU to monitor vehicle bus traffic and to download fault logs from interconnected control units. Provide integrated software to allow access to all connected units.
2. Independent PTU connection points:
  - a. Acceptable to provide at major control units, such as propulsion controls.
  - b. For such equipment it is expected that at least top-level fault information is still made available on the vehicle bus.
  - c. Detailed fault information will then be accessible by the PTU on the local connection.
  - d. PTU connections will be USB or Ethernet, as available on COTS laptop computers.

### *7.6 Vehicle Software and Systems*

#### *7.6.1 General*

Design software using modern programming techniques and compilers, and formal software design processes and management tools. Implement rigorous and documented testing, QC processes, and version controls.

#### *7.6.2 Software Functions*

Software will perform the following basic functions:

1. Implement the desired control scheme such that the Specified performance is achieved.
2. Monitor inputs for unsafe, erroneous, or unknown conditions or combinations of conditions.
3. Sample input conditions at rates sufficient to detect and remedy unsafe or damaging conditions in the shortest possible time. Sampling rates and program execution times will be such that the control system is not the limiting factor in response to unsafe or damaging conditions.
4. Limit output commands to safe levels regardless of the combination of input conditions.
5. Perform self-diagnostic routines and respond promptly, safely, and predictably to detected faults.
6. Respond safely and predictably when powering up or recovering from power interruptions. Detect power interruptions likely to have corrupted temporary storage and cause the system to re-initialize affected routines and temporary data. Detection of power interruptions may be by hardware.
7. Permit thorough interrogation of input, output, and internal conditions by external diagnostic equipment.
8. Present all user-accessible features in clear English.

#### *7.6.3 Software Revisions*

Following installation of software, continue to provide software revisions when software is updated by the Contractor or by subcontractors. Keep revisions current until the end of the warranty period.

## 7.7 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

### 7-1 Vehicle System Functional Description (SFD):

1. Define hardware and software components, the partitioning of the system functions, and the allocation of requirements (including derived requirements) to the individual systems.
2. Use terminology consistent with terminology of the Specifications and define names for subsystems and the interfaces between them to ensure consistent terminology used by all suppliers.
3. Diagram of the complete vehicle system:
  - a. Show individual systems with their interfaces, including network interfaces.
  - b. Show the location of system components within the vehicle and describe function.

### 7-2 Individual Systems SFDs:

Submit for each individual system. If individual systems are not submitted all at one time, comply with the requirements of Section 2 Program Control, Deliverables and Quality Assurance, for numbering and documentation for submittal packages that are submitted in more than one part.

1. Completely describe the system and how it meets the project requirements.
2. Documents will be consistent with the Vehicle SFD and with the TS.
3. Include the following in each individual system SFD:
  - a. Context Diagram: Show the system and external interfaces. Include a description of the functions of the system and the relationships of the system with other systems.
  - b. Decomposition Diagram and Description: Describe all system components and internal interfaces. Break components down into the hardware components, Software Configuration Items (SCIs), the internal interfaces within the system, and the external interfaces to other vehicle-level systems:
    - i. Hardware Components: Describe each to the level of its major components, LRUs, and LLRUs; the functions to be performed; and the interfaces.
    - ii. SCIs:
      1. Describe each in its own numbered section.
      2. Describe the major functions of the item and the relationship to the hardware, including memory and input/output hardware.
      3. Include version numbers and report upon request.
  - c. Software Summary Table:
    - i. Rows: Include one for each software item in the system
    - ii. Columns: Include one for SCI name and ID, Software Requirements Specification (SRS) name and ID, Software Design Description (SDD) name and ID, and section within the SFD where the SCI is described.



- d. Programmable Components: Define all specific hardware and programmed functions and the interfaces in a dedicated section.
- e. Data Files loaded to the individual systems (e.g., stop and station data, not programming code):
  - i. Include as separate configuration items and describe their content in a dedicated SFD section.
  - ii. Include version numbers in the data file and report upon request.
- f. Power On/Off:
  - i. Normal power on, power off strategy
  - ii. Startup sequences and durations
- g. Failure Detection and Remedial Action:
  - i. Describe monitoring the correct operation of system components, the failures to be detected, and the system reaction (e.g., shut down, announce)
  - ii. Distinguish between local system self-monitoring (and reporting) and external monitoring by higher level systems.

7-3 Vehicle Control System Design Package:

- 1. Vehicle control system circuit drawings and diagrams including the following:
  - a. Hardwired circuit drawings
  - b. Software diagrams
  - c. Functional descriptions
- 2. Sneak circuit and single point failure analysis that covers emergency loads, interlocks, and safety critical functions.

7-4 Vehicle Data Network Design Package:

- 1. Description of vehicle data network, network protocols, and transmission methodology.
- 2. Calculations of the variations in transmission time, as related to real-time control requirements, with a statement of acceptability by the propulsion and the brake supplier.
- 3. Detailed calculations of peak and average data traffic levels and calculations of network delays.
  - a. Network delay calculations: Include expected average delays and distribution of delay times.
  - b. Peak and average traffic levels for transmission media, as recommended by protocol Supplier.
- 4. Describe process whereby problems with networks will be detected, reported, and repaired.
- 5. Vulnerability assessment of hacking via Wi-Fi or vehicle ports.

7-5 Monitoring and Diagnostic System Design Package:

- 1. Mechanical specifications of the system
- 2. Mechanical assembly drawings with weights, dimensions, and parts lists
- 3. Electrical schematic drawings for system interconnections
- 4. Electrical schematic drawings for each device and assembly
- 5. Installation drawings
- 6. Layout of each screen with descriptions of each screen element and its use and operation
- 7. TOD:
  - a. Monitor details (size, resolution, colors, etc.)
  - b. Sample screen displays
  - c. Description of navigation
  - d. Listing of available displayed data for each system
- 8. Portable Test Unit (PTU):

- 1                   a. Laptop specifications
- 2                   b. Portable Test Unit Software
- 3   7-6   Software Quality Assurance (SQA) Plan
- 4   7-7   Software Requirements Specification (SRS)
- 5   7-8   Software Design Description (SDD)
- 6   7-9   Software Verification and Validation Plan (SVVP)
- 7   7-10 Software Verification and Validation Report (SVVR)
- 8   7-11 Software User Manual (SUM)

## Section 8 Communication Systems

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## 8.1 General

### 8.1.1 Scope

The on-board communication system includes Public Address System (PA), Intercom system, including cab-to-cab intercom and passenger emergency intercom (PEI), Automatic passenger information system (APIS), warning devices, radio, video surveillance (CCTV), vehicle position system, vehicle wireless communication to wayside, the event recorder, automatic passenger counting (APC), automatic vehicle locator (AVL), traffic light priority, and train-to-wayside communication (TWC) system.

### 8.1.2 Communication System Integration with MDS

The APIS, Communications, and MDS hardware, wiring, and functions may be integrated to the maximum extent possible.

### 8.1.3 Audio Communications Functional Description

The communications system will be configured to allow the following audio communications:

1. From the operator to passengers inside and outside the vehicle.
2. Between cabs in a vehicle, and the cabs of a vehicle being towed.
3. Between passengers inside the vehicle and the operator.
4. From the APIS to passengers inside and/or outside the vehicle via pre-recorded announcement sequences and visual displays.
5. From the door system to passengers inside and outside the vehicle, if door warnings are generated by one of the vehicle communication systems.

## 8.2 Public Address (PA) System

### 8.2.1 General

Comply with the following:

1. The PA system will permit the operator to make audio announcements to passengers inside or outside the vehicle, and to enable audio announcements from the APIS.
2. Operator-initiated PA messages will override APIS and door system messages generated by the APIS.

### 8.2.2 Performance

Comply with the following:

1. Messages will be intelligible and acoustically pleasing under all operating conditions.
2. The PA system, from the input of the microphone, or audio messages from the APIS, to the output of the speakers, will have a 90% intelligibility rating when tested according to ANSI S3.2.
3. The output volume and audio quality will be the same for each speaker.

### 8.2.3 Amplifiers

Comply with the following:

1. Provide network-connected amplifiers per vehicle section, driving one or more speakers, with sufficient power to drive all connected speakers at maximum levels, simultaneously, without distortion.

### 8.2.4 Automatic Volume Control

The PA system interior output levels will be automatically adjusted in accordance with ambient noise levels before each announcement, regardless of origin:

1. Range of automatic adjustment: Minimum 10 dB.

2. Maximum output level (interior): Minimum 15 dB above typical worst case ambient noise levels when the vehicle is moving at maximum operating speed.
3. Maximum output level (exterior): Minimum 15 dB above typical worst case ambient noise levels when the vehicle is stationary at a station selected by the City.

#### 8.2.5 Cab Microphone

Provide a microphone in each cab, usable for PA, cab-to-cab, and PEI modes:

1. Type: Console-mounted, noise-cancelling, dynamic.
2. Durability: Rugged, weatherproof construction, designed and constructed for transportation applications, and vandal resistant.
3. Location: Will permit a seated operator of the Specified size range to speak into the microphone without leaving the normal operating position or losing sight of traffic in front of the vehicle.
4. Microphone preamplifier: will include a compression circuit that maintains output regulation of + 1/- 0.5 dB, no load to full load, measured at the speaker terminals.

#### 8.2.6 Interior Speakers

Interior speakers will meet or exceed the following criteria:

1. Provide a minimum of one speaker for every 1800 mm (71 in) of vehicle length.
2. Select speaker dispersion and other characteristics to produce sound levels within 3 dB, and intelligible audio, at all seating locations, under all vehicle operating conditions.
3. Provide speakers with a continuous power rating of minimum 5 W.
4. Arrange speakers to eliminate feedback from any audio input source.
5. Provide audio fidelity Specified in this Section at all power levels.
6. Mount speakers in the ceiling, or other Approved locations.
7. Grilles will be flush mounted, finished to match the panel, perforated, removable for access to the speaker, and held in place with tamper-proof screws.
8. Provide a volume adjustment control for the Operator's cab PA speaker that can be adjusted by the Operator.

#### 8.2.7 Exterior Speakers

Exterior speakers will meet or exceed the following criteria:

1. Provide a minimum of four external speakers per vehicle, two per side.
2. Speakers will be impervious to environmental conditions Specified in Section 2, Design and Performance Criteria.
3. Provide speakers with a continuous power rating of minimum 15 W.
4. Mounting of speakers and routing of speaker wires will be waterproof.
5. Speaker locations will not violate the vehicle's dynamic outline.
6. Speakers will be immune to the chemicals and detergents normally used during vehicle washing, will not interfere with nor damage mechanical vehicle wash brushes, and will be designed to withstand forces generated by these brushes.

#### 8.2.8 PA Passenger Alert Tone

Comply with the following:

1. Preceding any public audio announcement, including automatic announcements, a local tone annunciator will be energized to alert passengers that an announcement is forthcoming.
2. The tone volume will be 3 dB above the normal speech level.
3. The annunciator will possess a pleasant, chime-like quality, Approved by the City.

## 8.3 Intercom System

### 8.3.1 General

The intercom system will allow communication between passengers and the operator, and between vehicle cabs.

### 8.3.2 Passenger Emergency Intercom (PEI)

#### *General*

The passenger emergency intercom will permit passengers to communicate with the operator.

#### *PEI Station Quantity and Location*

Comply with the following:

1. Provide 2 PEI units.
2. Location: Provide one in each of the two dedicated mobility aid parking areas mounted to be easily accessible for the use of mobility aid patrons.

#### *PEI Stations*

Comply with the following:

1. Description: Flat-faced, panel-mounted enclosure with microphone, loudspeaker, large pushbutton switch, indicating light (which may be part of the pushbutton switch), and any necessary auxiliary components to make the system function.
2. Enclosure:
  - a. Material: Stainless steel.
  - b. Rating: Splash-proof, and vandal-resistant.
  - c. Front panel: Perforated in front of microphone and loudspeaker with holes as small as possible to enable adequate performance while reducing opportunities for vandalism.
3. Microphone: Omni-directional, with external filters to reduce background noise.
4. Loudspeaker:
  - a. Materials: Like the interior PA speakers.
  - b. Continuous power rating: Minimum 3 W.
5. Pushbutton: Arranged to prevent unintended nuisance application during crowded conditions in passenger area.
6. Electrical connections: Use concealed multi-pin connectors.
7. Signage:
  - a. Text: English and Braille.
  - b. Identification: "Emergency Intercom."
  - c. Instructions: "To Contact Driver Push Button Once" or Approved similar language.
  - d. Unit location: Identify the vehicle and PEI unit location. Provide signage adjacent to unit.
  - e. Signage regulations:
8. Comply with 36 CFR 1191 Appendix D, Section 703, Signs.
9. Provide tactile symbols and characters that comply with 36 CFR 1191 Appendix D, Section 703.2, Raised Characters, in accordance with 36 CFR 1191 Appendix D, Section 407.4.9, Emergency Communication.
10. Installation: Flush mount each unit at a height of 1220 mm (48 in) above the floor. The installation will comply with 36 CFR 1191 Appendix D, Section 308, Reach Ranges.



## Functional Description

The system will function as follows:

1. Pressing the call-request button at a PEI station:
  - a. Causes each call request to enter a first-in, first-out queue in the PEI control system.
  - b. Indicates acknowledgement of the call request to the passenger with a light on the PEI station and an audible notification.
2. When the call request comes to the top of the queue:
  - a. The operator is hailed via a tone and indicator lamp at the active Cab Console.
  - b. 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.
  - c. 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.
  - d. 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. Audio from the PEI will be heard only in the active cab and at the active PEI station.
3. When the conversation is finished:
  - a. The operator terminates the call by pressing a button on the Cab Console and the active PEI station returns to an inactive state.
  - b. 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.
4. If the operator activates other audio functions on the Cab Console:
  - a. PEI activities are placed on hold and the queue maintained.
  - b. The PEI indicator lamp on the Cab Console will remain illuminated.
  - c. The operator will return to the PEI session by pressing a button on the Cab Console.

### 8.3.3 Cab-to-Cab Intercom

Provide a cab-to-cab intercom to allow communication between cabs within the vehicle, and between cabs of vehicles during towing operations:

1. Function: Similar to the PEI (may use the same equipment).
2. Call initiation: From any cab, with or without an active console.
3. Call annunciation: In every cab, by means of a one-time call chime and an indicating light.
4. Call acknowledgment: In any cab.
5. Indicating lights: Will stay on until the call is completed.
6. Connection between vehicles: Make provisions for connection during towing operations. A separate cable that attaches at either cab end through a weatherproof connector will be acceptable.

## 8.4 APIS

### 8.4.1 General

1. The vehicle will include equipment for automated broadcast of pre-recorded audible and visual announcements of transit system information as well as destination information to passengers on the wayside:
2. The APIS components will be fully integrated into a network-connected system, with a controller common to all.
3. The City will provide the Contractor with an initial data set of messages, station names and physical locations, announcement sign text/images, and other information necessary to commence revenue service.

#### 8.4.2 Functional Description

1. The APIS system will function as follows:
2. After the operator selects the route, announcements are triggered automatically without operator assistance or may be triggered manually by the operator:
  - a. Automatically:
    - i. By vehicle position, determined by a combination of GPS coordinates, distance measurement by wheel revolution count.
    - ii. Door open, door close and door release.
  - b. Manually: Via the APIS Control Panel in each cab.
3. Destination signs will automatically be set.
4. Audio announcements will be broadcast over the PA system, and corresponding visual announcements displayed on the interior information signs.
5. The message database structure will include instructions to direct audio to the interior, exterior, or both speaker sets.

#### 8.4.3 Passenger Information

The system will include as a minimum the following passenger information:

1. Station arrival announcement: Station identification may include station name, exit locations, and bus or train transfer information.
2. Door open, door close and door release: Public service announcements.
3. Station departure announcement: Broadcast the following information:
  - a. Next station
  - b. Vehicle destination/route information
  - c. Which doors will be opening at the next station.
4. End of Line
5. Public Service Announcements

#### 8.4.4 Operator Controls

Provide an APIS Control Panel in each cab:

1. Location: Integrated into the Cab Console in a less-frequently used area, or alternately, integrated into the TOD via the vehicle data network.
2. Functionality: It will allow the following:
  - a. Initiating the system
  - b. Entering temporary information such as vehicle ID and operator ID
  - c. Entering route ID
  - d. Selecting specific messages
  - e. Altering the normal message sequence, such as skipping stations
  - f. Display of system status and other relevant information
3. Interface Device:
  - a. It will include a keypad or similar with function specific keys. Entering commands via codes is prohibited.
4. Display: LED back-lit LCD display or authorized alternative showing the following information:
  - a. System states
  - b. Entered information.
  - c. System diagnostic and fault data
  - d. Presently announced messages
  - e. Similar information

8.4.5 System Initiation

Comply with the following:

1. Cab keyed On, or Hotel Load timer is Active: The system will initiate itself to the last route ID, or to a default setting if the last active ID is not present.
2. Cab keyed Off: The route ID will be stored.

8.4.6 Message Format, Uploading, and Recording

Comply with the following:

1. Audio format: Messages will be encoded and stored in a common, publicly available, digital format such as MP3.
2. Audio sample rates and compression levels: Chosen for excellent human voice and good music fidelity at the speaker.
3. Message, station, and route data: Up loadable via Ethernet, USB, or as Approved.
4. Recorded audio messages: The initial set will be created by the City using a text-to-speech algorithms.

8.4.7 Data Storage and User Programming

Comply with the following:

1. The APIS will use a non-proprietary, publicly available, database structure to store all data.
2. Each audio text message will 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.
3. Updating, creating, deleting, uploading, and downloading APIS information will be intuitive, database structured, and contained within one program; recording of audio messages can be performed using different software.

8.4.8 System Capacity

Comply with the following:

1. For storage, assume for audio messages at least 30 seconds per message and for text messages 100 characters each.
2. Message capacity will depend only on available memory; there will be no inherent limitation built into the control software or algorithms.
3. The system will have enough capacity to store the following:
  - a. 50 routes, with a minimum of 100 stations for each route.
  - b. 10 audio and 10 text messages per station.
  - c. Minimum 50 special messages, audio, and text.

8.4.9 Performance

APIS audio performance will be the same as for the PA.

8.4.10 Recording and Programming Equipment

Furnish to the City a complete set of equipment, including software, for modifying the visual and audible messages and routes:

1. The system will be composed of standard commercial off-the-shelf equipment.
2. This equipment will include everything required to reprogram the on-board systems with new information, such as messages, routes, and stations.

8.4.11 Information and Destination Signs

*General*

Provide an electronic information and destination sign system on each vehicle:

1. Regulations and Standards: Comply with 49 CFR 38 Subpart D (ADA requirements).
2. Quantity: Each vehicle will have a minimum of four interior information and four exterior destination signs.
3. Environmental protection: Protect signs from the following:
  - a. Environmental contamination
  - b. Ingress, as appropriate for the operating environment
4. Maintainability: LCD panels will be user-replaceable, and of a common design and format available from multiple sources in the U.S.

*Information Signs*

Comply with the following:

1. Type: Back-lit LCD displays capable of scrolling a message, single line display, for interior viewing.
2. Characters for announcements:
  - a. Minimum height: 75 mm (3 in).
  - b. Width-to-height ratio: Between 3:5 and 1:1.
  - c. Stroke-width-to-height ratio: Between 1:5 and 1:10.
  - d. Quantity: Minimum 15 alpha-numeric characters.
3. Viewing angle: Minimum 120 degrees horizontally.
4. Brightness: Minimum 500 cd/m<sup>2</sup>.
5. Temperature operating range:
  - a. At least 10 to 40 degrees C (50 to 104 degrees F).
  - b. No damage to the monitor in the temperature range as Specified.
6. Protective cover: Vandal resistant, clear polycarbonate shield over the display.
7. Ethernet connected to announcement controller.
8. Power source: Vehicle low-voltage system via local power supplies.
9. Cooling: Configure the enclosure, installation, and LCD panel to use conditioned interior air without forced air cooling.
10. Location:
  - a. Low-floor section: Mount two as a pair, back-to-back, hung from the ceiling near the center, oriented transversely.
  - b. High-floor sections: Integrate into fixed portion of cab partition.
  - c. Situate to permit any passenger in the vehicle to have a view of at least one sign.
  - d. Coordinate placement with CCTV cameras such that signs do not obscure CCTV field of view.

*Destination Signs*

Comply with the following:

1. Type: Single-line, dot-matrix LED, or back-lit LCD, capable of scrolling a message, for exterior viewing.
2. Message:
  - a. Length: Minimum 15 alphanumeric characters.
  - b. Color: Yellow or amber on black.
3. Characters:
  - a. Width-to-height ratio between 3:5 and 1:1.

- b. Stroke-width-to-height ratio between 1:5 and 1:10
4. Display: Destination or route information.
5. Cab front display:
  - a. Location: Above each cab windshield.
  - b. Character height: Minimum 150 mm (6 in).
  - c. Visible at a minimum distance of 150 ft (46 m) in bright sunlight.
  - d. Coordinate with upper lighting fixture design to ensure glare-free visibility under all conditions.
6. Side display:
  - a. Location: On each side near a side entry door; alternative locations may be submitted to the City.
  - b. Character height: Minimum 110 mm (4.3 in).

## 8.5 Warning Devices

### 8.5.1 General

Comply with the following:

1. Provide a horn and bell on each end of the vehicle for alerting automobiles and pedestrians.
2. Horns and bells will comply with appropriate federal, state, and local regulations.

### 8.5.2 Automobile Warning Device (Horn)

Comply with the following:

1. Horn: Multiple-tone electronic air horn or electronic horn.
2. Audible output: Minimum 95 dBA at 30 m (100 ft) in front of vehicle, adjustable by maintenance personnel.
3. Location: Mount underneath cab floor.
4. Operation:
  - a. Sound will continue while the switch is activated.
  - b. When activated, only the horn facing the direction of motion will sound.

### 8.5.3 Pedestrian Warning Device (Bell)

Comply with the following:

1. Bell: Electro-mechanical, traditional-sounding trolley bell with repeating sound of approximately two strikes per second.
2. Audible output: 75 – 80 dBA measured 30 m (100 ft) from front of vehicle, adjustable by maintenance personnel.
3. Operation:
  - a. Sound will continue while the switch is activated.
  - b. When activated, only the bell at the end where it was activated will sound.

## 8.6 Radio

### 8.6.1 General

Provide space for the future installation of vehicle radio chargers on the Cab Console and in the cab electrical locker. Details of the radio charger will be supplied during Design Review.

### 8.6.2 Radio Power Supply

For each set of radio equipment, provide an industrial grade dc-to-dc power converter, and includes the following:

1. Characteristics complying with radio manufacturer's requirements.
2. The following features:
  - a. Transformer-isolation
  - b. Input voltage transient suppression rated for minimum 150 J.
  - c. Output overvoltage protection
  - d. Short circuit protection
  - e. Current limiting
3. Output voltage: As recommended by the radio manufacturer.
4. Line and load regulation: 1% or less over the full range of the LVPS input voltage and from no-load to rated output.
5. Rating:
  - a. For continuous output current 25% greater than the maximum load current drawn by the radio transceiver and all other relevant loads.
  - b. The converter may be used to power other cab equipment that requires the same dc voltage as the radio, in which case the power rating of the converter will be selected accordingly.
6. Power the radio equipment via a dedicated dc circuit breaker. If the supplied radio is a fixed, non-portable unit, power the radio power supply through a circuit breaker directly connected to the battery, upstream of the battery circuit breaker.

## 8.7 CCTV

### 8.7.1 General

Provide each vehicle with an Ethernet TCP/IP-based Closed-Circuit Television (CCTV) system consisting of color cameras, display screens, DVR, CCTV Controller, and other ancillary equipment, as required. The City requires the use of Genetec equipment, all video surveillance must be integrated into the City's backend system; the current fleet uses Genetec Streamvault SVR-300AR for the CCTV Controller and NVR.

### 8.7.2 Cameras

Comply with the following:

1. Quantity:
  - a. Interior/exterior surveillance: At least twelve, to achieve the coverage Specified below
  - b. Exterior side view: Four
2. Type: Networked IP digital color cameras recording both video and audio, with pan and tilt adjustments.
3. Maintainability: Use the same camera for all applications, interior and exterior. Choose lenses and enclosures as appropriate for each application.
4. Camera characteristics:
  - a. Resolution: Minimum 720p (1280x720), with lower resolutions available and user selectable.

- b. Power source: From the CCTV system. Power over Ethernet (PoE) cameras are acceptable.
- c. Imaging: Automatic WDR.
- d. Illumination rating (light sensitivity): Maximum 0.2 lux, for low light conditions. Demonstrate that the camera does not “white out” when operating at night.
- e. Colors: Minimum 16-bit color depth.
- f. Compression: H.264 or H.265.
- g. Frame rate: Minimum 30 fps, with lower rates available.
- h. Control: Frame rate and bandwidth for each camera will be remotely controllable using the CCTV Controller.

### 8.7.3 Camera Enclosures

Comply with the following:

1. Interior Camera Enclosures: Vandal-resistant, industrial grade.
2. Exterior Camera Enclosures:
  - a. Waterproof.
  - b. Heating Elements: Provide for defrosting and de-fogging, with control such that clear view for exterior camera is available within 10 minutes of activation of any cab and is maintained while any cab is active.
  - c. Non-Snagging: Design will prevent snagging of carwash brushes or debris.
  - d. View Port: Tempered glass.
  - e. Removable: Without affecting camera adjustments.

### 8.7.4 Interior/Exterior Surveillance CCTV

Provide each vehicle with the following surveillance cameras:

1. Interior Surveillance:
  - a. Enough on the vehicle interior to ensure complete coverage of all passenger areas, including all door openings looking out to the platform.
  - b. Active when either cab is active.
2. Exterior front-facing Surveillance:
  - a. A front-facing camera in each cab to give a wide-angle front view, covering the area in front of the vehicle and signals. Provide two cab-forward cameras in each cab if deemed necessary by the City to cover a 180-degree arc in front of the cab.
  - b. Active when either cab is active.
3. Operator Surveillance:
  - a. Two cameras in each cab, oriented to view operator activities and audio. Ability to record operator’s front.
  - b. Active when either cab is active, but only at the end with the active cab.
4. Exterior side-view Surveillance
  - a. Side-facing cameras, two per vehicle side, located to give a clear view of the side of the vehicle with the doors opened, showing passengers entering and exiting the vehicle.

### Surveillance Display Screen

See section 6.10.8 Surveillance Display Screen.

8.7.5 CCTV Controller

Provide a network controller to perform the following functions:

1. Manage all cameras in the vehicle.
2. Provide network interfaces to the VNC and Specified display and recording devices.
3. Provide an interface to CCTV workstations.

8.7.6 Workstation Software and Hardware

Provide CCTV Workstation software (Genetec) for installation on personal computers with current Windows® OS:

1. Using a network port on the CCTV controller, the software will permit uploading operating parameters (such as sampling rates), viewing all or selected cameras in real time, downloading and viewing of video data from the DVR, verification of authenticity, image and video enhancement, and similar processes.
2. The software will be Web-browser based, and compatible with common Internet Web browsers, such as Google Chrome, Internet Explorer, or Mozilla Firefox.
3. The software will enable access to recorded video data that has been removed from the vehicle and is contained in a storage device removed from the vehicle or has been uploaded to the City's server.
4. The workstation software will include provision to connect to the City's server, navigate to stored data by vehicle number and date range, and display on the workstation.
5. Provide network-connected equipment that will accept the storage device as a simple plug-in and allow access to the data.

8.7.7 Digital Video Recorder (DVR)

*General*

Provide a DVR (Genetec) in each vehicle:

1. Inputs: Sufficient for the quantity of cameras to be recorded in each vehicle, plus two spares.
2. Capacity: Sufficient to record all cameras in use at one time.
3. Authentication: The recording method will include a process to detect any alteration of the data after recording.

*Recording*

Provide for recording the cameras described above as follows:

1. Interior surveillance cameras
2. Exterior surveillance cameras (both active and inactive cabs)
3. Operator surveillance camera (active cab only)

*Vehicle ID, Date, and Time*

The DVR will automatically include the vehicle ID and a date/time stamp on all images:

1. Vehicle ID: Entered by the user into non-volatile memory via the CCTV controller.
2. Camera ID: Provide a unique ID for each camera, such as an IP address, that is consistent in each vehicle.
3. Date and time: Maintained by an internal clock, synchronized by the GPS at agreed intervals.
4. GPS signal: Lack of a signal will not disrupt or alter the internal clock.



*Recording Frame Rate and Resolution*

Frame rate and resolution will be software adjustable, using a PTU via the CCTV controller:

1. Normal recording:
  - a. Speed: 15 fps.
  - b. Resolution: Lower than maximum, as agreed.
  - c. Bandwidth: Lower than maximum, as agreed.
2. High-rate recording triggered by external events:
  - a. Speed: 30 fps.
  - b. Resolution and bandwidth: Maximum camera.

*Recording Triggered by External Events*

Comply with the following:

1. Triggering events:
  - a. Silent alarm
  - b. EB application
  - c. MB application
  - d. Passenger emergency intercom activity
  - e. Manual (emergency) door release
2. High-rate recording: Continue for 15 minutes after an event trigger, user programable.
3. Storage: Provide protected area that prevents video recording from being overwritten or erased.

*Storage Capacity*

Comply with the following:

1. Storage capacity: Minimum 31 days of surveillance video, computed using a minimum 20 hours per day, maximum camera resolution and bandwidth, 15 fps, and Specified compression.
2. Recording durations: User selectable, from one day to full capacity.
3. Capacity status: Used/unused capacity of the DVR will be viewable by maintenance personnel and the operator on the TOD. Provide a warning on the TOD via the VNC when capacity is near full.
4. Full capacity: When reached, new data will over-write oldest data.

*DVR Data Storage*

Provide the DVR with hot-swappable non-volatile memory storage:

1. Type:
  - a. Solid State Drive (SSD) storage medium, if necessary, storage capacity is available with commercial drives, and the Contractor can ensure a minimum 10-year life at the Specified recording rates. Furnish confirmation of predicted lifespan from the SSD manufacturer.
  - b. Hard disk drive (HDD) if an SSD is determined to be inappropriate:
2. Reliability: Propose only HDDs with high reliability in continuous duty. Reliability will be as determined by independent groups, such as BackBlaze.
3. Installation: Comply with all manufacturer's recommendations, including ambient temperature and power quality. Provide resilient mounts.
4. Security: The memory storage device will be secured via a keyed lock, or other Approved mechanically secure methods.
5. Playback: Provide appropriate adapter hardware and software for the memory device, including a standard Ethernet interface, for playback on a standard Windows®-based PC.

#### *DVR Data Transfer*

1. The CCTV system will perform automatic and manual, software-adjustable data transfer between the DVR and wayside storage installations using a wireless data link:
2. The wireless data link may be external to the CCTV system.
3. Include Windows-based server software for the vehicle and wayside, and requirements for server equipment on the wayside.
4. The server software will automatically organize data from each vehicle according to vehicle ID, camera ID, and date/time.
5. Application software will allow rapid searching of recorded data by any parameter.
6. Include utility software for server diagnostics, storage capacity statistics, and similar.

#### **8.8 GPS Receiver**

Provide a WAAS-enabled GPS receiver for use by the APIS and CCTV system (see above) and MDS system, and other systems on the vehicle that require position and/or time information:

1. The GPS will furnish the primary vehicle time, which will be passed on to all relevant vehicle control systems via the vehicle network.
2. Provide satellite prediction and recent ephemeris data features for quicker location determination when the GPS is powered on.
3. Provide an interface at the VNC and MDS to GPS data, allowing access by other vehicle systems to vehicle location data and GPS time signals via Ethernet connection. Include appropriate access methods and software techniques for third parties to access such data.
4. The GPS will remain powered during vehicle layover periods.
5. Mount the GPS antenna on the roof, or other location, optimized for satellite access. Coordinate the antenna location with other vehicle antennas to avoid interference.

#### **8.9 Vehicle Wireless Communication to Wayside**

##### **8.9.1 General**

Provide wireless communication from the vehicle to the wayside for transmission of data to the vehicle maintenance workstation in the Shop.

##### **8.9.2 Wi-Fi IP Router**

Provide a Digi TX64 5G Rail cellular router or Approved equal.

##### **8.9.3 Vehicle Status and Health Data**

Provide a method for a third-party system to access vehicle status and health data via an Ethernet port on the MDS:

1. Include appropriate access methods and software techniques to access such data.
2. Provide robust protection against third party access to vehicle controls or other vehicle systems.
3. Ensure that data access has no effect on vehicle network performance.
4. Arrange the data fields to be accessed individually.
5. Place the data in a memory buffer, updated at agreed intervals, for asynchronous retrieval.
6. Examples of desired data fields:
  - a. Vehicle location via GPS
  - b. Passenger counts, from the APC system
  - c. Vehicle mileage
  - d. Vehicle faults, using agreed codes.
  - e. Vehicle incidents, such as passenger emergency door access, and MB/EB applications.

- f. Others, as may be requested by the City.

## 8.10 Event Recorder

### 8.10.1 General

Provide each vehicle with a fully electronic data recorder system, independent of the MDS:

1. The primary purpose of this recorder is to furnish documentation in support of accident investigations.
2. It must be a tamper-proof, self-contained design capable of withstanding high shock. The City's operating environment is described in Section 2, Design and Performance Criteria.
3. The event recorder will be based on a family of service proven designs, with at least five years' successful operating history in revenue service on rail vehicles.
4. Unless explicitly stated otherwise, the event recorder will comply with the requirements of IEEE 1482.1.

### 8.10.2 Functional Requirements

Comply with the following:

1. Signal sampling and recording rates will comply with IEEE 1482.1.
2. The event recorder will record at least the following information:
  - a. All applicable signals referenced in IEEE 1482.1, Table 1, Required event recorder signals.
  - b. The following signals are referenced in IEEE 1482.1, Table 2, Potential additional event recorder signals. Where trainline is referenced in the standard, the requirement applies to control line on a single vehicle:
3. Signal A15, Sanding
4. Signal A36a, A36b, etc., Wheel spin/slide activation (other trucks) (lead axle included in Table 1)
5. Signal A64a, A64b, etc., Door close command (left/right)
6. Signal A65a, A65b, etc., Door open command (left/right)
7. Signal A66a, A66b, etc., Door enable command (left/right)
8. Signal A81, Bell/gong activated.
9. Provide a minimum of six spare digital channels.
10. Provide a minimum of two spare analog channels.
11. The event recorder time base will be independent of other vehicle systems.
12. Event recorder functional status and failures will be reported to the MDS.

### 8.10.3 Data Storage and Retrieval

The recorder will be able to store a minimum of seven days of data, including signals from the spare channels, in non-volatile memory:

1. This memory will not require battery backup for data retention and will remain intact for a period of at least one year after removal from the vehicle.
2. Provide the following data retrieval capabilities:
  - a. Event data memory module removal
  - b. Data retrieval via a USB or Ethernet port using a laptop computer.
3. Downloaded data will be capable of being evaluated on an office computer. It will not be possible to erase the data via the USB or Ethernet port on the recorder.
4. Provide all necessary cabling and software to transfer, evaluate, display, and print the data in tabular and graphic form.

#### 8.10.4 Construction Requirements

The event recorder will be constructed in accordance with the requirements of IEEE 1482.1. These requirements may be met by:

1. Design of the data storage device itself.
2. Placing the device in an enclosure meeting the requirements.
3. Judicious placement of the device within the vehicle body envelope.
4. A combination of these methods.

#### 8.10.5 Installation Requirements

Comply with the following:

1. Locate the event recorder in the vehicle interior in an electrical locker that requires a key for access.
2. The installation will be such that the event recorder is tamper resistant and waterproof; however, installation will be such that the USB or Ethernet port is readily accessible once the recorder is installed.
3. Provide a terminal board with locations for all event recorder signals, including spares. Connections to the event recorder inputs will be made at this terminal board.

#### 8.11 Automatic Passenger Counting (APC)

The City will have an automatic passenger counter system, such as Init. The Contractor will furnish the equipment, provide wiring, installation, and verification of the equipment after installation.

#### 8.12 Automatic Vehicle Locator (AVL)

The City will have a real-time traveler-information management and display system, such as Init.

The Contractor will furnish the equipment, provide wiring, installation, and verification of the equipment after installation.

1. The system will provide vehicle location, updated at regular intervals, using GPS.
2. The system will use the vehicle GPS.
3. The GPS antenna will mount on the roof, or in other location, optimized for satellite access. Coordinate the antenna location with other vehicle antennas to avoid interference.

#### 8.13 Traffic Light Priority

The City will furnish a traffic light priority emitter for the roof of each cab. For each vehicle, perform the following:

1. Furnish and install mounting brackets for emitters.
2. Install City-furnished emitters.
3. Furnish, install, and connect wiring, consisting of power and an interlock with active cab.

#### 8.14 Automatic Train Stop (ATS) System

##### 8.14.1 General

Provide the vehicle-borne portion of the ATS system (Siemens) in accordance with requirements described in this Section. Provide vehicle ATS equipment completely compatible with the wayside equipment. Each vehicle set of ATS equipment to be provided will consist of at least the following:

1. Two dedicated ATS display panels (one in each cab), installed in an Approved location, or incorporated into the TOD.

2. Two magnetic receiver assemblies (one per end) mounted to interface with wayside equipment  
One or two ATS logic units.

#### 8.14.2 System Description

Fixed wayside magnetic transmitters will provide a stop signal at intermittent locations along the alignment.

#### 8.14.3 Functional Requirements

Comply with the following requirements:

1. Provide each end of the vehicle with vehicle-borne components of the ATS system to detect when a wayside stop signal is active at certain points along the route.
2. An emergency brake application will be commanded when a vehicle passes an active wayside stop signal.
3. Once a direction is selected via the reverse switch, only the receiver at the leading end of the vehicle or consist will be active.
4. System event history will be fully incorporated into the MDS.

After Contract Award:

1. Additional ATS transmission requirements will be covered during system design.

### 8.15 Train-to-Wayside Communication System (TWC)

#### 8.15.1 General

Provide the vehicle-borne portion of the TWC system in accordance with requirements described in this Section. Provide vehicle TWC equipment completely compatible with the existing wayside equipment.

Each vehicle set of TWC equipment to be provided will consist of at least the following:

1. Two operator TWC control modules, installed in the cab console (one per end), in Approved locations.
2. Two transponder assemblies (one per end)

One or two TWC logic units

#### 8.15.2 System Description

Provide each end of the vehicle with vehicle-borne components of the TWC system to transmit digital information from the vehicle to the wayside or wayside to vehicle, at certain points along the route.

1. Fixed wayside loop antennas placed in the trackway send out an interrogation signal several times a second.
2. When a vehicle passes over the loop antenna and an activated vehicle borne TWC transponder receives the interrogation signal it will transmit a message to the wayside in the form of high-speed serial digital data.
3. Provide vehicle-borne equipment compatible with the City's existing wayside systems:
  - a. Type: Philips Vetag

#### 8.15.3 Functional Requirements

Comply with the following:

1. Furnish and install vehicle TWC equipment such that there is accurate, secure transmission of a 19-bit data message to/from wayside loop antennas.

2. Transponders will transmit when properly located over the loop and polled by the wayside interrogator.
3. The format of the data message to be transmitted will be a function of vehicle status. The vehicle will be configured to furnish the TWC system with inputs representing active cab status and end-of-vehicle status.
4. Vehicle number (to be transmitted by inactive cabs) will be encoded via jumpers inside the TWC control module.
5. The Vehicle TWC system will transmit the following information to the wayside:
  - a. Train Number
  - b. Route Number
  - c. Vehicle Number
  - d. Stationary Preempt/Activation
  - e. Switch Call (Left or Right)
  - f. Active Cab (on for active cab)
  - g. Wireless or On-wire operation
  - h. End-of-train
6. The wayside TWC system will transmit the following information to the Vehicle:
  - a. Wireless segment begin/end
7. After Contract Award:
  - a. Additional TWC transmission requirements will be covered during system design.

The exact assignment of bits, including start/stop bit will be furnished to the Contractor by the City after Contract award.

#### 8.15.4 Vehicle-Borne Equipment

##### *General*

Comply with the following:

1. Equipment will be identical in all cabs.
2. Provide interconnection hardware and cables to mount and connect transponders and TWC control modules.

##### *Operator TWC Control Module and Associated Wiring*

Comply with the following:

1. The TWC control module will consist of the following:
  - a. A unit of four pushbutton switches; these will be backlighted when the transponder for the active cab is over a wayside loop and is being interrogated.
  - b. A unit of four thumbwheel switches, each with ten positions.
2. Inputs to the TWC control module:
  - a. Battery positive, through a dedicated circuit breaker
  - b. Negative Return
  - c. Cab active signal
  - d. End-of-train signal
3. Installation: All inputs will be brought to a terminal board mounted under the console in an appropriate location near the TWC control module and connected to the TWC control module via a multi-conductor cable and quick-disconnect connector.
4. TWC status: Show on the TOD, as Specified.

### Transponder

Mount each transponder under the vehicle as follows:

1. Mounting Bracket:
  - a. Fabricate bracket to mount the transponder to the vehicle body.
  - b. Material: Follow manufacturer's requirements for electromagnetic properties.
  - c. Finish: Paint the bracket as under-vehicle equipment.
2. Location and Orientation:
  - a. Locate on the centerline of the vehicle body and approximately 2340 mm (92 in) from the end of the vehicle.
  - b. Location and orientation will conform to the TWC manufacturer's installation guidelines, including proximity to ferrous materials.
  - c. Do not mount to truck frame unless specifically permitted by manufacturer.
3. Cable Connection:
  - a. Provide a multi-conductor cable and connectors suitable for exposure in an under-vehicle environment.
  - b. Attach one end of the cable to the vehicle via a connector at a bulkhead or junction box.
  - c. Attach the other end of the cable to the transponder by methods appropriate for the transponder design.

### TWC Logic Unit

Comply with the following:

1. Provide dc power to each TWC logic unit via dedicated circuit breakers.
2. Install logic units in equipment lockers/racks with other vehicle control units.

## 8.16 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Each design package will include the following, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested
2. Functional description
3. Electrical specifications
4. Control schematics
5. Circuit schematics
6. Electrical schematics
7. Component ratings: Top level components, and ratings of other components if requested
8. Vehicle integration drawings
9. Mechanical specifications
10. Mechanical assembly drawings with weights, dimensions, and parts lists
11. Software functional description: Include top level control parameters and values
12. Assembly and Installation drawings.

### 8-1 Public Address Design Package

### 8-2 Intercom Design Package

### 8-3 Automatic Passenger Information System Design Package:

1. Instructions for updating, creating, deleting, uploading, and downloading APIS information.
2. Audio encoding, recording and playback processes.

- 1        3. Locations of destination and information signs.
- 2        4. Samples of audio messages.
- 3    8-4 Warning Devices Design Package:
- 4        1. Manufacturer’s literature.
- 5        2. Sounds (electronic audio files)
- 6    8-5 Radio Design Package
- 7    8-6 CCTV Design Package:
- 8        1. Camera manufacturer’s data.
- 9        2. Camera locations, coverage, capacity, control software, and arrangement.
- 10       3. Display screen manufacturer’s data.
- 11       4. Details of CCTV network controller
- 12       5. DVR manufacturer’s data.
- 13       6. DVR authentication process to detect any alteration of the data after recording.
- 14       7. Workstation software
- 15    8-7 Vehicle Position Design Package:
- 16       1. Details on accuracy, error detection and other parameters as required
- 17    8-8 Wi-Fi Router Design Package
- 18    8-9 Event Recorder Design Package:
- 19       1. Event recorder manufacturer’s data
- 20       2. Details of interfaces and installation.
- 21       3. List of signals to be made available at the Specified terminal board.
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- 23    8-11 Automatic Vehicle Locator Design Package:
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## Section 9 Passenger Doors

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## 9.1 Scope

This Section includes:

1. Passenger doors and related equipment and controls
2. Bridgeplates

## 9.2 General Description

Comply with the following:

1. Door type: Sliding-plug, flush with the vehicle body exterior skin when closed.
2. Protrusion from vehicle: Maximum 75 mm (3 in) during any portion of the open or close cycle.
3. Door size and configuration: As Specified in Section 4 Design and Performance Criteria.

## 9.3 Door Design Requirements

### 9.3.1 Accessibility

Comply with the following for door controls, cutouts, access covers, and other Specified functions:

1. Location: Accessible by the fifth-percentile female, as defined in *The Measure of Man and Woman: Human Factors in Design*.
2. Operating forces: Suitable for the same fifth-percentile female group.

### 9.3.2 Door ADA and Interface Requirements

The doors and doorways will meet ADA requirements, 49 CFR 38 Subpart D, and the station platform interface requirements of Section 4 Design and Performance Criteria.

### 9.3.3 Safety

Design the door and bridgeplate system in accordance with the safety requirements as Specified. No single point failure in the door system or the vehicle controls will cause:

1. A door to unlock or open when an Open request has not been commanded.
2. A Door Open or Enable command to be transmitted or responded to when the vehicle is in motion.
3. A Door Locked and Closed indication when any Door is unlocked or open.
4. A traction interlock OK status when any door is unlocked or opened, Bridgeplate is unlocked or Extended.
5. A Door Closed and locked indication when a Door Enable or Open command is stored anywhere in the system.
6. A Bridgeplate to unlock or extend when a Bridgeplate Extend request has not been commanded.
7. A Bridgeplate extend or Enable command to be transmitted or responded to when the vehicle is in motion.
8. A Bridgeplate Retracted and locked indication when any Bridgeplate is unlocked or extended.
9. A Bridgeplate Locked and Retracted indication when a Door Enable or Open command is stored anywhere in the system.

### 9.3.4 Dynamic Performance

Comply with the following:

1. Doors will be vibration and rattle free while the vehicle is underway, and while doors are operating when the vehicle is stationary.
2. The door system, in conjunction with the vehicle's aerodynamics, will prevent whistling and other objectionable noises at all vehicle speeds.

9.3.5 Adjustability

Comply with the following:

1. Door system: Include provisions for independent adjustments to location and alignment of the door operator, door panels, and other components to accommodate equipment installation, replacement, and system wear.
2. Mounting of sensors and switches: No readjustment will be possible when a device is replaced.

9.4 Door Panels

9.4.1 Material and Construction

Comply with the following:

1. Material: HSLA steel, aluminum, aluminum honeycomb, or similar.
2. Construction:
  - a. Panel will be joined into an integral unit by adhesive bonding or resistance welding.
  - b. Edges and joints must be completely sealed to prevent the entrance of moisture.
  - c. For interior cavities, provide drain holes at the bottom if it is possible for condensation to form.

9.4.2 Windows

1. Each door panel will contain a window:
2. Type: Safety glass of the same materials and color as the side windows.
3. Size:
  - a. As high and wide as possible to allow passengers maximum view of station platforms and to make door positions more clearly identifiable to waiting passengers.
  - b. Height will be sufficient to permit a passenger on the platform to see the door closing warning signal when the doors are closed.
4. Mounting: Windows will be retained in the door panel by the same method used for passenger windows. The arrangement will be watertight.

9.4.3 Strength Requirements

The door panel skin, structure, and mounting hardware must sustain the following load with the door supported at the top and bottom in an agreed fixture:

1. Concentrated load: 890 N (200 lbf).
2. Load application: Perpendicular to the plane of the door at any location on the panel.
3. Load-bearing surface: 100 mm by 100 mm (4 in by 4 in).
4. Deflection under these conditions: Maximum 10 mm (0.4 in), with no permanent deformation after the force is removed.

9.4.4 Sealing Requirements

Seal door panels and doorways:

1. Weather seal: Watertight under these conditions:
  - a. When the vehicle is being washed
  - b. For all service speeds with the worst-case combination of climatic Specified
2. Air seal: Sufficient to maintain required HVAC pressurization
3. Seal locations:
  - a. Vehicle body edges
  - b. Forward edge of the door where the panels meet in the closed position
  - c. Top edge of the door

- d. Bottom edge of the door
4. Maintainability: Apply seals in a manner that enables them to be easily replaced with the door panels in place. Grease or applying any substance to the seal is prohibited.

## 9.5 Manufacturing and Installation Requirements

Comply with the following requirements for doors and door equipment:

1. Manufacturing:
  - a. Use jigs and fixtures for doorways, mounting points, hardware, and other door-related features of the vehicle, with dimensions and tolerances as defined by the door manufacturer, and in accordance with the standards of workmanship Specified.
  - b. Doors and door equipment will be interchangeable from one location to any other location and from vehicle to vehicle without modification.
2. Installation:
  - a. Install according to the door manufacturer's requirements and tolerances. Modification of door equipment is prohibited.
  - b. Make permanent to each doorway shimming or other adjustments made to achieve proper door fit.

## 9.6 Performance Requirements

Comply with the following:

1. Door motion: Smooth and free of shock and impact. At the end of travel, door will have smooth deceleration in both the opening and closing directions.
2. Control delay-time: Maximum 0.15 second from receipt of a door command signal from the Cab Console or local door pushbutton to the first motion of a door panel.
3. Door panel operating speed:
  - a. Initial setting: 200 mm/s (8 in/s) in opening and 200 mm/s in closing, plus or minus 30 mm/s (1.2 in/s), from time of first motion to the point of completion, including cushioning.
  - b. Maximum door closing speed: 300 mm/s (12 in/s).
  - c. Operating speeds will be adjustable by the City.

## 9.7 Door Operator

### 9.7.1 General

For door movement, provide one electrical operator per doorway:

1. Power: Sufficient to open and close doors at Specified performance levels with the most unfavorable ambient wind, vehicle pressurization conditions, and grade.
2. Operation: Left and right door panels will move simultaneously.

### 9.7.2 Operator Mechanical Requirements

Comply with the following:

1. Connection between door operator and door panels:
  - a. Mechanical via screw shaft, linkages, or toothed belts.
  - b. Fluid or pneumatic devices are not permitted.
2. Location of operator equipment:
  - a. In the transom area above the doorway.

- b. Concealed, except as necessary for the sliding mechanism, such that it is not directly visible when the door is opening and closing, or when door is in fully closed position.
3. Access to operator:
  - a. By opening a cover or removing an access panel, without the need to move or disconnect other equipment.
  - b. Provide sufficient clearance and access space to maintain components on the operator assemblies, and to remove the assemblies as complete units.
4. Door tracks: Locate within the vehicle body or within the door panel.
5. Separate sliding door lock assemblies: Locate within the vehicle body, if required by the door design.

### 9.7.3 Operator Electrical Requirements

Comply with the following:

1. Power source: Low-voltage dc power system.
2. Voltage range: Capable of operating over the entire voltage range of the low-voltage dc power system without affecting the reliability, Specified performance, or service life of the operator.
3. Stall current:
  - a. The operator will be capable of withstanding stall current indefinitely.
  - b. Alternately, it will be capable of detecting stall current and removing power if it persists for a preset time and will reset automatically when the door controls are cycled.
  - c. Stall current will have no adverse effect on the reliability and service life of the equipment.

## 9.8 Door Control System

### 9.8.1 General

Comply with the following:

1. Door operator control type: Microprocessor-based control logic unit.
2. Location: Either immediately adjacent to, or within the door operator compartment.

### 9.8.2 Control and Monitoring

The door control system will control and monitor the door system, including the following:

1. Door motion control:
  - a. Opening speed
  - b. Closing speed
  - c. Closing forces
  - d. Detection of stalls
  - e. Acceleration and deceleration
  - f. Door-close time delays
2. Command and status monitoring:
  - a. Commands from the Cab Console and local passenger switches
  - b. No-motion status.
  - c. Door obstructions
3. Door Position Monitoring:
  - a. Monitor continuously from fully opened to fully closed.
  - b. For position sensing, provide non-contact proximity-type sensors not requiring adjustment, **alternative solutions maybe proposed for review and Approval by the City.**
  - c. This position sensing is in addition to the position sensing requirements in the Interlock Requirements section, below.



### 9.8.3 Diagnostics, Data Network, and Adjustments

#### *Diagnostics*

Comply with the following:

1. Status of door system: Available via a diagnostic system integral to the door control system software.
2. Monitored items:
  - a. Critical internal functions
  - b. External inputs
  - c. Mechanical door system, including door open, closed, and lock status.
  - d. Actual door performance, such as door speeds on opening and closing.
3. Access to diagnostics: Available from each door control logic unit either via separate connector at the control logic unit, or via the network connector itself.

#### *Data Network*

Each door control logic unit will be linked to the vehicle's data network:

1. Status and diagnostic information: Will be available at a single common location, and on the TOD, from each door.
2. Inter-communication: Door control logic units in the vehicle may communicate with each other, but interfaces with the vehicle door commands and no-motion interlocks will be on a per-doorway basis.
3. Failure of network links:
  - a. Will have no effect on door operation.
  - b. Will be announced at the diagnostics port and TOD.

#### *Adjustments*

Comply with the following for adjustments of the door control system:

1. Permissible adjustments: All operating variables, including but not limited to the following:
  - a. Door opening and closing speed or time.
  - b. Door closing forces.
  - c. Door timing
2. Adjustment access: Locally and via the vehicle's network, using a PTU, and software furnished by the door supplier.

## 9.9 Door Operation

### 9.9.1 General

Doors may be opened using switches on the Cab Console, passenger switches, or the crew door-switch.

### 9.9.2 Door Operation Restrictions

Door operation will be possible only under the following conditions:

1. The vehicle has achieved no-motion.
2. The Master Controller is in the MSB position.
3. If the MC key switch is in the Off position, the Hotel Load timer has not yet expired.

### 9.9.3 Cab Console Controls

Provide pushbutton door controls on the Cab Console as described in Section 5 Operator's Cab. In addition, comply with the following:

1. Door Open:

- a. Pressing the Door Open pushbutton will open all doors and enable the passenger bridgeplate pushbuttons on the inside and outside of the vehicle on the vehicle selected side.
  - b. Doors will remain open until the Door Close pushbutton is pressed.
  - c. If a passenger bridgeplate request has been stored within the system, pressing the Door Open pushbutton will cause the actions described in TS 9.17.8, Bridgeplate and door functional integration.
  - d. The Open command will be interlocked with the no-motion circuitry both in the cab and at each doorway, independently of the Enable command.
  - e. An Open command will override any ongoing obstruction detection and reset the obstruction detection counter to zero.
2. Door Enable:
- a. Pressing the Door Enable pushbutton for the doors on a given side of the vehicle will enable the passenger door and bridgeplate pushbuttons on the inside and outside of the vehicle on the selected side.
  - b. If a passenger bridgeplate request has been stored within the system, pressing the Door Enable pushbutton will cause the actions described in TS 9.17.8, Bridgeplate and door functional integration.
  - c. The Enable command will be interlocked with the no-motion circuitry both in the cab and at each doorway.
  - d. The door enable function will not be affected by vehicle or local network failures.
3. Door Close:
- a. Pressing the Door Close pushbutton will close all doors and bridgeplate on the selected vehicle side, including doors opened by a Crew switch and doors fixed open by the obstruction detection counter.
  - b. The Close command will cancel door Enable and Open commands.
  - c. The Close command will cancel a passenger stop request and bridgeplate request.
  - d. Upon successful closing, the bridgeplate obstruction detection will be disabled.
  - e. Upon successful closing, the door obstruction counter will be reset to zero.
4. Bridgeplate Retract/Extend:
- a. See TS 9.17.8, Bridgeplate and door functional integration.

#### 9.9.4 Passenger Controls

##### Pushbuttons

At each doorway:

1. Provide illuminated pushbuttons, one inside the vehicle and one outside the vehicle, to control doors:
  - a. Type: Momentary contact, heavy-duty, recessed to prevent inadvertent operation, suitable for frequent use in the City environment, rated IP65.
  - b. Illumination: Red and green LED, to indicate active and non-active status.
  - c. Color: Pushbutton and surrounding bezel color-coded with a City-Approved color.
  - d. Identification: Switch nomenclature or symbol molded into the switch in raised lettering, dimensioned to permit sensing by a visually impaired person.

##### Door Open Function

Door Enable command activated by the operator:

1. Inside and outside passenger door pushbuttons will illuminate green.

2. Pressing a passenger door pushbutton will cause the respective door to open.
3. Door will stay open for a preset time, then automatically close:
  - a. Initial preset time: 10 seconds.
  - b. Adjustability: May be set by maintenance to any value between 0 and 60 seconds, and to infinite time such that the doors remain open until commanded closed.
4. Door open: The associated passenger pushbuttons will be disabled and go dark.

#### *Passenger Stop Request Function*

Door Enable command not activated by the operator:

1. Interior passenger pushbuttons will activate the passenger stop request function.
2. Activation of the passenger stop request anywhere in the vehicle:
  - a. Passenger area: Sound the local stop request chime only.
  - b. Operator's cab:
    - i. Sound an audible alert for 0.5 seconds, then latch Off.
    - ii. Illuminate a light on the Cab Console.
    - iii. Reset audible alert and light after the doors have been closed by the operator via the Door Close cab control.

#### *9.9.5 Crew Door-Switch*

Provide crew door-switches on each vehicle:

1. Location:
  - a. At each ADA doorway, on each side of the vehicle.
  - b. Inside and outside the vehicle, a total of two per doorway.
  - c. Locate outside switches beyond the open position of the door panel.
2. Switch Description:
  - a. Weatherproof, momentary electrical rotary switch.
  - b. Three positions: Open, Neutral, and Close with spring return to center (Neutral).
  - c. Operated by an Operator key.
3. Switch Operation:
  - a. Turning the switch momentarily to the Open position, without holding it in that position, will cause the adjacent door to open fully. If both cabs are keyed Off, it will turn On the Auxiliary and start the Hotel Load timer.
  - b. Turning the switch momentarily to the Closed position, without holding it in that position, will cause the door to completely close and lock.
  - c. Turning the switch to the Closed position, holding greater than 3 seconds, will cause the door to completely close and lock, and the vehicle to Aux Off.
4. Comply with the following:
  - a. Crew door-switch and related circuits will have applied power only when both cabs in the vehicle are keyed Off, or when the vehicle has reached no motion, and the Master Controller is in a brake position.
  - b. Arrange crew door-switch and adjacent door operator such that they can function independently of the Cab Console controls.
  - c. Crew door-switches and associated circuits will be considered a safety circuit and will meet the safety requirements as Specified.

9.9.6 Loss of Control Power

In the event of loss of local control power, doors will remain in the last commanded position during absence of control power and when power is restored.

9.10 Door Locks

Door panels will be positively retained in the closed position via mechanical means:

1. Lock function: Separate mechanical lock, or an over-center function of the operating linkage, if the linkage is directly connected to the door panels.
2. Drive belt (if used): Lock mechanism will not rely on the belt.
3. Lock engagement: Automatic when both door panels reach the closed position; electrical power will not be required to maintain locked status.

9.11 Door Obstruction Detection

9.11.1 General

The door system will automatically detect obstructions, prevent a person from becoming entrapped, and limit the forces imparted to a person standing anywhere in the doorway.

9.11.2 Detection Methods

Provide two means of detection:

1. Electrical sensitive edge: Incorporate within the leading edge of each door panel. The design, sensitivity, and response of each panel to obstructions will be the same.
2. Restrictions in door motion: Detect via current sensing, speed vs. time tracking, or other City-Approved method.

9.11.3 Operation Requirements

Upon detection of an obstruction, the door panels in the affected doorway will perform as follows:

1. Immediately decelerate.
2. Open and remain open for a preset period, controlled by an adjustable time delay circuit, adjustable in software from 0 to 10 seconds.
3. Attempt to close.
4. If the obstruction is no longer detected, close and lock.
5. If the obstruction is still detected, continue to recycle for a preset number of times.
6. If the recycle count is exceeded, remain in the open position until reset by the vehicle operator via cab controls. The recycle count will be software settable by the user, initially set to 5.

9.11.4 Maximum Force

The kinetic energy contained within the door system during door closing will be less than or equal to, 10 J (7.4 ft-lbf).

9.11.5 Sensitivity Requirements

Comply with the following:

1. Each door panel's obstruction detection system will detect any force opposing door motion (stall force), at any position in the door travel from fully open to fully closed, as follows:
  - a. Single panel doors: Greater than 50 N (11.2 lbf).
  - b. Dual panel doors: Greater than 50 N (11.2 lbf).

2. The obstruction detection system will detect the following for each panel separately:
  - a. Flat bar:
    - i. Size: 10 mm (0.4 in) wide and 75 mm (3 in) high
    - ii. Position: Held rigidly between and perpendicular to the door panel, as a hand might be held to stop the doors
    - iii. Sensitive Area: Everywhere along the length of the panel except the uppermost 75 mm (3 in) of the nosing seal.
  - a. Cylindrical object:
    - iv. Size: 20 mm (0.8 in) in diameter
    - v. Position: Held rigidly between and perpendicular to the door panels
    - vi. Sensitive Area: All locations along the length of the door nosing seal, except the uppermost 75 mm (3 in) and lowermost 25 mm (1 in) of the seal.

#### 9.11.6 Obstructions Not Detected

The door edge will allow a thin flexible object not detected by the obstruction detection system, such as an article of clothing, to be pulled free from the leading edge of a door that is fully closed and locked.

### 9.12 Manual Door Release Mechanism

#### 9.12.1 Functional Description

Provide interior and exterior manually operated door release mechanisms to permit doors to be opened locally regardless of the availability of electrical power or door status, including a previously cutout door:

1. Activation of the release device will unlock the door and open the door approximately 25 mm (1 in) to permit the door to be manually pushed open.
2. Power will be removed from the door motor, but the door controller will remain active if power is available.
3. The door controller will monitor and announce activation of the manual release to the vehicle network.
4. The release device will not electrically bypass the local no-motion interlock.
5. Activation of the release device will interrupt the door status interlock, causing propulsion power to be removed and a MSB brake application to be applied.

#### 9.12.2 Interior Manual (Emergency) Door Release

Provide a lever or pull knob device at each doorway in a location accessible to all passengers:

1. Design and location: Select to prevent inadvertent operation and discourage everyday use.
2. Signage: Explain operation in an emergency, warn against unlawful use, and advise that emergency door opening device is also an emergency stop device.
3. Annunciation when activated: As Specified in the Indicators and Annunciators section, below.

#### 9.12.3 Exterior Manual Door Release

Provide two manual door-release devices meeting the following requirements:

1. Location: Diagonally opposite each other on each side of the vehicle, above platform level.
2. Mechanism: Waterproof; operable without a key.
3. Functionality: Same as the interior device, except Passenger Emergency message will not be sent when activated.
4. Cover: Flush with the side of the vehicle when closed.
5. Graphics: Provide adjacent to each cover, suitable for emergency responders or other users.

#### 9.12.4 Reset Device

Comply with the following:

1. Function: Restores doors to normal operating condition after use of the Interior Manual release mechanism.
2. Operation: Operator Key
3. Location: Within the door control panel or transom area above the doors.

### 9.13 Door Interlock Requirements

#### 9.13.1 No Motion Interlock

Electrically interlock door operators and controls in a failsafe manner with the vehicle's no-motion circuits, such that doors can be powered, opened, or released only when the vehicle has reached no-motion:

1. No-motion deactivated: Door motor Open wiring will be switched Open with critical circuit relays. Door motor's Close circuits will remain connected.
2. Motion detected: Close command will be issued to all doors in the vehicle.
3. Vehicle in motion: Diagnostic and fault monitoring and logging will remain active.
4. Controllers:
  - a. Will monitor no-motion circuits independent of the motor interlocks.
  - b. Will ignore Open or Enable commands without a no-motion signal present and if this condition occurs, issue a fault indication.

#### 9.13.2 Door Status (Open) Interlock

Provide circuitry to monitor door panel position and door lock status for each side of the vehicle:

1. Components: High reliability position-sensing switches for each panel, and separate switches for detection of lock status.
  - a. Switches will positively and directly detect actual panel and lock positions. These switches are in addition to those Specified above for the Door Control System.
  - b. Switch mounting will be such that no readjustment is necessary when a switch is replaced.
  - c. Tolerances for switch, switch mounting device, and door component will not permit a newly installed switch to indicate a false close or locked status.
2. Circuitry: Wire switches on each side of the vehicle in series.
3. Function:
  - a. Door panels properly closed and locked: Activate a Summary Door Status non-welding critical circuit relay.
  - b. One or more closed or locked switches not made up:
    - i. De-energize the Summary Door Status relay.
    - ii. Illuminate the Cab Console Door-Open light for that side of the vehicle.
    - iii. Remove propulsion power.
    - iv. Apply MSB.
  - c. Operating sequence if the vehicle operator attempts to apply propulsion with a door panel not closed and locked:
    - i. Propulsion is inhibited.
    - ii. Master Controller must be moved to the MSB position.
    - iii. The door closed button must be pressed and doors close and locked.
  - d. Door status interlock will have a user adjustable timer, 0 – 10 seconds. The timer will delay the activation of the interlock, inhibiting propulsion and status after the doors are closed and locked.

4. No false signals:

- a. No single point failure in the loop circuit will cause a false door closed and locked signal.
- b. Where failures in the loop circuit are not self-annunciating, they will not lead to a false door closed and locked signal, from the door interlock circuit, or in association with other single point failures.

## 9.14 Door Bypass Devices

### 9.14.1 General

Provide bypass devices 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.

### 9.14.2 Door Interlock Bypass

Provide a door interlock bypass feature in each cab:

1. Bypass will permit movement of the vehicle under emergency conditions, bypassing the door status interlock so that the brakes can be released, and power applied.
2. Bypass will not give a false Doors Closed indication.

### 9.14.3 Door Cutout

Provide a door-cutout device in an Approved location adjacent to each door, that performs the following functions:

1. Disconnects door motor from any source of electrical power.
2. Bypasses door-closed and door-locked interlocks for that door.
3. Ensures that the door remains closed by mechanical restraint.
4. Illuminates the local passenger pushbutton light Red.
5. The door controller will remain active when the door is cut out.

## 9.15 Indicators and Annunciators

### 9.15.1 Door Open Indications

Provide two Door Open indicator status lights on the TOD, one for each side of the vehicle. The indicators will be illuminated when any door on the associated side of the vehicle is sensed as being unlocked, open, or both.

### 9.15.2 Manual (Emergency) Door Release

Activation of an interior manual door release (Passenger Emergency) will cause the following:

1. At the doorway: Audible and visual warning.
2. In each cab:
  - a. Audible alert
  - b. On TOD: Annunciation of "PASSENGER EMERGENCY"

### 9.15.3 Door Closing Warning Announcements

Provide audible and visual door closing warnings independently for each doorway:

1. Audible door closing warning:
  - a. Duration: For 2 seconds prior to doors closing (adjustable 0 - 2 seconds)
  - b. Sound: Pleasant two-tone alarm, audible inside and outside the vehicle

- c. Source: The warning will be generated using a piezo buzzer, via the door control system.
2. Visual door closing warning:
  - a. Timing: Will activate at the same time as audible warning
  - b. Appearance: Flashing amber
  - c. Location: Both sides of each doorway on the side of the door frame
  - d. Visibility: Inside and outside the vehicle with doors in the open position

## 9.16 Door Control Signals

See Section 7 Electronic Controls, Software, and MDS, for door system control signal requirements.

## 9.17 Bridgeplates

### 9.17.1 Design

#### *Integration*

Integrate the bridgeplate system with the door system.

#### *ADA and Interface Requirements*

Comply with the following:

1. Bridgeplates will meet ADA requirements, 49 CFR 38 Subpart D, and the station platform interface requirements of Section 2.
2. The bridgeplate ramp design will comply with 49 CFR Part 38.83 (c), Vehicle ramp or bridgeplate, except that the bridgeplate width will be no less than the width of the fully open doorway:
  - a. The referenced 50% load requirement will be interpreted as AW2 loading.

#### *Dynamic Performance*

Comply with the following:

1. Bridgeplates will be vibration and rattle free while the vehicle is underway and when the vehicle is stationary and bridgeplates are deployed.
2. The bridgeplate system, in conjunction with the vehicle's aerodynamics, will prevent whistling and other objectionable noises at all vehicle speeds.

#### *Adjustability*

Include provisions in the bridgeplates for independent adjustments to location and alignment of the operator and other components to accommodate equipment installation, replacement, and system wear.

### 9.17.2 Manufacturing and Installation

Comply with the following:

1. Manufacturing:
  - a. Bridgeplates and related equipment will be interchangeable from one location to any other location and from vehicle to vehicle.
  - b. Use jigs and fixtures for bridgeplate, components, and mounting holes for hardware to ensure interchangeability, in accordance with the standards of workmanship Specified.
2. Installation: According to the manufacturer's requirements and tolerances.

### 9.17.3 Location, Size, and Strength

Comply with the following:

1. Location: The bridgeplate and its mechanisms will be beneath the door threshold.
2. Size: The bridgeplate will span the full usable width of the door opening and be capable of filling the vertical and horizontal gaps encountered at station platforms.



3. Strength: The ramp will support a load per 49 CFR 38.83 (c) (1), Design load.

#### 9.17.4 Ramp Configuration

Comply with the following:

1. Doorway threshold:
  - a. Include an interior hinged portion that moves with the bridgeplate, such that the bridgeplate and doorway threshold form a continuous ramped surface.
  - b. The threshold as Specified, may be integral to the bridgeplate.
  - c. Ramp slope: Must not exceed the slope requirements of 49 CFR 38.83 (c) (5).
2. Ramp and threshold edges:
  - a. Thickness: Minimum 3 mm (1/8 in) and maximum 13 mm (1/2 in)
  - b. Treatment: Beveled, and rounded to eliminate sharp edges
3. Wear strip:
  - a. Type: Replaceable
  - b. Material: Same as ramp
  - c. Location: At or beneath the outboard edge of the ramp where it contacts the wayside platform
4. Platform interface: The bridgeplate must function correctly, without interference, at all vehicles loads and uncompensated wheel wear.

#### 9.17.5 Material and Components

Comply with the following:

1. Structural components: Aluminum or stainless steel.
2. Guide rollers (if used): Stainless steel with permanently lubricated bearings.
3. Other rolling and sliding surfaces: Designed not to require periodic lubrication.
4. Ramp and threshold: Cast aluminum or stainless steel.
5. Ramp surface: Slip resistant, with static coefficient of friction 0.8. Adhesive backed, non-skid "tape" or sheets are not permitted.

#### 9.17.6 Operator

Comply with the following:

1. Type: Electrically operated.
2. Operation:
  - a. Deploy bridgeplate horizontally outward and then allow it to tilt downward to meet and rest on platform surface.
  - b. The bridgeplate will be able to extend and then retract without landing on a platform.
3. Vertical range of motion: Sufficient to allow ramp to rest on the platform surface by gravity alone under all Specified conditions.
4. Manual operation: Provide a manual operator that allows the bridgeplate to be manually deployed or retracted in the event of power failure:
  - a. The mechanism will not be readily accessible to passengers or require removal of any floor paneling.
  - b. Bridgeplate interlocks will not be defeated by manual operation.

#### 9.17.7 Control System

##### General

The bridgeplate controller will be integrated with the door controller.

*Control and Adjustment*

The bridgeplate control system will control and allow adjustment of the following, and similar features via laptop computer and software provided by the bridgeplate supplier:

1. Extend speeds, forces, and timing.
2. Extend obstruction detection threshold force.
3. Retract speeds, forces, and timing.
4. Retract obstruction detection threshold force.

*Monitoring and Position Sensing*

The bridgeplate controller will monitor the performance and position of the bridgeplate to accomplish the following:

1. Detect stalls or obstructions over the full travel length.
2. Detect positioning on extension and retraction.
3. Detect lock status.
4. Retracted position and locked status will be via non-contact proximity-type sensors not requiring adjustment, **alternative solutions maybe proposed for review and Approval by the City.**

**9.17.8 Bridgeplate Operation**

*General*

Bridgeplates may be extended by the vehicle operator, or by passengers on the inside or outside of the vehicle as Specified.

*Operation Restrictions*

Bridgeplate operation will be possible only under the following conditions:

1. The vehicle has achieved no-motion.
2. The Master Controller is in the MSB position.
3. The associated door is in the closed position.
4. The MC Key Switch is in one of the following positions:
  - a. On position.
  - b. The operator has Enabled the doors, then moved the MC key switch to the Off position. This will enable the local bridgeplate request pushbuttons until the Hotel Load timer has expired.

*Bridgeplate and door functional integration*

The Bridgeplate and door operation will be coordinated, so the Bridgeplate will retract or extend only if the Door is closed. The following actions will occur in the sequence listed with the positions stated, when an Operator activates the Extend/Retract pushbutton or a Passenger Bridgeplate Request is activated:

1. Door open and bridgeplate retracted:
  - a. Door closing warning.
  - b. Close doors
  - c. Start interior and exterior bridgeplate movement audible warning.
  - d. Extend bridgeplate.
  - e. Stop interior and exterior bridgeplate movement audible warning.
  - f. Open doors
2. Door closed and bridgeplate retracted:
  - a. Keep door with bridgeplate request closed.
  - b. Start interior and exterior bridgeplate movement audible warning.

- c. Extend bridgeplate.
- d. Stop interior and exterior bridgeplate movement audible warning.
- e. Open door
3. Door open and bridgeplate extended:
  - a. Close door
  - b. Start interior and exterior bridgeplate movement audible warning.
  - c. Retract bridgeplate.
  - d. Stop interior and exterior bridgeplate movement audible warning.
  - e. Cancel passenger bridgeplate request.
4. If the bridgeplate is extended, a passenger bridgeplate request will not retract the bridgeplate.
5. All other system combinations will alert the operator of a system fault.
6. Optional Control: The door system will have the option to have the Bridgeplate Extend command open all doors on the selected side of the vehicle. The option will be user selectable using a PTU connected to each associated door control unit.

#### 9.17.9 Passenger Controls

##### *Control Switches*

At each bridgeplate doorway:

1. Provide illuminated bridgeplate request pushbuttons, one inside the vehicle and one outside the vehicle:
  - a. Type and illumination: Comply with the Pushbuttons and Tape Switch section, above.
  - b. Color: Comply with the Pushbuttons and Tape Switch section, above, except color will be different from door control switches.
  - c. Identification: Comply with the Pushbuttons and Tape Switch section, above, except also provide the International Symbol of Accessibility (wheelchair) on or adjacent to the switch.

At each mobility aid parking area:

2. Provide a bridgeplate request tape switch, mounted horizontally:
  - a. Type: Momentary contact, heavy-duty, impact resistant, easy to operate, suitable for frequent use, rated IP65.
  - b. Color: Provide colored switch, or mount over a colored band at least 25 mm (1 in) wide to improve visibility, using a City-Approved color.
  - c. Identification: Nomenclature or symbols indicating function of switch and how to operate, as suitable for the type of switch, dimensioned to permit sensing by a visually impaired person, on or adjacent to switch.

##### *Passenger Control Functional Description*

The local passenger bridgeplate request pushbuttons and tapes switch will operate as follows:

Doors closed and locked:

1. The inside passenger bridgeplate pushbuttons will function as a passenger bridgeplate request.
2. Activation of the pushbutton or tape switch will:
  - a. In the passenger area, activate the local passenger stop request chime.
  - b. In the operator's cab, sound an audible alert for 0.5 seconds and illuminate Bridgeplate Request indicator. Once activated, the audible alert will be latched off and indicator will

stay illuminated until the doors have been closed or the bridgeplate retracted by the operator.

- c. Send a bridgeplate request to all bridgeplate controllers on the vehicle. The operator door and bridgeplate commands will control which bridgeplate is extended.

Doors enabled or opened, bridgeplate retracted or extended, send bridgeplate extend request to DCUs.

#### 9.17.10 Loss of Control Power

In the event of a loss of local control power, the bridgeplate will remain in the last commanded position during absence of control power and when power is restored.

#### 9.17.11 Locks

The bridgeplate will be positively retained in the retracted position via mechanical means:

1. Type: May be a separate mechanical lock or an over-center function of the operating linkage if the linkage is directly connected to the bridgeplate.
2. Drive belt (if used): Lock mechanism will not rely on the belt.
3. Operation: Lock will automatically engage when bridgeplate reaches retracted position and will not require electrical power to remain locked.

#### 9.17.12 Performance

Comply with the following:

1. Bridgeplate motion: Smooth and free of shock and impact.
2. Control delay-time: Maximum 0.15 seconds from receipt of a bridgeplate command signal by the operator or local bridgeplate pushbutton to the first motion of the bridgeplate.
3. Bridgeplate operating speed:
  - a. Initial setting: 200 mm/s (8 in/s) in extending and 200 mm/s (8 in/s) in retraction plus or minus 30 mm/s (1.2 in/s), from time of first motion to the point of completion, including cushioning.
  - b. Maximum speed: 300 mm/s (12 in/s).
  - c. Operating speeds will be adjustable by the City via PTU.

#### 9.17.13 Obstruction Detection

##### *General*

The bridgeplate system will automatically detect obstructions, prevent a person from becoming entrapped, and limit the forces imparted to a person when the bridgeplate is extending or retracting.

##### *Detection Methods*

The bridgeplate control equipment will detect restrictions in bridgeplate motion via current sensing, speed vs. time tracking, or other Approved methods. If the bridgeplate is equipped with movable side barriers, the detection will detect an obstruction within the movement of the side barriers.

##### *Operation Requirements*

Comply with the following:

1. Upon reaching the detection threshold, the bridgeplate will perform as follows:
  - a. Immediately decelerate and stop.
  - b. Send a fault message to the operator.
2. Fault reset: After activation of operator bridgeplate Retract/Extend command the bridgeplate will continue with the last commanded movement, extend, or retract.

*Sensitivity Requirements*

Comply with the following:

1. Detection threshold: Force opposing bridgeplate motion exceeding 130 N (29 lbf).
2. Threshold adjustment: User adjustable from 130 N (29 lbf) to 400 N (90 lbf).

9.17.14 Indicators and Annunciators

*Bridgeplate Extended Indicators*

Provide bridge-plate-extended indicator status lights:

1. Quantity: Two, one for each side of the vehicle.
2. Location: On the TOD
3. Activation: When any bridgeplate on the associated side of the vehicle is sensed as being unlocked, extended, or both.

*Bridgeplate Warning Announcement*

Provide audible and visual door closing warnings independently for each bridgeplate indicating that bridgeplate is moving, extending, or retracting:

1. Audible bridgeplate warning:
  - a. Activation: 2 seconds prior to the bridgeplate moving (adjustable 0 - 2 seconds)
  - b. Termination: When extension or retraction is complete
  - c. Sound: Different from the audible door warning, generated electronically by the local bridgeplate control system, audible inside and outside the vehicle
  - d. Location: Vehicle exterior, adjacent to the bridgeplate
  - e. The warning will function only at bridgeplates where motion is commanded.
2. Visual bridgeplate warning:
  - a. Timing: Provide at the same time as audible warning
  - b. Appearance: Flashing amber
  - c. Location: Both sides of each doorway on the side of the door frame
  - d. Visibility: If the visual door warning cannot be seen from outside the vehicle with the doors closed, provide a duplicate weatherproof device on the outside of each doorway
  - e. The door closing visual warning can be used for the bridgeplate movement visual warning.

*Status Indicators*

Show the following bridgeplate status indications on the TOD:

1. Extended
2. Enabled
3. Retracted and Locked
4. Cutout
5. Failure and/or fault

9.17.15 Bridgeplate Interlock Requirements

The following door interlocks will also apply to bridgeplates:

1. No Motion Interlock: Requirements for door operators and controls will apply to bridgeplate operators and controls, such that the bridgeplates can be powered and released only when the vehicle has reached no motion.
2. Door Status (Open) Interlock: Requirements for components and circuitry to monitor door panel position and lock status will apply to bridgeplates and will indicate whether door panels are properly closed and locked and bridgeplates are retracted and locked.

**9.17.16 Bridgeplate Bypass Devices**

*General*

Refer to the Door Bypass Devices section, above, for details related to these devices. Requirements for doors apply also to bridgeplates.

*Door Interlock Bypass Applied to Bridgeplate*

This door interlock bypass switch will bypass the interlock which prevents propulsion in case of a deployed bridgeplate, in addition to its function related to the door interlock circuit, as Specified.

*Bridgeplate Cutout*

Provide a bridgeplate cutout device in an Approved location adjacent to each bridgeplate door, behind a locked panel, that performs the following functions:

1. Disconnects bridgeplate motor from any source of electrical power.
2. Ensures that the bridgeplate remains retracted by mechanical restraint.
3. Indicates bridgeplate cutout on TOD.
4. Illuminates the local bridgeplate pushbutton light Red.
5. The Cutout will not bypass the bridgeplate retracted indication.

**9.18 Contract Deliverables Requirements List (CDRL)**

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

**9-1 Door System Design Package:**

1. Dimensioned drawings of door with general description and materials
2. Door operator details and drawings
3. Door lock and details
4. Manual (emergency) release details and drawings
  - a. Include interior and exterior manual release and cover for exterior manual release.
  - b. Include graphics.
5. Door Control Switches Design Package:
  - a. Data sheets for crew door-switches and passenger control-switches, including sizes, bezels, colors, graphics, and other features.
  - b. Sample of each switch, pushbutton, and tape switch. Switches will be returned to the Contractor.
  - c. Location drawings for all switches, including both plan and elevation views.
  - d. Submit door control switches located in cab under Section 5, Operator's Cab and Controls, not as part of this package.

9-2 Door-Platform Interface Design Report:

1. Vehicle dynamic envelope drawing.
2. Detail drawings: Show platform interface dimensions, including platform and vehicle tolerances.

9-3 Door Control System Design Package:

1. Door controller
2. System circuit diagrams
3. Sneak circuit and single point failure analysis
4. Interlocks and safety critical functions
5. Door Interlock Design:
  - a. No motion interlocks.
  - b. Door Status (Open) Interlock
6. Door Diagnostics and Adjustments Design:
  - a. System circuit diagrams
  - b. List of available adjustments
7. Obstruction Detection Design:
  - a. Design and methods for door obstruction detection
  - b. Door closing kinetic energy calculation and results.

9-4 Door Indication and Warning Design Package:

1. List of warnings and indications with location and features of each
2. Door Closing Audible Warning: Tone and intensity.
3. Door Closing Visual Warning:
  - a. Location drawing
  - b. Product information
  - c. Sample demonstration

9-5 Bridgeplate Design Package:

1. Functional description with sufficient detail to confirm compliance with the TS.
2. Parts list.
3. Drawings of bridgeplate in the retracted and extended positions, including sections and assembly drawings.
  - a. Show the platform interface in the extended position and indicate ramp slope, using minimum platform height. Include vehicle at AW0, half of AW2, and AW3.
  - b. Show details of adjustability
  - c. Show details of locking in the retracted position
  - d. Show details of manual deployment mechanisms.

- 1 e. Show all dimensions, including thickness of materials.
- 2 f. Show details of non-skid surface.
- 3 g. Indicate materials on the drawings.
- 4 4. Circuit diagrams and schematics if not incorporated into door submittals.
- 5 5. Details of locks, manual release, and securement of a cut-out bridgeplate.
- 6 6. Details of the following if not incorporated into door submittals:
  - 7 a. Bridgeplate operator details and drawings
  - 8 b. Bridgeplate control system
  - 9 c. Software design description
  - 10 d. Position sensing
  - 11 e. Cab and passenger controls
  - 12 f. Bridgeplate obstruction detection
  - 13 g. Bridgeplate cutout
  - 14 h. Warning announcements



## Section 10 HVAC

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## 10.1 General

### 10.1.1 Scope

This section includes air comfort systems for the passenger areas and for the operator's cab.

### 10.1.2 Power Source

The System Specified in the system will be powered per the following:

1. Air comfort systems: Three-phase ac from the auxiliary power supply.
2. Control systems: Low-voltage dc system.

### 10.1.3 Quality Requirements

Comply with the following:

1. Quality Control: The equipment manufacturer will have an ISO 9001 certified factory quality control program, as a minimum.
2. Manufacturer's Instructions: Comply with manufacturer's instructions for receiving, storing, lifting, installing, and commissioning equipment.
3. Service-Proven: Provide a system and components that meet the requirements for service-proven design.

## 10.2 System Design

Provide required capacity in both heating and cooling/dehumidification to bring outside ventilation air and recirculated air to the Specified interior temperature.

Comply with the following design requirements:

1. Perform heat loss/heat gain calculations for each interior space.
2. Base calculations upon recognized heating, ventilating, and air conditioning industry criteria.
3. Use actual thermal transmission characteristics of the materials used in vehicle construction.
4. Outdoor ambient temperatures: See the Design Criteria sections for heating and cooling, below.
5. Heating Calculations:
  - a. Do not include on-board electrical loads, such as lights.
  - b. Assume no passengers.
6. Air Conditioning Calculations:
  - a. Include all on-board electrical devices adding heat to the compartment.
  - b. Assume AW2 passenger load.
7. Assume the adverse effects of exterior solar and wind conditions in all calculations but assume no beneficial effects due to these outside influences.

## 10.3 Unitized Package

### 10.3.1 HVAC Units

Provide HVAC in independent unitized packages ("HVAC units") containing heating, ventilating, and air-cooling components, and related controls, except for floor heaters:

1. Location: Roof of the vehicle.
2. Rapid removal: Attached using bolted fasteners and multi-pin electrical connectors only; no refrigerant circuit connections will be required.
3. Quantity: Minimum one HVAC unit for each vehicle body section, with independent temperature regulation for each body section. Alternative arrangements maybe propose for review and approval by the City.
4. Independence: Failures in one HVAC unit will not affect the operation of the other units.

5. Communication link: Provide between all HVAC units and VCU. For units connected in series, single connection to VCU, each network controller will have a failure mode bypass.
6. Alternative HVAC arrangements may be proposed for review and approval by the City.

#### 10.3.2 HVAC Enclosure

Provide HVAC enclosure including the following elements and meeting the Specified requirements:

Frame: Stainless steel or corrosion-resistant aluminum.

1. Cover:
  - a. Material: Same as frame, or composite material. Composite materials, where used in weather-exposed conditions, will have appropriate UV inhibitors against break down in ambient sunlight sufficient for a 30-year life.
  - b. Strength: Horizontal covers will be capable of withstanding, without damage or permanent deformation, the loads from a 95th percentile male walking on the cover with a 12 kg (25 lb.) toolbox.
  - c. Design: Hinged type that allows open access to all serviceable parts.
2. Drain pans: Stainless steel.
3. Gaskets: Units will be fully gasketed to prevent ingress of rain and snow.

#### 10.4 Air Distribution

##### 10.4.1 General

Provide an air distribution system throughout the vehicle:

1. Design: Based upon temperature uniformity requirements in the Temperature Variation section, below.
2. Air quantities: Sufficient to produce heating and cooling capacities calculated for vehicle interior spaces.

##### 10.4.2 Ducts and Diffusers

Convey supply air and return air through dedicated and sealed duct work:

1. Main air distribution ducts:
  - a. Location: In vehicle ceiling.
  - b. Insulation: Suitable to minimize noise, heat transfer through ducts and roof by direct conduction, and formation of condensation.
  - c. Material: Non-flammable.
2. Air leakage: Maximum 5%, by volume, when measured at 20 degrees C (68 degrees F).
3. Supply air: Deliver to both sides of vehicle at ceiling level through continuous slot diffusers.
4. Diffusers: Adjustable by the vehicle manufacturer only, to permit adjustment of the airflow balance to maintain temperature differences within Specified limits throughout vehicle interior.
5. Return air: Convey from the passenger area through ceiling return air grilles and dedicated ducts of the shortest possible length to HVAC unit.

##### 10.4.3 Air Filters

Provide air filters for fresh and return air to remove airborne dirt, lint, and other fibrous material:

1. Access and replacement: Via a single cover opening/removal using common hand tools.
2. Size: Readily available commercial size.
3. Frames: Designed to accommodate both disposable cardboard-frame filters and metal-frame washable filters.

4. Filter type: Metal-frame, washable, reusable
5. Face velocity: Not to exceed filter manufacturer's recommendation.

## 10.5 Controls

### 10.5.1 General

Provide air comfort controls to accomplish the following:

1. Automatically activate appropriate operating modes.
2. Achieve Specified temperature and humidity inside the vehicle depending on ambient and vehicle interior conditions and variable passenger and solar loads.

### 10.5.2 Pump Down

Provide an automatic pump down circuit to reduce the possibility of refrigerant migration during off cycles.

### 10.5.3 Controllers

Control HVAC functions using microprocessor-based control logic units:

1. Control logic units: Comply with Section 7 Electronic Controls, Software, and MDS.
2. Design requirements: Comply with Section 2 Program Control, Deliverables and Quality Assurance, and with Section 7.
3. Temperature sensors: Locate as necessary in the vehicle to achieve Specified temperature regulation and other performance requirements.
4. Network: Link controllers to the vehicle's data network, and provide warnings, status, and diagnostics information to the network and TOD (see Section 7).
5. Controls: Provide with status and fault indication displays and locate for convenient observation by maintenance personnel.

### 10.5.4 Temperature Variation

Vehicle interior temperatures will not vary by more than 3 K (5.4 degrees F) per the following:

1. At any given time, except during pull-down and warm-up, among all points in the same horizontal plane from one end of the vehicle to the other, except for the articulation section.
2. At any given time, except during pull-down and warm-up, in the plane 1200 mm (47 in) above the floor and any point directly underneath, 150 mm (6 in) above the floor.
3. At any given point within the vehicle after stabilization, with the doors closed, due to cycling of HVAC equipment.

### 10.5.5 Overhead Heat Control

Provide control circuitry to accomplish the following:

1. Regulate the required heat to the interior space.
2. Prevent damage from excessive heat buildup in the heating element plenum, such as may occur with loss of air flow.
3. As a minimum, provide the following sensors and controller functions:
4. Heater duty cycle: Regulate to meet control parameters corresponding to interior temperature requirements stated below in the Heating Temperatures section.
5. Air flow: Switch off overhead heat without sufficient air flow acknowledged by the controller.
6. High-limit temperature sensors: Provide adjacent to each overhead heater unit to detect excessive temperature:
  - a. Upon detection of excessive temperature by either sensor, heater will switch off and send an indication to controller and TOD.

- b. If the temperature cools below lower limit at both sensors, heater may switch on automatically.
7. Back-up protection device: Provide in addition to the heater circuit breaker, to remove power in the event of excessive current draw or excessive heat:
  - a. The device will be a fusible link, or Approved equal, in the power line to the overhead heating elements.
  - b. Provide a means to suppress the arc at rupture if fusible links are used.
8. In the event of a controller failure, the heating elements will fail in the power-off condition.

#### 10.5.6 Floor Heat Control

Provide controls to modulate floor heat and avoid temperature fluctuations in the passenger area.

#### 10.5.7 HVAC Layover Mode

Provide an HVAC layover mode:

1. Temperature settings: User-adjustable.
2. Initial settings:
  - a. Layover heat: Maintain average vehicle temperature at 7 degrees C +/- 3 K (45 degrees F +/- 5 degrees F).
  - b. Layover air conditioning: Maintain average temperature at 26 degrees C +/- 3 K (79 degrees F +/- 5 degrees F).
3. Activation: Automatic when the Hotel Load timer expires.

### 10.6 Heating

#### 10.6.1 General

Provide thermostatically controlled electrical heating using overhead heat and floor heaters.

#### 10.6.2 Heating Design Criteria

Design the system based on the following winter conditions:

Heating Design Ambient Temperature	-4 degrees C DB (25 degrees F DB)
Passenger Load:	None
Solar Load:	None
Heating Load:	None

#### 10.6.3 Heating Temperatures

Comply with the following:

1. Heating capacity:
  - a. Sufficient to maintain heating interior temperature within the range Specified below.
  - b. Sufficient without reliance on passenger heat contribution or solar loading as heat sources.
2. Heating interior temperature range: 18 to 22 degrees C (64 to 72 degrees F) with an ambient exterior temperature equal to the Heating Design Ambient Temperature.
3. Heating equipment surface temperature: Maximum 52 degrees C (125 degrees F) where exposed to passengers or operator.

#### 10.6.4 Overhead Heat

Incorporate heating elements into HVAC units:

1. Capacity: Sufficient to temper outside fresh air to required vehicle interior temperature for all heating conditions, as a minimum, and to compensate for the deficiency of floor-heater capacity if floor heaters cannot fully compensate for the vehicle-body heat loss due to lack of space.
2. Reheat function: Use overhead heating elements to provide reheat for dehumidification and cooling offset at conditions lower than design cooling conditions.

#### 10.6.5 Floor Heat

Provide floor heating:

1. Capacity:
  - a. Sufficient to compensate for vehicle-body heat loss through conduction and radiation without consideration of any internal vehicle heat sources or heat from passengers.
  - b. If every wall space suitable for floor heat has been used and floor heat capacity is still insufficient to compensate for vehicle-body losses, use overhead heat to supplement floor heat.
2. Surface temperature of heater guards: Maximum 52 degrees C (125 degrees F) in their installed configuration.

#### 10.7 Ventilation

Provide ventilation of each vehicle-body section of the vehicle, as part of the HVAC unit, using the air conditioning system evaporator unit blower fans:

1. Full ventilation: Continuously available in the event of cooling or heating apparatus failure.
2. Air distribution: By ducts and diffusers.
3. Fresh air:
  - a. Deliver minimum 3.5 l/s (7.5 ft<sup>3</sup>/min) per passenger at AW2 load.
  - b. Fresh air intake will be on HVAC units.
4. Static pressure: Positive, minimum 25 Pa (0.1 inches of water) within a closed or stopped vehicle.

#### 10.8 Air Conditioning

##### 10.8.1 General

Provide cooling and dehumidification as part of each HVAC unit:

1. Type: Vapor-compression direct-expansion refrigeration cycle.
2. Capacity: Adequate to produce the required interior temperatures and humidity throughout the entire range of operating conditions.

##### 10.8.2 Cooling Design Criteria

Design the system based on the following summer conditions:

Cooling Design Ambient Temperatures:	33 degrees C DB (91 degrees F DB) 19.5 degrees C WB (67.5 degrees F WB)
Maximum Operating Conditions	38 degrees C DB (99 degrees F DB) 22.5 degrees C WB (73 degrees F WB)
Passenger Load:	450 Btu/h per passenger at 55% Sensible Heat Ratio
Solar Load:	Follow ASHRAE recommendations
Heating Load:	Total wattage of interior lights and vehicle equipment

### 10.8.3 Cooling Temperatures and Humidity

Comply with the following:

1. Cooling capacity:
  - a. Sufficient to maintain cooling interior temperature range Specified below.
  - b. Conditions:
    - i. AW2 passenger load
    - ii. Maximum solar load based on worst case sun position and vehicle orientation.
    - iii. Cooling interior temperature range:
  - c. Ambient Temperature Within Design Ambient Temperature Range:
2. Interior temperature: Within the range of 22 to 26 degrees C (72 to 79 degrees F).
3. Relative humidity: Below 60% with the design and less than design load conditions.
4. Ambient Temperature Above Design Ambient Temperature (by maximum 5 K): Maintain interior temperature below the ambient temperature by at least 7 K.

### 10.8.4 Refrigerant

HVAC units will use City-Approved refrigerant meeting the following requirements:

1. Listed in U.S. EPA SNAP list for Motor Vehicle Air Conditioners for Passenger Train end-use.
2. ASHRAE Safety Rating of not less than A1.
3. Comply with current environmental regulations governing refrigerant use, handling, and recovery.

### 10.8.5 Compressors

Refrigerant compressors will comply with Specified requirements and include each listed item:

1. Type: Hermetically sealed, scroll type design.
2. Power: Three-phase ac.
3. Capacity control: Include a thermo-expansion valve (for each evaporator circuit), and compressor capacity control, whether single-circuit or multi-circuit units are provided.

### 10.8.6 Evaporators and Condensers

Comply with the following requirements for heat exchanger coils:

1. Material: Copper tubing, copper, or corrosion resistant aluminum fins.
2. Fin spacing: Adequate to facilitate cleaning in transit vehicle service conditions. Demonstrate cleanability and procedure.
3. Fin strength: Capable of withstanding 175 kPa (25 psi) water or air pressure from a cleaning wand.
4. Fin thickness: Minimum 0.2 mm (0.008 in). If less than the minimum thickness is proposed, demonstrate fin/coating strength and longevity by a salt spray test according to ASTM B117 or ISO 9227 and by similar rail transit reliability data.
5. Coil tube sheets: Die-formed support collars for each tube.

### 10.8.7 HVAC System Devices

Provide the following:

1. Filter-drier: Replaceable; provide in refrigerant liquid lines.
2. Sight glass with moisture indicator: Provide in refrigerant liquid lines.
3. Pressure relief device: To protect the refrigeration system against explosion. Comply with ASHRAE 15, and applicable requirements of UL 1995 and UL 207.



4. Schrader valves:

- a. Location: External, to connect pressure gauges while unit is running.
- b. Type: Self-sealing, with chain-retained, metal-to-metal seal caps.

10.8.8 Air Conditioning System Piping and Fittings

*Layout and Design*

Comply with the following requirements:

1. Design tubing installations such that a single length of tubing may be replaced without dismantling or removing surrounding equipment, piping, wiring or other appurtenances.
2. Keep joints to a minimum with no inaccessible joints or fittings; inaccessible runs of tubing will be without joints.
3. Provide suction lines without traps. Size the liquid line adequately to prevent flashing due to pressure drop.
4. Mount and support copper piping such that shock and vibration do not cause failure of solder joints. Provide vibration eliminators in piping connections to the compressor. Equipment and piping will meet the criteria of IEC 61373.

*Type*

Comply with the following standards:

1. Air conditioning refrigerant lines: Per ASTM B280 or ASTM B88 type L, seamless copper tubing. Fittings will be wrought copper sweat type.
2. Condensate drain lines: ASTM B88 type K.

*Fabrication*

Comply with the following fabrication requirements:

1. Tubing may be bent only with an appropriate tube bending tool.
2. Deburr piping after cutting and thoroughly clean after installation.
3. After pre-fabrication, clean piping, and pipe subassemblies, dry (if required), and cap all openings.
4. Caps will remain in place until immediately prior to incorporation into the final assembly.

*Refrigerant Line Soldering*

Comply with the following soldering requirements:

1. Soldering of copper piping and fittings:
  - a. Perform to AWS A5.8M/A5.8; or
  - b. Equivalent standard used in the country of equipment origin (i.e., AWS A5.8M/A5.8, welding procedure BAg-5 is commonly used on refrigerant pressure lines in the U.S.).
2. Refrigerant pressure piping filler metal:
  - a. Silver content: Minimum 15% for copper-to-copper joints; between 35% and 45% for dissimilar metal joints.
  - b. Cadmium free.
3. Non-pressure copper lines silver content: Minimum 15%.

*Insulation*

Insulate lines subject to condensation forming:

1. Insulate condensate drain lines and suction line piping with insulation that meets the flammability, smoke emission, and toxicity requirements as Specified.

2. Insulate the liquid line in all areas where required to give additional mechanical or thermal protection.
3. Apply the insulating material to the piping with suitable contact cement.
4. Miter and seal joints and directional changes in the insulation.

#### 10.8.9 Air Conditioning System Charging and Testing

Charge and test each self-contained air conditioning unit at the factory before shipping:

1. Perform system charging to the manufacturer's own procedure, but as a minimum incorporate the following steps:
  - a. Leak test per procedure Approved by the City.
  - b. Evacuate and dehydrate the entire refrigeration system to a pressure of 100 microns of mercury, or less.
  - c. Maintain this vacuum level for a minimum of two hours with the vacuum pump running.
  - d. After two hours, isolate the vacuum pump from the system.
2. The system pressure should not rise above 300 microns of Mercury in a two-hour period after vacuum pump isolation.
3. Decay in the vacuum indicates that moisture remains in the system, or a leak.
4. Measure vacuum levels at the system, not at the entrance to the vacuum pump
  - a. Charge with the predetermined amount of refrigerant by weight.
5. Factory testing will include air conditioning unit routine tests Specified in Section 18 Vehicle and Systems Testing.

### 10.9 Operator's Cab Air Comfort System

#### 10.9.1 General

Provide heating, cooling, and defrosting in each cab as Specified below

Provide conditioned air into the cab from the passenger HVAC system described above.

#### 10.9.2 Cab Heaters

##### *General*

Provide one or two forced-air cab heaters for defrosting and heat in each operator's cab.

##### *Cab Heater Housing, Ducting, and Vents*

1. Provide listed components and comply with the following requirements:
2. Heater housing:
  - a. Material: Heat-resistant, nonflammable
  - b. Configuration: Fully enclose the heater elements.
  - c. Surface temperature: Maximum 52 degrees C (125 degrees F) where exposed to operating personnel.
3. High limit thermostat: Provide in the heater housing to remove power in the event of excessive temperature.
4. Grounding: Permanently ground heater assembly and enclosure to vehicle structure.
5. Ducting and vents:
  - a. Direct heater output onto side windows and windshield.
  - b. Direct heater output onto the operator's feet and provide manually adjustable damper.
  - c. Ducting and damper arrangements will not permit airflow to be blocked to the extent that the heater overheats or trips the over-temperature sensor.

#### Cab Heater Capacity

Comply with the following:

1. Cab heaters will have capacity adequate to maintain a temperature of minimum 21 degrees C (70 degrees F) in the full-width cab compartment under the following conditions:
  - a. Exterior ambient temperature equal to the Heating Design Ambient Temperature in the Heating Design Criteria section, above.
  - b. Overhead air diffuser shut-off.
  - c. Side windows closed.
2. Provide sufficient capacity to defrost the cab side windows and windshield, without aid of the windshield's electrical defrosting heater circuits, as follows:
  - a. Time period: Maximum 20 minutes.
  - b. Exterior Ambient Temperature: Equal to the Heating Design Ambient Temperature in the Heating Design Criteria section, above.
  - c. Condition: Vehicle is activated after being de-energized for a period of 8 hours and exposed to Specified ambient temperature during that period.

#### Cab Heater Controls

Heater functions must include Off, Fan (no heat), and at least two stages of heat with appropriate fan speeds for each. Provide control of heaters from the Cab Console as Specified.

#### 10.9.3 Conditioned Air From Passenger HVAC System

Provide conditioned air to the cab from the passenger HVAC system. Temperature and humidity in the cab will conform to the passenger area requirements at least under the following conditions:

1. Cooling conditions: Include the worst-case solar load in the cab and two persons (operator and observer/instructor).
2. Heating conditions: Will not include solar load or personnel inside the cab. The heating capacity of the cab heater described in the Cab Heaters section above will be considered.
3. Provide adjustable diffusers for the operator to set air flow and direction:
  - a. Air flow adjustment range: Include full off.
  - b. Direction adjustment range: Include the ability to direct air flow away from operator.

#### 10.9.4 Windshield Defrosting and Defogging

Provide electrical defrosting heater circuits embedded in the cab windshield controlled via the Cab Console. The windshield heater system will have sufficient capacity to defrost the windshield, without aid of the cab heater defroster, as follows:

1. Time period: Maximum 20 minutes.
2. Exterior Ambient Temperature: Equal to the Heating Design Ambient Temperature in the Heating Design Criteria section, above.
3. Interior Dew Point: 20 degrees C (68 degrees F).
4. Condition: Sufficient moisture has condensed to just begin to run down the glass.

#### 10.10 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description

3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

10-1 Calculations:

1. Include assumptions.
2. Heat Loss/Heat Gain
3. Heating and cooling capacity
4. Include both the operator and passenger cabins and show separately.

10-2 HVAC Unit Design Package:

1. HVAC unit arrangement drawing showing the quantity, location, heating/cooling capacity of each unit on the vehicle.
2. Certifying letter of manufacturer's ISO 9001 certified factory quality control program.
3. Manufacturer's dimensioned layout drawings for all types of HVAC units.
4. Electrical data for all types of HVAC units.
5. Electrical load (or coefficient of performance) for heating and cooling at maximum capacity for each unit on the vehicle.
6. Details of overhead heating.
7. Details of ventilation.
8. Air Conditioning:
9. Component identification
10. Materials identification
11. General layout drawings
12. Electrical and controls schematic
13. Piping schematic
14. Make and model number for compressor, purchased controls, sensors, and instrumentation.
15. Acceptable charging procedure for the system charged with blended refrigerant.
16. Air Conditioning Piping:
17. Description of all fastening and joining methods for refrigerant piping, including silver solder procedures.
18. Manufacturer's data for air conditioning system piping insulation and insulation joint-sealing material.

10-3 Air Distribution Design Package:

1. Airflow velocity and noise calculations for both the operator and passenger cabins, shown separately.
2. Pressure drop calculations.
3. Overhead ductwork and diffuser drawings.
4. Air Filters:
  - a. Manufacturer's data on air filter including brand, type, and size.
  - b. Include quantity.

10-4 HVAC Control Design Package:

Include the following:

1. Brand(s), type, and model of microprocessor-based control units or PLC and control devices
2. Manufacturer's data on overhead heat back-up protection device used to remove power in the event of excessive current draw. Include the means used to suppress the arc at rupture.

- 1        3. Layover Climatic Control:
- 2        4. Manufacturer’s data on components.
- 3        5. Location of the layover thermostat if a separate thermostat is used.
- 4    10-5 Floor Heat Design Package:
- 5        1. Design drawings, including details of heating units and layout.
- 6        2. Manufacturer’s data on heating elements.
- 7    10-6 In-Factory Charging and Testing Booklet:
- 8        1. Include one booklet for each self-contained air conditioning unit.
- 9        2. The booklet must contain charging certification and results of air conditioning unit routine tests,
- 10       as Specified.
- 11   10-7 Operator’s Cab Air Comfort System Design Package:
- 12       1. Description and details of controls
- 13       2. Details of how passenger compartment conditioned air will be supplied to the cab, including the
- 14       following:
- 15       3. Ducting size and locations
- 16       4. Airflow
- 17       5. Heat gain/loss and verification that airflow is sufficient to maintain Specified temperatures.
- 18       6. Cab Heaters:
- 19       7. Manufacturer’s heater details, including the following:
- 20       8. Electrical requirements
- 21       9. Housing material
- 22       10. Automatic high-limit thermostat in the heater housing to remove power in the event of excessive
- 23       temperature.
- 24       11. Layout drawing indicating ducting and vents and showing how heat will be directed for both heat
- 25       and defrosting.
- 26       12. Details of windshield embedded defroster, including controls, temperature limits, and over-
- 27       temperature protection

## Section 11 Lighting

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### 11.1 General

All lighting, indicators and lamps will be via LEDs.

Provide lamps with standard dimensions and electrical connections. Lamps, sockets, and connectors are considered consumable items, and will be commonly stocked and available from U.S. suppliers.

### 11.2 Lighting System Design

The lighting system design and illumination requirements will meet the following federal regulations, APTA standards, and other applicable standards for vehicle lighting:

- 49 CFR 38 subpart D, ADA Accessibility Specifications for Transportation Vehicles, Light Rail Vehicles and Systems
- APTA SS-E-013-99, Standard for Emergency Lighting System Design for Passenger Cars
- APTA PR-E-RP-012-99, Recommended Practice for Normal Lighting System Design for Passenger Cars
- For exterior lighting, 49 CFR 571.108, Lamps, Reflective Devices, and Associated Equipment. Apply requirements for buses of 2032 mm (80 inches) or more in overall width.
- ANSI and SAE standards, as Specified in sections below.
- Where a conflict exists, the most restrictive requirement will apply.

### 11.3 Lighting Levels

Lighting levels Specified below will be achieved at the nominal rated voltage:

Area	Measurement Type and Location	Minimum Lighting Level
Within the vehicle	Average, at elevation of 840 to 1675 mm (33 to 66 in) above the floor	215 lux (20 fc)
Passenger aisles and articulation section	Average, at the floor	110 lux (10 fc)
Vehicle entrances and exits	Average, within 500 mm (20 in) of the doors at the floor	110 lux (10 fc)
Door thresholds and platform	On platform surface 915 mm (36 in) from vehicle side	55 lux (5 fc)
Stairways	Surface of the steps	55 lux (5 fc)
Cab (from ceiling light)	Average, at 840 mm (33 in) above the floor	215 lux (20 fc)
Within passenger area of vehicle with emergency lighting only	Average, 640 mm (25 in) above the floor	22 lux (2 fc)

### 11.4 Power Source and Control

Comply with the following:

- Lighting power source: Low-voltage dc power system, without intermediate power supplies or dropping resistors.
- Lighting Control:
  - Dimming (where Specified): PWM circuitry appropriate for the LED design, such that dimming levels may be set by voltage level. LEDs used as indicators, such as on the cab console, may be powered from a separate PWM supply.
  - Electronic controllers: Comply with the design requirements Specified.
- See Section 5 Operator's Cab, for additional control requirements.

## 11.5 General Fixture and Lamp Requirements

Comply with the following general requirements:

1. Maintainability: All lighting fixtures will have easy access for lamp replacement, cleaning, and maintenance:
  - a. Lamp access: Via gasketed enclosure covers secured by captive, stainless steel fasteners, except for permanently sealed light fixtures.
  - b. Enclosure covers: Retained by hinges, where possible. Hinges located on the vehicle exterior will be stainless steel.
2. Lighting fixtures: Integral frosted diffuser/lens. Clear lenses are not permitted except for indirect lighting applications.
3. Lamps:
  - a. For illumination purposes:
4. Type: White LED assemblies
5. Voltage range: Provide full illumination within the range Specified in Section 9, Electrical Equipment
6. Passenger area: Energy Star® Qualified, or equivalent documented performance, when installed in the proposed fixtures.
7. Life expectancy: Minimum 50,000 hours, in the proposed fixtures
  - a. For indicators:
8. Life expectancy: Minimum 100,000 hours

## 11.6 Interior Lighting

### 11.6.1 General

Comply with the following:

1. Performance: Provide lighting free from glare.
2. Diffusers: Frosted type, such that individual LEDs are not discernible.
3. Lighting levels: Provide as Specified in the Lighting Levels table, above.
4. Environmental:
  - a. Fixtures will be dustproof.
  - b. Fixtures within 610 mm (2 ft) of a doorway will be watertight except for interior ceiling lights.
5. Flammability, Smoke Emission, and Toxicity: Light fixture, lamp, and associated parts or equipment will meet the guidelines Specified.

### 11.6.2 Passenger Area Lighting

#### General

Comply with the following:

1. Correlated Color Temperature (CCT): Mimic the color of warm white (3000K) or cool white (4100K) fluorescent tubes in accordance with ANSI C78.377, Table 1, Nominal CCT Categories.
2. Color Rendition: Adjust CCT as necessary to complement the City's choice of interior colors.

#### Main Linear Lighting

Provide linear lighting fixtures in the main passenger areas:

1. Type: Ceiling mounted, recessed, and integrated into the interior finish.
2. Layout: Two parallel rows.



3. Continuous Illumination: When viewed from the end of the vehicle, there will be no visible dark spots, such as where electronic controllers might be located.
4. Circuits: Power each row of light fixtures from a separate circuit. Fixtures across the aisle will be connected to different circuits.
5. Door area: Provide a minimum of one overhead standard-length light fixture at each door area. See Emergency Lighting, below, for requirements in case of power failure.

#### *Doorway Floor Lights*

Provide light fixtures at each doorway for threshold and platform illumination:

1. Location: Mount near floor on doorposts, windscreen, or other location that will produce the required minimum illumination (see Lighting Levels table, above).
2. Operation: The light will be illuminated when the passenger door starts to open and not illuminated when the door is closed and locked.
3. Alternate: If emergency passenger area lights furnish the required lighting level for door threshold and platform illumination, dedicated doorway floor lights may be omitted.

#### *Stairway Floor Lights*

Provide light fixtures at each stairway:

1. Step illumination: Provide the required minimum (see Lighting Levels table, above).
2. Control: The lights will be illuminated when the interior lights are illuminated.

### **11.6.3 Cab Lighting**

#### *Operator's Cab Ceiling Light*

Provide a light fixture in each cab located in the ceiling to illuminate the Cab Console:

1. Location: The light beam will be placed to avoid glare on the windshield.
2. Control: By the Cab Console, as Specified.

#### *Cab-Console-Mounted Light*

Each Cab Console will be illuminated to enable the operator to see the console labels, pushbuttons, and switches under varying lighting conditions:

1. Light Location: Mount at the top edge of Cab Console, shielded from operator's eyes.
2. Glare: When illuminated, light will not cause glare on the windshield or the Cab Console.
3. Control:
  - a. The console light will be energized automatically when the Cab Console is powered.
  - b. Provide dimmer control as Specified.

## **11.7 Exterior Lighting**

### **11.7.1 General**

Comply with the following:

1. Fixture assemblies:
  - a. Dustproof and inherently waterproof.
  - b. Mount to vehicle with gaskets to prevent water ingress into the vehicle. Caulks, sealers, and similar materials are prohibited.
2. Bezels and trim:
  - a. Stainless steel: If light fixtures are Specified to have bezels and trim, or if proposed fixtures have bezels and trim.

- b. Fasteners: Captive stainless steel, and consistent with good mechanical mounting principles.
3. Taillights, stop lights, marker lights, and turn signals: Permanently sealed plastic LED assemblies, colored as indicated.
4. Headlights, taillights, stoplights, marker, and clearance lights, and turn signals: Conform to 49 CFR 571.108 for buses of 2032 mm (80 inches) or more in overall width.

#### 11.7.2 Headlights

Comply with the following requirements for headlights:

1. Type: LED with high beam and low beam; adjustable to permit proper aiming of beams.
2. Location: Provide on each side of each end of the vehicle.
3. Life: Minimum 50,000 hours.
4. Heat management:
  - a. Comply with headlight manufacturer's clearance and airflow recommendations to maintain temperatures within LED manufacturer's recommended limit.
  - b. Ensure that adjacent components have sufficient clearance and protection from high-temperature areas of the headlights to prevent heat damage.
5. Visibility: Capable of revealing a person or motor vehicle in clear weather at a distance of 107 m (350 ft).
6. Adjustment: Set so as not to interfere with the vision of drivers of motor vehicles.
7. Control: As defined in Section 5, including appropriate circuitry for low/high beam cycling function.

#### 11.7.3 Taillights and Stop Lights

Comply with the following requirements for taillights and stop lights:

1. Taillights:
  - a. Quantity: Two at each end of each vehicle
  - b. Color: Red
  - c. Standard: Comply with requirements of SAE J2040
  - d. Visibility: Plainly visible from a distance of minimum 150 m (500 ft), when illuminated
2. Stop lights:
  - a. Quantity: Two at each end of each vehicle
  - b. Color: Red
  - c. Intensity: Approximately 150% of the intensity of the taillights
  - d. Standard: Comply with requirements of SAE J2261
3. Combination: Alternatively, the taillights and stop lights may be combined.
4. Control: Automatic.

#### 11.7.4 Marker Lights

Comply with the following requirements for marker lights:

1. Standard: Comply with the requirements of SAE J2042.
2. Visibility: Plainly visible from minimum 150 m (492 ft), when illuminated.
3. Quantity and Location:
  - a. On each side of the vehicle:
    - i. One amber light located as close to each end as possible for a total of two (front side marker lights)
    - ii. One amber light located at or near the midpoint (intermediate side marker light)

- iii. One red light located as close to each end as possible for a total of two (rear side marker lights)
- b. On each end of the vehicle:
  - i. Two amber marker lights located symmetrically about the vertical centerline to indicate the overall width, located as near the top as practicable (front clearance lamps)
  - ii. Two red marker lights located symmetrically about the vertical centerline to indicate the overall width, located as near the top as practicable (rear clearance lamps)
4. Control: Automatic.

#### 11.7.5 Warning Lights

Comply with the following for warning lights:

1. Quantity:
  - a. End sections, 1 horizontal center of end section
  - b. Center section, 2 centered between adjacent doorways.
2. Standard: comply with the requirements SAE J595 Class II
3. Flash pattern will be submitted to the City for review and Approval.

Warning lights maybe combined with side Marker Lights.

#### 11.7.6 Turn Signals

Comply with the following requirements for turn signals:

1. Type: Flashing
2. Location: Front, sides, and rear of vehicle. On vehicle ends, turn signals may be integrated with headlights or other lights in accordance with 49 CFR 571.108 and as Approved by the City.
3. Standards:
  - a. Front and rear turn signals: Comply with the requirements of SAE J2261.
  - b. Side turn signals: Comply with the requirements of SAE J2039.
4. Visibility: Plainly visible from minimum 150 m (492 ft) when illuminated.
5. Control: See Section 5 Operator's Cab, for normal control and use of turn signals as hazard lights.

#### 11.8 Emergency Lighting

Comply with the following requirements for emergency lighting:

1. Standard: Comply with the minimum performance requirements of APTA-SS-E-013-99.
2. Power Source: Low-voltage dc power system, and in the event of loss of normal power, from emergency power.
3. The following are considered emergency lighting:
  - a. Doorway overhead lights
  - b. Doorway floor lights
  - c. Stairway lights
  - d. Enough overhead lights to illuminate aisles in accordance with NFPA 130.
  - e. Active cab, overhead lights
  - f. Active cab, Cab Console lights
  - g. Exterior lights

**11.9 Wiring Requirements**

Comply with the following requirements for wiring of lighting:

1. Lamp circuits will be electrically isolated from the fixture and the vehicle structure.
2. Metallic fixtures and exposed metallic surfaces will be grounded to the vehicle structure as Specified.

**11.10 Contract Deliverables Requirements List (CDRL)**

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

**11-1 Lighting System Design Package:**

1. The design package may be submitted as two packages, interior and exterior lights.
2. Include the following:
  - a. Verification of lighting performance by computer analysis, including emergency lighting.
  - b. Drawing of each lighting fixture.
  - c. Drawing of the vehicle showing light fixture locations and identities.
  - d. Listing of lamps by function, type, part numbers, and source of U.S. supply.
  - e. Energy Star® Certification for passenger area lighting, or comparable documentation.
  - f. Warranty information for all equipment, including LED lamps.
  - g. Nominal electrical load of the lighting system, measured in kW.

**11-2 Emergency Lighting System Design Package:**

3. Emergency lighting load calculations.

## Section 12 Electrical Equipment

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## 12.1 General

### 12.1.1 Scope

This Section specifies general electrical requirements; electrical systems not addressed in their own sections; and electrical components used throughout the vehicle. Electrical materials, including but not limited to conduit, wireway, junction boxes, wire, and cable, are Specified in Section 19 Materials and Workmanship.

## 12.2 General Electrical Requirements

### 12.2.1 Equipment Enclosures

Electric or electronic equipment will be enclosed in equipment enclosures, unless Specified otherwise.

### 12.2.2 Electrical/Electronic Design Standards

Electrical and electronic equipment will comply with the requirements of IEC 60571, EN 50155, or IEEE Std 16.

### 12.2.3 Equipment Voltage Range

Comply with the following:

1. Electrical equipment will operate as Specified and without damage over the full operating range of its source voltage, and the worst-case voltage drop in the distribution system.
2. All equipment will be protected against damage from voltages outside the Specified range, or their design range, whichever is greater.
3. Equipment operating from the ac system will operate as Specified and without damage at any voltage within the limits Specified in the Auxiliary Power Supply (APS) section, below.
4. Equipment operating from the low-voltage dc power system will be rated for continuous operation at the actual LVPS terminal voltage, in compliance with the Low-Voltage DC Power System section, below.
5. Equipment operating from the battery without the battery charger will operate as Specified and without damage at the battery voltage resulting from discharge down to 1 V per battery cell.

### 12.2.4 Circuit Protection

Comply with the following:

1. Arrange circuit protection in a logical branching organization to facilitate fault isolation and minimize operational impacts on other systems:
  - a. Coordinate local circuit protection with main source protection such that faults or overloads downstream of the local protection will trip the local protection only, and not trip the main source protection.
  - b. Local protection trip settings will be lower than the main source power or current limit settings.
2. Size circuit breakers and fuses, to protect both the equipment and the minimum wire size used for power distribution within the protected circuit. The use of fuses must be submitted to the City for review and approval.
3. Individually protect each circuit as follows:
  - a. Propulsion high-voltage dc circuits: HSCB
  - b. Auxiliary high-voltage dc circuits: High speed fuses
    - i. Use of HSCB maybe proposed, with alternative dead battery system.
  - c. AC circuits: Circuit breakers
  - d. Low-voltage dc circuits: Circuit breakers



4. Location of circuit protection devices:

- a. Mount ac and low-voltage dc circuit breakers in panelboards located in electrical lockers in each operator's cab. Group low-voltage dc control breakers logically.
  - b. AC loads that are in the cab will have their respective breakers in the cab.
  - c. Locate other ac distribution breakers within the vehicle such that they may be readily inspected by the operator but are not accessible to passengers.
  - d. AC and low-voltage dc circuit breakers may be located elsewhere only as Approved, or as Specified.
5. Display the OFF state of all circuit breakers for those systems that do not report failure status to the TOD upon loss of power, such as track brakes.

**12.2.5 Grounding and Return Circuits**

Size all grounding and high voltage return conductors, ground brushes, and related components to limit voltage rise to less than 50 V under worst case fault currents.

*Shunting Resistance*

See Section 15 Trucks, for wheel shunting resistance requirements. See Section 18 Vehicle and Systems Testing, for required resistance tests.

*Safety Grounding*

Comply with the following:

1. Safety ground all conductive equipment on the vehicle to the vehicle structure, including metallic raceways, resiliently mounted equipment, enclosures, the truck frame, and truck mounted equipment.
2. Safety ground the vehicle structure to the axles using dedicated safety ground brushes.
3. Safety ground axles to wheel tread with shunts as Specified in Section 15 Trucks.

*High-Voltage Return Circuits*

Comply with the following:

1. Connect all high voltage return circuits to an isolated return current terminal for each propulsion and APS unit per vehicle section.
2. Interconnect these isolated return current terminals throughout the vehicle.
3. Connect these isolated terminals to all brushes on the corresponding truck by ground wires of identical impedance.
4. Install an isolated ground plate within the truck if needed to facilitate impedance balance for each ground brush.
5. Provide high-voltage dc current return to the running rails as follows:
6. Connect the high-voltage dc return circuits to the axle using ground brushes and to the rail using the wheels with appropriate visible shunts around the wheel resilient elements. See Section 15 Trucks, for additional requirements related to wheel assembly conductive paths.
7. Prevent any current return through the journal bearings, gear units, or motor bearings.

*Low-Voltage Return Circuits*

Provide return wiring for each system or circuit fed from a circuit breaker or fuse. Each circuit return wire will be connected, via its own separate terminal, to a return bus located in the same electrical locker that contains the circuit breaker that supplies the circuit.

Ground the return circuits as follows:

1. Connect the low-voltage dc return circuits to the vehicle structure through an RC filter at a single point only.
2. Ground the ac neutral at a single point.

The vehicle structure will not be used as a normal circuit-return path for any electrical equipment.

*Ground Brushes*

Provide ground brushes for each wheel or for each through-axle in a conventional (non-stub axle) truck:

1. Rating: 2.0 times the circuit rms current, and 1.5 times the circuit peak current.
2. Life: Minimum 500,000 km (310,686 mi).

*Grounding Conductors*

Grounding wires to fixed equipment may be standard vehicle.

Provide tinned, braided copper ground cables fitted with flared terminal barrels designed for strain relief for the following applications:

1. Grounding connections to resiliently mounted equipment.
2. Grounding connections between the vehicle body and truck frame.
3. Grounding connections in other locations with relative movement.

*Grounding Connections*

Grounding connections to vehicle body, truck frame, and other vehicle structures:

1. Ground pads: Provide welded stainless-steel pads or tinned or silver electro-plated copper pads silver soldered or brazed to both the vehicle body and the grounded item, through-drilled.
2. Connection: Fasten the ground wire to the ground pad using a bolt, flat washer, and locknut. The flat washer will bear on the ground wire terminal.
3. Aluminum structures:
  - a. Weld an aluminum ground pad onto the structure. Thick aluminum structures may not require a separate ground pad, if Approved.
  - b. Through-bolt the ground cable to the structure with zinc-plated steel fasteners and washers.
  - c. Treat the connection with an anti-corrosion paste.
4. DC resistance: Maximum 0.0025 ohms.
5. AC impedance: Maximum 0.025 ohms at 150 kHz for an applied ac voltage.

**12.2.6 Ground Fault Detection and Protection**

The vehicle will have ground-fault protection at the inputs of high-voltage dc equipment, and generic ground-fault protection for ac circuits, low-voltage circuits, and ac convenience outlets.

**12.3 Equipment Temperature Management**

Comply with the following:

1. Cooling systems may be water or air cooled.
2. Forced-air cooled systems: Use ambient air only where exposed voltage is 50 V or less.

3. Water-cooled systems:

- a. Use tap or distilled water treated with anti-corrosives and antifreeze.
- b. Use of chlorofluorocarbons (CFCs) is prohibited.
- c. Provide fluid pH as appropriate to minimize corrosion on all components.
- d. Permanently sealed, with no preventive maintenance required for life of equipment.
- e. If cooling system must be opened for other maintenance purposes, this will not be required more often than yearly.
- f. Provide no-leak quick-disconnect fittings.

4. Motors for cooling pumps or fans: Three-phase ac or dc brushless, except as Specified in the Failure Management section, below.

5. Equipment temperatures:

- a. Continuously monitor via sensors or, where appropriate, by calculation.
- b. Manage system power levels as necessary to protect equipment from over-temperature damage.
- c. Record abnormal temperatures, temperature trends, and resulting equipment power limitations and present to the MDS and TOD.

## 12.4 Primary Power System (OCS)

### 12.4.1 General

Equipment operated from the OCS will comply with the Primary Line Voltage requirements.

### 12.4.2 Pantograph

#### General

Vehicle power will be collected from the OCS by a roof-mounted pantograph:

1. Type: Service-proven, single-arm design, with a spring-suspended contact assembly capable of stable bi-directional operation at all Specified vehicle speeds and external system characteristics.
2. Dimensions and operating height range: Comply with Section 2.
3. Bearing Shunts: Provide tinned, braided copper conductors around all pantograph moveable joints.
4. Design Standard: IEC 60494-2 or Approved equal.

#### Contact Assembly

Comply with the following:

1. Type: Double carbon with replaceable flat carbon inserts of one-piece design.
2. Carbon lateral radius: 6 m to 10 m (20 ft to 33 ft), or other Approved value.
3. Maintainability: Contact assembly and carbon inserts will be individually replaceable with common hand tools.

#### Contact Force

Contact force on the contact wire will be adjustable and will be selected for optimum tracking and minimum wear:

1. Range: 80 N to 110 N (18 lbf to 25 lbf).
2. Linearity: Contact force will vary by maximum 25 N (6 lbf) over the combined full ranges of operating height, vehicle speed, and direction.

#### Dynamic Stability

Pantograph dynamic stability will be sufficient to maintain contact and stable wire tracking at the Specified speeds on all tracks at all contact wire heights and transition grades.

*Pantograph Raising and Lowering*

Comply with the following:

1. Manual raising and lowering:
  - a. Make provision for manually lowering and raising the pantograph in the event of a loss of power or control.
  - b. The manual mechanism will be operated from within the vehicle, using a hand crank or similar tool.
  - c. Provide a switch in the manual operator socket that disconnects motor power while the manual operator is inserted.
  - d. Provide one tool for each vehicle, plus five spares.
  - e. Provide tool storage in the cab.
2. Pantograph raising:
  - a. The pantograph will be spring raised when the restraining mechanisms are released.
  - b. The raising speed will be damped or otherwise controlled to prevent carbon strip damage upon striking the OCS. This speed control and damping will be active only during the raising process and will be inactive during normal wire tracking.
3. Raising and lowering circuit:
  - a. Will be operable from either cab, by a Pantograph Up/Down Switch on the Cab Console, but only while the vehicle is at rest or moving in a coast or brake mode.
  - b. Lowering the pantograph by any means will not affect any requested brake rate and will result in a coast mode if the vehicle is in a coast or power mode.
  - c. Lowering command of the pantograph will open the HSCB and turn off the APS.
  - d. Electric raising and lowering mechanisms will operate throughout the voltage range Specified for low-voltage equipment.
4. Pantograph restraining mechanism:
  - a. Provide a mechanism to automatically restrain the pantograph in the fully lowered position.
  - b. The mechanism will always function regardless of failures in power, control, or other system elements.
  - c. The mechanism will be released automatically when the pantograph is commanded to be raised.

*12.4.3 High Speed Circuit Breaker*

Provide a roof-mounted, high speed circuit breaker (HSCB) to protect the propulsion high-voltage dc power circuits:

1. Standards: Comply with IEC 60077-1, IEC 60077-3, and IEC 61373.
2. Power supply: Low-voltage dc power system.
3. Performance:
  - a. Trip opening in maximum 10 ms.
  - b. Complete arc extinguishment and fault interruption in less than 50 ms.
4. Trip values and ratings: Coordinate with the traction electrification system supplier such that the HSCB will clear all vehicle system fault currents without nuisance trips of the wayside breakers.
5. Trip and reset capability:
  - a. Remote trip by the propulsion logic, reset from the cab, as part of the HSCB (Propulsion) Reset switch as Specified.

- b. Limit the number of electrical resets to three within any 15-minute period, after which resetting must be done via the portable test unit (PTU) or MDS maintenance screen.
- c. If locked after too many trips, reset will be via a PTU or MDS maintenance screen.
6. Provide annunciation of a tripped or open HSCB to the operator.

#### 12.4.4 Battery Charging

The LVPS will charge batteries whenever power is available, either via the OCS or OESS:

1. Battery charging will not depend on the state of the HSCB.

#### 12.4.5 Dead Battery Operation

All vehicle systems will start automatically, and function as Specified, whenever there is high-voltage dc available at the pantograph, regardless of the charge state of the vehicle battery.

#### 12.4.6 Surge Arrester

Provide an MOV-type surge arrester suited for rail application, on or adjacent to the pantograph base:

1. Type: Rated by the manufacturer for outdoor dc operation.
2. Standards: Designed, constructed, and tested in accordance with the general requirements of IEEE C62.11.
3. Rating: Selected to prevent voltage transients and surges from damaging or degrading vehicle-borne equipment, including the arrester itself.

### 12.5 Maintenance Shop Power

#### 12.5.1 General

Power to the vehicle while in the Shop currently is 750 Vdc, supplied by a plug-in cable from the Shop Vehicle Power Unit (SVPU). In the future the City is planning to move to a 3-phase shop power arrangement.

#### 12.5.2 Coordination

Coordinate with the City to ensure compatibility of the vehicle with the existing Shop:

1. Furnish a summary of vehicle auxiliary loads that will be powered from the Shop to ensure compatibility of Shop circuit sizes with vehicle loads. Reduce loads if necessary for compatibility with the Shop.
2. Ensure that City-furnished SVPU's are compatible with vehicle plugs and interlocking.
3. Furnish a dimensioned sketch showing the location of the receptacle on the vehicle to allow designers to locate SVPU's correctly in the Shop.

#### 12.5.3 Shop Switch

Provide a dedicated transfer switch on the vehicle as follows:

1. Type: Fully enclosed, three-position rotary-type.
2. Positions:
  - a. Off, Normal mode, and Shop mode.
  - b. Clearly marked on the outside.
3. Operating handle:
  - a. Easily operable with one hand.
  - b. Grounded to the enclosure.
  - c. The handle will block the shop receptacle while in Normal mode, so the handle needs to be in shop mode prior to inserting the shop plug.

4. The switch will operate as follows:

a. Off mode:

- i. Disconnect pantograph from all vehicle circuits.
- ii. Disconnect shop voltage from all vehicle circuits.

b. Normal mode:

- i. Disconnect shop voltage from all vehicle circuits.
- ii. Connect pantograph to APS, traction inverters, and other line-voltage-operated equipment.

c. Shop mode:

- i. Disconnect pantograph from all vehicle circuits.
- ii. Connect shop voltage only to APS, and LVPS if powered directly from line voltage.
- iii. Provide an interlock in the shop switch to prevent the pantograph from moving in this mode.
  - 1. Under no circumstances will the propulsion system, pantograph, or pantograph frame be energized by shop power.

5. Shop Switch Enclosure:

- a. Box: Painted steel, stainless steel, or aluminum; grounded to the vehicle structure.
- b. Cover: Latching hinged type or threaded, watertight when subjected to a water test equal in severity to that for the vehicle body; grounded to the enclosure with ground strap.
- c. Interior: Fully insulated with no grounded components inside.

6. Location: Roof or an alternate location if Approved by the City.

**12.5.4 Receptacle and Plug**

Provide receptacle, mating plug, and associated equipment rated for the maximum continuous and peak auxiliary currents to allow connection to the SVPU:

1. Receptacle:

- a. Location: On the shop switch enclosure, or in an alternate location if Approved by the City.
- b. Grounding: If the receptacle body is metallic, it will be grounded to the vehicle structure.
- c. Model: VEAM, CIR030-22-21S-F80T1. Verify that this receptacle is acceptable for the proposed load.

2. Plug: For each vehicle furnished under this Contract, furnish one mating plug to the City for installation on the shop cable by others.

3. Interlocking: The receptacle and plug will include interlock contacts to ensure that the SVPU is energized only when the SVPU cable is plugged into the receptacle. Arrange interlock contacts on the receptacle/plug to break before the main receptacle/plug power contacts separate when removing the plug.

**12.5.5 Auxiliary Loads Under Shop Power**

Under Shop power, the following loads will be powered, unless otherwise agreed by the City:

- 1. All ac loads, including maximum HVAC loads.
- 2. All low-voltage dc loads and battery charging.

Verify that vehicle circuits and loads stay within the limits furnished to and Approved by the City.

## 12.6 Onboard Energy Storage System (OESS)

### 12.6.1 General

Provide onboard power for all vehicle functions and operation during wireless operations. The vehicle shall be equipped with at least two onboard energy storage systems, one per truck, with the combined capacity to operate the vehicle as Specified in TS 4.2.4; alternative, functionally redundant design maybe proposed for review and Approval.

1. Provide one OESS assembly per powered truck; alternative arrangement maybe proposed for review and Approval.
2. Split auxiliary loads between each OESS

### Design Standards

OESS will comply with IEC 62864-1, IEC 61287-1, IEC 6113, IEC 61377, IEC 62928, IEC 61881-3, NFPA 130 or Approved equal.

### System Capacity

The Contractor will determine and provide energy storage capacities as follows:

1. Initiate wireless operation at the beginning of each wireless segment described below with an OESS that is no more than 80% fully charged.
2. Provide energy capacity in the OESS equivalent to twice the energy necessary to operate once on each segment under the defined operating conditions, plus sufficient reserve to remain above the recommended minimum state of charge (SoC).

### Installation

Comply with the following:

1. Location:
  - a. OESS assemblies shall be installed on the roof of the vehicle. Consideration may be given to underfloor installations, subject to demonstration of safety under impact with rail vehicles, automobiles, or other road vehicles.
  - b. No OESS storage devices, HV components, or HV wiring shall be installed within the passenger or cab compartments.
2. Environment: All installations shall provide protection from damage from worst-case ambient conditions, including heavy wind-blown rains, and the Owner's vehicle wash facilities and wash materials.
3. Structure: Comply with the equipment load requirements as Specified.

### Service Life

The OESS energy storage devices shall have a minimum life of eight years, under the defined operating conditions.

### 12.6.2 Charging and Discharging

#### Voltage Range

Equipment shall operate over these voltage ranges without damage, failure of the equipment to function as Specified, or reduction of required service life.

1. Charging: When connected to an active OCS, the OESS shall operate over the OCS range Specified in Section 4 Design and Performance Criteria.

2. Discharging: When the OESS is providing power to the vehicle, the primary input source will be defined by the OESS design, but the operating voltages must be within the normal OCS range Specified in Section 4 Design and Performance Criteria.

#### *Charging*

Comply with the following:

1. The OESS shall charge as follows:
  - a. Connected to the OCS: always, including when both cabs are OFF.
  - b. In wireless segments: Whenever the vehicle is in regenerative braking.
2. The OESS shall be capable of being charged within a maximum of 10 minutes, without a reduction in service life, as follows:
  - a. Starting SoC: 80%
  - b. DOD: Vehicle completes a single trip on the defined wireless segments with defined operating conditions.
  - c. OESS charging: To 80% SoC, with all auxiliaries operating, any vehicle mode (stopped, accelerating, or decelerating), and connected to the OCS with a voltage range of 600 Vdc to 925 Vdc.
3. For SoC conditions greater than above and a moving vehicle, recharge times may be extended, as Approved.
4. For a stationary vehicle, automatically limit pantograph currents to protect the pantograph and OCS contact wire.

#### *Discharging*

The OESS shall discharge energy only to its local vehicle circuits. Provide equipment to automatically prevent OESS discharge to the OCS when the pantograph is raised, or to the Shop circuits via the Shop connector.

### 12.6.3 Controls and Indications

#### *Interlocks*

Provide a pantograph interlock function that allows off-wire operation only when the pantograph is in a fully stowed position.

Provide a bypass for this interlock, see Section 5 for additional requirements.

#### *Automatic Operation*

Provide automatic control to transition in and out of wireless segments, at speed, without operator intervention:

1. Communicate with the GPS and TWC systems at locations along the right-of-way that define the wireless segment(s).
2. Provide controls to automatically initiate and terminate off-wire operation, including lowering and raising of the pantograph, at speed.
3. Provide controls and interlocks to manage vehicle equipment loads and pantograph currents during on- and off-wire transitions, such that no equipment damage or loss of life occurs.
4. Coordinate with owner for preferred location of wayside TWC loops, and signal coding.

### 12.6.4 OESS isolation

Comply with the following:

1. Segregate OESS equipment and controls such that failures within one OESS unit can be isolated from, and not affect or prohibit operation of the remaining OESS units.



2. Upon isolating an OESS unit, at least one-half the total installed OESS capacity shall remain available, permitting continued operation with remaining OESS equipment at reduced performance and range.

#### 12.6.5 Emergency Disconnect Switch

Provide a switch on the exterior of the vehicle, at ground level, to disconnect all OESS units from vehicle circuits:

1. The switch may control remote circuit breakers, contactors, or similar devices. Rate all such devices to safely interrupt OESS currents and voltages.
2. Location of switch to be determined jointly with the Owner during design reviews.
3. May be integrated into the Vehicle Battery ground level disconnect, such that a single action disconnects both systems.

#### 12.6.6 Shop Disconnect Switch

Provide a manually operated two-pole switch at each OESS:

1. Disconnect all energy storage devices, including the Battery Management System, from vehicle circuits.
2. Disconnect both positive and negative OESS circuits from vehicle circuits.
3. The positive terminal shall break before the negative terminal.
4. Arrange the switch mechanisms such that the negative terminal cannot be opened without the positive terminal being open.
5. Include provision for tag ID and lock out.

#### 12.6.7 OESS Load Management Control

Provide an OESS load management control function to perform the following:

1. Interface with the propulsion and auxiliary loads.
2. SoC Low: Provide load shedding for non-essential loads, with low SoC as defined by the OESS manufacturer and Approved by the Owner. The SoC level setting for load shedding shall be user adjustable.
3. SoC Critically Low: Provide load shedding for all loads except those needed to move the vehicle, with critically low SoC as defined by the OESS manufacturer and Approved by the City.
4. Integrate with the propulsion system logic and the vehicle control unit.

#### 12.6.8 OESS Components

The OESS shall include the following:

1. Pantograph interlock: Such that high-voltage power draw is terminated, or reduced to safe levels, before the pantograph is lowered.
2. Bi-directional converter:
  - a. To charge the energy storage device and control energy storage power flow to the OCS, propulsion system and auxiliary loads.
  - b. May be integral to the propulsion inverter package.
  - c. May be packaged with and share components with the propulsion system.
  - d. Alternative converter designs may be proposed, subject to the Owner's review and approval.
3. Energy Storage Devices:
  - a. Batteries:

- i. Permitted: No maintenance, lithium-ion (Li-Ion) type, railway or transit quality, service proven in similar applications.
    - ii. Prohibited: Lithium-cobalt-oxide and lithium-sulfur-dioxide type.
  - b. Capacitors: High-current, high-capacity cells, of service proven railway or transit quality.
- 4. Storage Device Enclosure:
  - a. Type: Sealed, non-combustible enclosure, temperature-controlled with integral or external cooling system.
  - b. Fire Resistance: Designed and constructed to contain battery fire without failure of enclosure.
  - c. Material/Coatings: Selected to withstand spilled battery cell electrolytes.
  - d. Maintenance: Provide access to service the devices and cooling systems
  - e. Layout: The enclosure will have at least three compartments, one compartment will house the energy storage devices, one will store the electrical components and control, one will house the fuses.
  - f. Cooling Systems:
    - i. Liquid cooling: Use non-leaking quick disconnects to isolate the cooling system from the storage assembly.
    - ii. Air cooling: Use baffles and filters to exclude contamination. Filter shall not require replacement more frequently than 6 months. Loss of air flow shall be detected and announced to the MDS.
  - g. Prohibited: Circuit breakers shall not be installed in OESS battery compartment, or within assemblies that may enclose the OESS battery compartment, regardless of ventilation methods. Alternative circuit protection, within the OESS battery compartment maybe proposed for review and Approval by the City
  - h. Graphics: Provide clear indications of the presence of lethal high voltage; and instructions and warnings on opening the enclosure and breaking/making electrical and cooling connections.
- 5. Battery Management System:
  - a. Monitor individual cell states or parallel packaged cells
  - b. Apply charging regimes as appropriate for cell charge states, providing Specified performance and OESS life.
  - c. Provide cell balancing for series-connected cells.
  - d. Prevent damage to cells due to too high or low charge in specific cells.
  - e. Provide a state of charge for indication in the cab via the MDS.
  - f. Detect and announce failed cells, and cells with pending failures to the cab, and to MDS.
  - g. Provide remaining life expectancy calculations based on actual usage and duty to the MDS.
  - h. OESS power control switches: Provide high-voltage solid state switches for connecting OESS power to vehicle circuits. High voltage dc contactors may be employed for this function, subject to approval. See Emergency Disconnect Switch section, in this Section, above.
- 6. HSCB:
  - a. Function may be combined with the propulsion system HSCB.
  - b. If independent of the propulsion system HSCB, install in the high-voltage connection to the energy storage system.
  - c. Automatic reset logic: Coordinate with the primary HSCB to maximize vehicle availability and enhance performance and operation capabilities.

7. Circuit protection:
  - a. Provide internal high-voltage fuses in the positive and negative circuits for each OESS. Arrange circuitry such that fuses can be replaced safely by opening the OESS Shop Disconnect Switch. Alternative protection arrangements maybe proposed for review and Approval by the City.
  - b. Install in series with both the positive and negative terminals of the energy storage device.
8. Ground fault detection circuits:
  - a. To monitor the OESS for ground faults, including between energy storage cells.
  - b. Upon detection of a fault, open OESS power control switch, as defined above.
9. Cabling and connectors:
  - a. Provide keyed connectors for all external connections into the OESS storage device enclosure.
  - b. Connector and keying design shall not permit cross-polarity connection of OESS power cables.
10. Temperature controls and forced ventilation equipment:
  - a. To control the energy storage device cell temperature.
  - b. To keep the cells at optimum temperature for capacity and long life.
11. Fire alarm system:
  - a. Provide an independent Fire alarm system, for heat and smoke detection.
  - b. Trip the OESS circuit breaker upon detection of excessive heat or smoke and announce to the MDS.
  - c. Vehicle system(s) will notify City staff via Wi-Fi or cellular link, defined during design review.
  - d. Temperature setting as recommended by the OESS manufacturer.

## 12.7 AC Auxiliary Power Supply (APS)

### 12.7.1 General

Provide a source of three-phase ac and single-phase ac power for ac auxiliary loads identified in the TS.

1. Provide one or two independent auxiliary inverters, powered from the high-voltage dc power system, supplying power to the ac auxiliary loads.
2. Each inverter will supply the loads for either the complete vehicle or in its respective vehicle half (see Failure Management section, below).

### 12.7.2 Voltage and Frequency

The three-phase ac source voltage 480 Vac, 60 Hz. The single-phase ac source voltage will be 120 Vac, 60 Hz. Three-phase 208 Vac maybe proposed for review and Approval by the City.

### 12.7.3 Auxiliary Inverters

Comply with the following:

1. The auxiliary inverters will start automatically and operate at full performance when the steady-state input voltage is within the supply normal voltage range as Specified.
2. The inverters may shut down when the steady-state input voltage is less than or greater than the range Specified.
3. The output of the inverters will be galvanically isolated from the high-voltage dc power system.
4. The inverters will be sized for the worst-case continuous operation of all loads, and the maximum peak individual load with all other steady-state loads applied, plus 10% additional capacity. If forced ventilation is provided, it will be maintenance free.

5. The inverters will produce the output voltages Specified above, with the three-phase output in compliance with the following requirements:

Output frequency tolerance:	plus, or minus 2%
Distortion under nominal load:	less than 10%
Maximum dv/dt of the output voltage:	less than 10 V/μsec
Maximum allowable phase current imbalance:	less than 10%

#### 12.7.4 Inverter Controls

The controls for the auxiliary inverters will prevent damage to connected equipment and the inverter itself, resulting from the following:

1. High and low frequency
2. Over- and under-voltage
3. Out-of-tolerance voltage-to-frequency ratio
4. Frequent repetitive starts (manufacturer defined limits)
5. Rapid variations and transients in line voltage or loads.
6. High-voltage dc power interruptions
7. Excessive harmonic distortion
8. Phase loss

The control logic will permit the equipment to automatically restart after shutdowns caused by self-correcting failure conditions. Major faults will latch the equipment off until reset by maintenance personnel.

#### 12.7.5 Auxiliary Inverter Fault Monitoring

Provide a fault monitoring system to automatically detect auxiliary inverter status and transmit the information to the TOD in the operator's cab via the vehicle network.

#### 12.7.6 Failure Management

Loss of a single auxiliary inverter will not result in loss of propulsion, brakes, or other functions critical for vehicle operation:

1. Vehicle equipped with two auxiliary inverters:
  - a. Include provisions to transfer ac power for essential loads to the second or a back-up inverter in the event of an inoperable inverter.
  - b. As a minimum, a vehicle with a failed inverter must be able to operate over the whole alignment without speed restriction on its own power from the remaining inverter with all safety and vehicle operation related functions operational, including maintaining power to the following:
2. Circuits for propulsion cooling, and other ac loads required by the propulsion system.
3. Critical friction brake loads, where permitted to be powered by ac.
  - a. The ratings of each inverter will include these redundancy transfer loads in addition to its normal loads.
  - b. The transfer mechanism may be via three-phase transfer breakers, or other City-Approved methods.
4. Vehicle equipped with one auxiliary inverter:
  - a. The critical loads, including propulsion cooling, will be operated from the vehicle's low-voltage dc power system.

- b. A vehicle with a failed inverter must be able to operate over the whole alignment without performance restriction.
- c. Motors used in critical components will be brushless dc motors.

## 12.8 Low-Voltage DC Power System

### 12.8.1 General

Provide a nominal 24 Vdc low-voltage dc power system including low-voltage power supplies, battery charger, and vehicle battery for Specified vehicle loads.

### 12.8.2 Voltage

Comply with IEC 60571, except as may be Specified elsewhere.

### 12.8.3 Low-Voltage Power Supply

Comply with the following:

1. IEC 60571 for a nominal 24 Vdc system, except as may be Specified elsewhere.
2. Provide one or two independent regulated low-voltage dc power supplies (LVPS) for each vehicle, each with separate, independently controlled outputs for battery charging.
3. Battery charging will be controlled independently of the other dc load outputs. The LVPS and battery charging will be activated automatically when OCS voltage is present and when connected to shop power.
4. Designs that include the LVPS as part of the auxiliary inverter will be acceptable. If combined, operation or failure of the LVPS will not affect operation of the auxiliary inverter.
5. The LVPS output will have complete galvanic isolation from the high-voltage dc power system.
6. The LVPS will have the following capacity:
  - a. Each LVPS or LVPS output channel will have sufficient capacity to maintain terminal voltage at the regulated value while simultaneously charging a dead battery and providing adequate power to all vehicle low-voltage dc loads, for all body sections, with the assumption that the other LVPS or output channel is not functioning.
  - b. If necessary, the LVPS may limit its peak current during track brake applications, allowing the battery to supplement the loads.
  - c. Each LVPS will have 20% reserve capacity for optional and future loads.
7. The LVPS will have the following capabilities:
  - d. Transfer of loads to one LVPS with the loss of the other LVPS will be automatic, and not require any action by the user. The transfer of loads will include battery charging. When the failed LVPS resumes operation, the load transfer control will detect this and automatically restore operation and load distribution between the two LVPS units.
  - e. The LVPS will automatically start when high-voltage dc power is applied. Battery power will not be required as a prerequisite to starting, or for closing circuit breakers or contactors needed to permit LVPS operation.
  - f. If forced ventilation is provided, it will be maintenance free.

### 12.8.4 Battery Charger

Float-charge the battery via the dedicated battery charging circuit that is part of the LVPS:

1. Charging algorithm to be optimized for battery type.
2. The charger will include a current-limiting feature that ensures the battery manufacturer's recommended charging current level is not exceeded.
3. The battery charging voltage will be optimized for the battery selected by the Contractor, per the battery manufacturer's recommendations. The charging voltage will be adjustable by the user via

software to allow alternative battery vendors. The adjustment may be restricted such that only authorized personnel can adjust.

4. Adjust charging voltages and currents automatically for battery temperature via a temperature sensor in the battery compartment.
5. Battery charging will be provided and managed by one LVPS. If more than one LVPS is provided, include provisions to transfer battery charging between LVPSs in the event of LVPS/battery charging failure. The transfer circuit will be automatic, or via a dedicated manual circuit.

#### 12.8.5 Vehicle Battery

##### *Battery*

Provide a vehicle battery to power emergency loads in the event of failure of the low-voltage power supplies:

1. Type: Low-maintenance 19 or 20 cell NiCd, or as Approved by the City.
2. Quality: Service-proven railway or transit quality.
3. Capacity: Sufficient to power emergency loads for the durations Specified below.
4. Charging: From the LVPS battery charging output.
5. Charging voltage: Set as recommend by the battery manufacturer.
6. Installation: Battery and associated circuitry will comply with NFPA 130.

##### *Battery Enclosure*

Provide a ventilated battery enclosure on the roof or under the vehicle and outside the passenger compartment:

1. General:
  - a. Size: Large enough to accommodate batteries from at least two independent suppliers.
  - b. Integral Tray: Provide for capture of spilled electrolyte.
  - c. Paint: If battery enclosure components are painted, they will be impervious to electrolyte.
2. Roof:
  - a. Enclosure Covers:
    3. Hinged, large enough to permit battery removal and inspection.
    4. With features that prevent cover or hinge damage from over-rotation.
      - a. Enclosure Structural Strength: Sufficient to withstand a 275 lb. man walking on the covers without permanent deformation or contact with underlying circuits.
5. Under Vehicle: Provide roll-out tray to hold the batteries:
  - a. Material: Stainless steel.
  - b. Support: Ball bearings.
  - c. Extension Depth: Sufficient to permit battery to be fully extended such that all cells may be inspected and filled.

##### *Battery Circuit Breaker*

Provide a circuit breaker for battery and battery-circuit protection:

1. Type: Two-pole dc breaker. Parallel circuit breakers are not permitted.
2. Rating: Sufficient to withstand the short circuit capacity of the battery.
3. Connection: To the B+ and B- leads from the battery terminals.
4. Vehicle battery disconnect: Include provision to trip the breaker from the side of the vehicle, by persons standing on the ground.

**Battery Heat Detection and Emergency Cutoff**

Provide an independent heat detection system:

1. The system will trip the battery circuit breaker upon detection of excessive heat.
2. The temperature setting will be as recommended by the battery manufacturer.
3. Provide an accessible emergency battery-cutoff above platform height on the side of the vehicle, per NFPA 130.

**12.8.6 Battery Load Control**

Provide automatic controls to prevent discharge of the vehicle battery by parasitic loads when the MC key is switched to Off, and the battery is not being charged. Allow operation of passenger area lights until the Delayed Off timer expires, if the vehicle loses battery charging after the Hotel Load timer is triggered.

**12.8.7 Emergency Power**

The vehicle battery will power emergency loads upon the loss of LVPS units or outputs:

1. Capacity:
  - a. Vehicle stationary: All emergency load for 90 minutes
  - b. Vehicle moving: Sufficient to supply all the loads at the duty cycles shown in the table below.
2. Voltage: All indicated loads and systems will have sufficient input voltage to operate for the Specified duration.

Emergency Load	Operation	Duration (minutes)
Emergency Lighting	Continuous	45
Communications	Continuous	45
Door Control	Cycle doors open for 20 seconds every 5 minutes	45
Propulsion Control	Continuous	45
Braking power and control, including pumps if dc operated	Continuous	45
Operator's console indicators and interlocks	Continuous	45
Horn and bell	On for 10 seconds every 2 minutes	45
Track brakes	On for 10 seconds at end of each 15-minute period	45
Pantograph Control	Raise and lower twice	45
Headlights, tail and stop lights	Continuous	45
Windshield wiper	Continuous	45
Passenger Information System	Normal station announcements	45

**12.8.8 Failures and Fault Indications**

Include circuitry in the low-voltage dc power system to detect LVPS and battery charging failures:

1. The circuit will transmit fault indications to the TOD in the operator's cab via the vehicle's network.



## 12.9 Vehicle-to-Truck Wiring

For each wiring system on a truck, provide flexible cable connecting the vehicle and truck, with waterproof quick disconnect cable connectors as Specified, to facilitate removal of trucks:

1. Route cable to accommodate all truck motions without interference or excess strain.
2. Provide cable with strain relief on both the vehicle end and the truck end.
3. Flexible cable construction will be selected for 30-year life under repeated flexing caused by truck motions.
4. Waterproof quick disconnect connectors will be selected for the shock and vibration environment.
5. Cabling to connectors on the truck side will be restrained to prevent fatigue and chafing to the wiring or connectors.
6. Wire lengths, supports, and dress will minimize strain at termination and support points under worst-case truck motions.

## 12.10 Line Filters

### 12.10.1 General

Provide devices to perform the following filtering functions:

1. Protect vehicle equipment from line transients.
2. Filter ac voltage and currents impressed on the line by the propulsion system and all other systems fed by dc line voltage.
3. Suppress high-frequency voltage transients caused by converter or inverter switching operations.

### 12.10.2 Performance

Comply with the following:

1. Filters will suppress all frequencies to the levels Specified in Section 4 Design and Performance Criteria, under normal and abnormal equipment operation, at any location along the City tracks:
  - a. Prove through reliable simulations that the vehicle complies with these requirements for any allowable line voltage and any combination of active and inactive substations.
  - b. If the simulations are inconclusive, or cannot be performed to the full extent, include an EMI frequency monitor for all critical frequencies used by the City.
2. The resonant frequency of each filter will be less than 40 Hz and will be inductive above 50 Hz.

### 12.10.3 Self-Test

Provide a line-filter self-test feature that operates during the power-up or power-down sequence:

1. If the tested capacitance value is outside of the allowed tolerance band, a failure message will be sent to the MDS.
2. The detection of a failure will not immobilize the vehicle, but upon detection of a failure, the power draw of the inverter with the defective filter will be reduced by 50% until the defective condition is corrected.

### 12.10.4 Configuration

Line filters may be configured as follows:

1. As individual elements of various systems that are fed by high-voltage dc power; or
2. Combined, with the following limitations:
  - a. If APS/LVPS is integral to propulsion inverter, they can share the input filters.
  - b. Only line inductors may be shared; capacitor banks may not be shared.



- c. If line inductors are shared, system isolation switches or contactors will be supplied to permit independent operation of each supplied system.

### 12.10.5 Components

#### *Line Inductors*

Comply with the following:

1. Thermal rating: Sufficient for maximum power dissipation under worst case conditions defined in Section 4 Design and Performance Criteria.
2. Forced ventilation cooling: Allowed only if part of the inverter cooling. Standalone inductors will be convection cooled.
3. Insulation and construction: Designed for the indicated service life in the Specified environment.
4. Physical protection:
  - a. Full enclosure; or
  - b. Protected from physical damage by screens.
5. Electrical connections: Environmentally sealed.
6. Standards:
  - a. Construction and testing: Comply with IEC 60310
  - b. Shock and vibration: Comply with IEC 61373, or another Approved standard.
7. Service life: 30 years.

#### *Filter Capacitors*

Comply with the following:

1. Capacitor life: Minimum 20 years, as used in this application.
2. Prohibited types: Electrolytic capacitors.
3. Location: Install in the same enclosure as the system's power components.
4. Bleeder resistor: Permanently connect across the terminals of each capacitor in the capacitor bank:
  - a. Resistance: Select value to reduce voltage at the terminals of the capacitor bank to maximum 50 V within 3 minutes after high-voltage dc is removed from the bank.
  - b. Traction inverter: Use the brake resistor to discharge the input filter capacitors when inverter is shut down.
5. Signage: Provide a permanent sign to warn maintenance personnel:
  - a. Warning language: Lower the pantograph, wait 5 minutes, manually bleed, then short circuit the capacitor before commencing work.
  - b. Sign location: Adjacent to the capacitors, visible when the door to the enclosure that houses the capacitor bank assembly is open.

### 12.11 Panelboards and Control Panels

Comply with the following:

1. Panelboards, control panels, circuit breakers, and related devices will be rail industry proven.
2. Panelboards: Conform to NFPA 70 Article 408, Switchboards, Switchgear, and Panelboards, except as specifically Specified otherwise or as Approved by the City.
3. Control panels: Conform to NFPA 70 Article 409, Industrial Control Panels, except as specifically Specified otherwise or as Approved by the City.
4. Dead fronts: Moisture-proof, electrically insulating, laminated phenolic; or grounded metal.

5. Power distribution to circuit breakers and switches will be from a bus bar or bus circuit. Distributing power by successive or daisy-chained connections between device terminals is prohibited.
6. Provide minimum 10% spare capacity in each distribution panel but not less than one space for future circuit breakers for each voltage class, except provide minimum eight spaces for low-voltage dc in each of the vehicle's A- and B-sections. Provide covers for unused spaces.
7. Provide a nameplate for each breaker, switch, and indicating light:
  - a. Lettering: Raised or recessed
  - b. Required information:
    8. Circuit designation
    9. Operating voltage
10. Instructions such as "Do Not Operate Under Load" as appropriate.
  - a. Location: On the dead front

## 12.12 Fuses and Circuit Breakers

### 12.12.1 General

Fuses may be used only where specifically required or allowed in the TS, and where applicable circuit breakers are not commercially available. Fuse assemblies are subject to City approval.

Each circuit breaker and fuse will have a permanent label installed adjacent to the device.

### 12.12.2 Fuses and Fuse Holders

Comply with the following:

1. High-voltage dc fuses: High speed, with minimum rating of 2000 Vdc:
2. Provide totally enclosed fuse holders with no exposed high-voltage connections. When the fuse holder is opened, the fuse will be extracted from the circuit and the exposed fuse safely isolated from any circuit connection.
3. Mount on the vehicle roof.

### 12.12.3 AC and Low-Voltage DC Circuit Breakers

Comply with the following:

1. Circuit breakers will be rugged, fully suitable for the service intended, and of the highest quality procurable. Comply with the following:
2. Circuit breakers of the same rating will be of the same manufacture and model throughout the vehicle.
3. A circuit breaker operated continuously at its full rating must be listed for operation at 100% of its rating by a nationally recognized testing laboratory, such as UL, and the breaker must be housed in the same enclosure used to establish the listing. A continuous load is a load where the maximum current is expected to continue for three hours or more.
4. Type: Molded case, DIN-rail mounted whenever possible.
5. Standards:
  - a. Primary protection: Conform to UL 489; IEC 60947-2 may be proposed for approval by the City.
  - b. Supplementary protection: Conform to UL 1077.
6. Circuit breaker terminals will not be used as junction points.

#### 12.12.4 Circuit Breaker Prohibited Locations

Circuit breakers will not be installed in the following locations, regardless of ventilation methods:

1. Within any location or arrangement that would permit accumulation of explosive gases near the breaker.
2. Within the vehicle battery enclosures.
3. Within assemblies that may enclose the vehicle battery enclosures.

#### 12.13 Contactors and Relays

##### 12.13.1 General

Comply with the following general requirements for both contactors and relays:

1. Document successful history of operation in rail transit control applications.
2. Mount and orient as recommended by the supplier.
3. Identify with the appropriate circuit designation. The label will not be obscured by wiring or other equipment and will not be mounted on relay covers, arc chutes, or other removable items.
4. Terminate maximum two wires on a terminal.
5. Contacts:
  - a. Current rating:
    6. Based on continuous, inrush, or interrupting requirements, whichever is worse, and then derated by at least a factor of four.
    7. Based on the worst condition of reduced surface contact which may result from tip misalignment during normal operation of the device.
  - a. Material:
    8. Selected for the actual loads, and not solely on the device rating.
    9. Silver bifurcated contacts for low-level circuits and gold-alloy bifurcated-crossbar contacts for dry circuits.
      - a. Series connected: will not be operated in circuits where the voltages and currents exceed the single derated contact ratings.
      - b. Parallel connected: Not permitted.
10. Coils:
  - a. Will operate within the voltage range Specified in IEC 60571.
  - b. Will have MOV suppression except where performance may be affected.
  - c. Unsuppressed coils are permitted only with the explicit approval of the City.

##### Contactors

Comply with the following additional requirements for contactors:

1. Provide with arc-blowout coils.
2. Guaranteed mechanical service life: Minimum 1 million switching operations, except as Approved where infrequent operation is expected.

##### Relays

Comply with the following additional requirements for relays:

1. Guaranteed mechanical service life: Minimum 5 million switching operations.
2. Contact rated electrical life: Minimum 500,000 operations, or 10 years, whichever is greater.
3. Time delay relays: solid-state type.
4. Plug-in relays: Provide with a retainer that is captive to the relay socket. The retainer will be arranged such that, when released, contact cannot be made with energized adjacent circuitry.

## 12.14 Switches

### 12.14.1 High-Voltage DC Switches

High-voltage dc switches capable of manual operation are prohibited, except for the Shop switch.

High-voltage dc circuits will be manually interrupted only as follows:

1. By activating the respective circuit breaker.
2. By activating a low-voltage switch that subsequently controls a high-voltage contactor.

### 12.14.2 Low-Voltage Switches

Comply with the following:

1. Type: Industrial grade rated at least IP65 in conformance with IEC 60529.
2. Use prohibited: Switches will not directly control highly inductive or high inrush loads.
3. Contacts:
  - a. Rating: Within manufacturer's recommendations for voltage and current, with current derated by at least a factor of four
  - b. Type: Silver, double break
  - c. Mechanism: Uses a wiping motion when contacts make or break
  - d. Series connected: will not be operated in circuits where the voltages and currents exceed the single derated contact ratings.
  - e. Parallel connected: Not permitted.
4. Switch bodies: Keyed to prevent rotation.
5. Mounting hardware: Metal, including the body portion extending through the panel.
6. Connections: Maximum two wires to each switch terminal.

## 12.15 Low-Voltage DC-DC Power Supplies

Comply with the following:

1. DC power supplies will be high efficiency, industrial grade, switching supplies providing rated voltage and power over the full range of LVPS and battery voltage Specified elsewhere.
2. Comply with IEC 61287.
3. Power supplies will be commercially available units from established power supply manufacturers, except where designed and integrated into specific systems.
4. Each power supply will have the following protective features:
  - a. Galvanic Input-to-output isolation of 1500 Vdc
  - b. Short-circuit-proof output
  - c. Automatic output current limiting
  - d. Input and output overvoltage protection
5. Power supplies will be powered from the vehicle's LVPS, with a dedicated circuit breaker for each in accordance with the requirements in this section.

## 12.16 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics

4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

12-1 One-Line Power Distribution Diagrams:

1. Include diagrams for each voltage level.
2. The diagrams will show loads, return current paths, protection, and grounds.

12-2 AC and DC Load Calculations:

1. Submit CDRL 12-1 before or at the same time as CDRL 12-2.
2. Include ac and dc load calculations in both normal and emergency (battery) modes.
3. Emergency loads will include the emergency loads Specified in this Section.
4. List the power for each load, assumptions used, and derating of loads, if any. Include wire sizes and breaker ratings.
5. Include calculations showing loads that must be supplied during loss of a single auxiliary inverter. Furnish a narrative and schematics, as necessary, to demonstrate the ability of the system to power necessary loads.

12-3 Safety Grounding Design Package:

1. Furnish sufficient information to show the complete grounding scheme.
2. Data sheets for ground conductors and ground connections.
3. Ground path impedance for all ground paths.
4. Shop drawings showing routing of ground conductors.
5. Assembly drawings.

12-4 Ground Brush Design Package:

1. Description of the ground brushes
2. Calculations showing rms and peak current.
3. Data sheets showing ratings of hardware.
4. Hardware drawings
5. Assembly drawings showing ground brush arrangements and ground connections.
6. Circuit diagram for both high-voltage dc current return and safety grounding showing physical current path.
7. Impedance calculation for high-voltage ground wires between ground brushes and corresponding insulated ground pad

12-5 Ground Fault Detection and Protection Design Package:

1. Data sheets for hardware used.
2. Sensitivity levels of each detection scheme
3. Assembly drawings
4. Wiring diagrams

12-6 Primary Power System Design Package:

1. High speed circuit breaker: Data sheets
2. Primary voltage fuses: Data sheets for fuses and associated components.
3. Surge arrester:
  - a. Data sheets
  - b. Rating selection design analysis

12-7 Pantograph Design Package:

1. Submit the pantograph dynamic envelope as a dedicated section in the design package.
2. Furnish sufficient information to verify that the pantograph does not lose contact with the OCS under normal and abnormal operating conditions identified in these TS.
3. Include the following:
  - a. Data to support ratings of components
  - b. Data sheets on each component
  - c. Parts lists
  - d. Electrical drawings
  - e. Assembly drawings

12-8 Shop Power Design Package:

1. Load calculations to support the ratings of the components, if not already submitted previously ("AC and DC Load Calculations")
2. Transfer switch design documentation
3. Data sheets on each major component, including but not limited to receptacle, receptacle enclosure, mating plug, and components used for interlocking.
4. Electrical wiring diagrams and schematics for both power and control wiring showing functionality and interlocking.

12-9 OESS Design Package

1. Narrative on the overall OESS, including a brief description of each Specified component and how it is implemented, with sufficient detail to demonstrate that all Specified requirements are satisfied.
2. Details of interfaces with propulsion and braking systems
3. Data sheets on Specified components, including part numbers and ratings.
4. Description of how the equipment operates under extreme conditions and faults.
5. Description of how OESS capacities vary between new, and near end of life.
6. Recommended minimum SoC, including justification for the recommendation.
7. Description and data on reduced vehicle performance characteristics, including tractive effort vs speed vs dc link voltage over the range of OESS voltages.
8. Description and data on HVAC reduced performance modes and anticipated interior temperatures.
9. Description of replacing storage elements at end of life. System replacement at end of life.
10. Software descriptions

11. Design description for raising and lowering the pantograph before and after operation on wireless segments.
12. Description of OESS charging strategy.
13. Description of the methods used to validate and confirm the performance of the proposed OESS.
14. Description of prior deployments or bench/road test history with the proposed system. Include the following as a minimum:
  - a. Evaluation of ability to meet duty cycle.
  - b. Vehicle efficiency
  - c. Battery state of charge
  - d. Vehicle acceleration
  - e. Length and slope of alignment grades
15. Drawings:
  - a. Electrical schematics
  - b. Assembly drawings
  - c. Plan view and cross section drawings of energy storage device and enclosure.
16. Calculations:
  - a. Load analysis, including peak and rms current at ambient temperatures of -10 degrees C (14 degrees F), 25 degrees C (77 degrees F), 40 degrees C (104 degrees F), and 50 degrees C (122 degrees F) while powering the vehicle on the alignment duty cycle.
  - b. Battery state of charge profile while completing the route alignment at AW0, AW1, AW2, and AW3.
  - c. Worst case maximum charging rates while dwelling in stations or other points where the vehicle is stopped, and while in motion. Submit in a timely manner to allow for coordination with OCS design.
17. Dynamic simulations of the vehicle operating on the indicated alignment:
  - a. Provide speed, time, distance, total vehicle power demands, OESS charge and discharge rates, and OESS charge states and voltage levels.
  - b. Assume worse case ambient conditions, and the end-of-life OESS characteristics if worse than new.
  - c. Use 1 second or less simulation time steps.

**12-10 OESS Thermal Capacity Calculations:**

1. Submit with Thermal Capacity Calculations under Section 2, Design and Performance Criteria.
2. Temperature predictions (or actual test results) for OESS energy storage device.

**12-11 AC Auxiliary Power Supply (APS) Design Package:**

1. Functional description: Justify selected configuration and confirm compliance with requirements of this Section.
2. Load study
3. Data indicating how the equipment operates under extreme conditions and faults.
4. Assembly drawings

**12-12 Failure Management Design Package:**

1. List of critical safety and vehicle operation loads required during failure of an auxiliary inverter to maintain vehicle operation.
2. Data sheets on transfer mechanism, if applicable

12-13 Low-Voltage DC Power System Design Package:

1. Low-voltage power supply:
  - a. Data sheets
  - b. Capacity calculations showing ability to carry normal and transfer loads.
2. Battery charging:
  - a. Single LVPS (if proposed): Switch-over circuit functional description, data sheets for hardware, and electrical schematics.
3. Vehicle battery:
  - a. Battery description and specification
  - b. Recommended charging processes
  - c. Battery circuit breaker, including breaker data sheet, enclosure data sheet, location of enclosure, and electrical schematic.
  - d. Load calculations and assumptions
  - e. Mounting location
  - f. Ventilation design
  - g. Battery heat detection system, including component data sheets, electrical schematic, and locations of components.
  - h. Battery cut-out switch, including data sheet and location, if required by battery circuit breaker configuration
4. Battery Drive System
  - a. Calculations

12-14 Line Filters

The following may be submitted as part of the CDRL for the respective system, if required elsewhere in the Contract Documents.

1. For each system filter:
  - a. Frequency characteristics
  - b. Component types, values, manufacturer
  - c. Calculations demonstrating life expectancies.
  - d. Installation details, if not included within system enclosure
  - e. Filter degradation monitoring methods
2. Simulation results with sufficient information to demonstrate compliance with the TS.
3. EMI frequency monitor details if simulation does not demonstrate compliance with TS.
4. Line filters not included with other system submittals:
  - a. Data sheets showing ratings of hardware.
  - b. Functional description: Include failure detection.



- 1                   c. Wiring diagrams
- 2 12-15 Electrical Panels, Components, and Devices Design Package:
- 3       1. Manufacturer’s data: Include certification of compliance to Specified standards or sufficient data
- 4       to confirm compliance.
- 5       2. Location and application of each product submitted.

## Section 13 Propulsion System

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**13.1 General**

**13.1.1 Scope**

Provide traction inverters, traction motors, drive gear units, sensors, control logic, friction brake blending logic, wheel spin/slide correction, protection devices, and all accessories necessary to meet the Specified requirements of propulsion and dynamic braking.

**13.1.2 System Configuration**

Comply with the following configuration requirements:

1. Configure each propulsion system to function independently, regardless of the condition of other propulsion systems.
2. Sharing of components between propulsion systems will be minimized, and only as Approved.
3. Provide either one inverter per powered truck or one inverter for each motor.
4. Power collection and primary protection equipment may be shared between the two truck control systems.

**13.1.3 Propulsion Control Signals**

See Section 7 Electronic Controls, Software, and MDS, for propulsion system control signal requirements.

**13.1.4 Inverter Drive Technology**

Comply with the following:

1. Propulsion and dynamic braking: Use state of the art IGBT (insulated-gate, bipolar-transistor) inverters.
2. Brake chopper: Use a high-side IGBT switching device and a freewheeling diode across the brake resistor.
3. Drive control system: Use a modern vector control system, with sufficient accuracy to produce stable operation at any speed down to standstill, including the ability to maintain the vehicle stationary on a grade.

**13.1.5 Drive Configuration**

Comply with the following:

1. Powered trucks: Each motor will drive one axle or one wheel.
2. Drive configuration:
  - a. Proven in similar service.
  - b. Minimizes unsprung weight on the drive axles or wheels.

**13.1.6 Interchangeability**

Propulsion system components will be identical and interchangeable between trucks and all vehicles.

**13.1.7 Circuit Protection**

Refer to Section 9, Electrical Equipment.

**13.2 Equipment Thermal Capacities**

The thermal capacity of the propulsion equipment will be based on either the normal duty cycle or the abnormal duty Specified, whichever is worse.

### 13.3 Equipment Temperature Management

Comply with the following:

1. Provide equipment cooling on a per-truck basis such that continued operation is possible via the remaining propulsion system, at proportionally reduced performance, in the event of cooling system failure.
2. Comply with equipment temperature requirements in Section 12 Electrical Equipment.

### 13.4 Transients and EMI

#### 13.4.1 Switching Line Transients

Comply with the following requirements:

1. Suppress switching line transients normally generated by the propulsion system such that the instantaneous voltage complies with IEC 60850 or EN 50163.
2. Vehicle-borne equipment will withstand vehicle and wayside generated transients without damage or reduction in life.

#### 13.4.2 Electromagnetic Interference

Comply with the following:

1. The propulsion system will not exceed electromagnetic interference (EMI) limits, as Specified, in any mode, including regenerative braking and abnormal operating conditions. See Fault Detection section below, and Section 12 Electrical Equipment for line-filter monitoring.
2. The propulsion system will operate successfully in an environment of high ambient electrical noise, whether self-generated, generated by other vehicle systems, or generated off-vehicle.

### 13.5 Performance Requirements

Comply with the requirements Specified in Section 4 Design and Performance Criteria.

### 13.6 Propulsion System Functions

#### 13.6.1 Load Compensation

Comply with the following:

1. Normal Operation: The propulsion control system will adjust tractive and braking efforts to compensate for varying passenger loads as Specified.
2. Failure Mode: In the event of a failed load compensation signal, the system will default to the load value of the nearest healthy truck and notify the operator through the MDS.

#### 13.6.2 Braking

##### *Friction Brake Control*

The propulsion control system will interface directly with the friction brake controls to optimize blending, slide control, and failure management.

##### *Dynamic Braking*

Comply with the following:

1. Type: Combined regenerative and rheostatic braking.
2. Operating range: Continuously available from vehicle design speed down to a vehicle speed of 5 km/h (3 mph) or less.
3. Zero speed: Friction brakes will be fully blended in to ensure a secure zero speed detection.
4. For brake initializations below 5 km/h, the dynamic brake will be disabled.

5. The dynamic brake control system will perform the following:
  - a. Continuously monitor line voltage.
  - b. Supply to the line the maximum amount of energy possible within the line-voltage limits prescribed in Section 2.
  - c. Divert to the braking resistors only that generated energy more than the energy accepted by the line.
6. No line voltage: Once initiated, dynamic braking will be available independent of the presence of line voltage.
7. Friction brake coordination: Provide a per-truck dynamic brake effort signal to the friction brake system, indicating achieved dynamic brake effort. Coordinate signal characteristics and values with the friction brake supplier.
8. Regenerative braking:
  - a. Maximum OCS voltage: Per IEC 60850, Table 1, Nominal voltages and their permissible limits in values and duration.
  - b. Possible to cut out by PTU for test purposes.

### 13.6.3 Fault Detection

#### *General*

Provide a comprehensive fault detection and health monitoring system, on a per-inverter basis:

1. The system will detect and report the following:
  - a. Actual and pending equipment failures.
  - b. Out-of-range voltages or signals
  - c. Loss or reduction of requested efforts or performance; and similar problems
2. Record detected faults in local fault logs, and report to the MDS and TOD.
3. System health monitoring will identify the potential for excess EMI. See also Section 9, Electrical Equipment, Line Filters section.

#### *Dynamic Brake Fault*

Comply with the following:

1. Design of dynamic brake failure detection and associated interface circuits:
  - a. Conform to the general safety design requirements Specified in Section 2, Design and Performance Criteria.
  - b. Minimize nuisance fault annunciations due to transient events, including momentary loss of primary power when braking is initiated.
2. Performance: When failures in dynamic braking are detected, the system will perform the following:
  - a. All residual dynamic brake effort will be disabled.
  - b. The dynamic brake signal to friction brake will be clamped to zero.
  - c. A dynamic brake fault will be indicated for that truck.

#### *Fault Annunciation*

Provide visual annunciation in the cab for all propulsion system faults, including but not limited to the following:

1. Cut-out
2. Dynamic brake failure
3. General faults
4. Ventilation failure

5. Overheating

6. Line voltage out of range

#### *Reduced Overspeed Set Point*

Propulsion system faults may impose a reduced overspeed set point, as appropriate (see Overspeed Protection section, below).

#### 13.6.4 Direction Change

The inverter control will perform as follows regarding direction change:

1. Respond to cab reverser switch direction control signals only when no-motion is detected, and tractive effort is zero.
2. Monitor correspondence between the control-line command and motor rotation, and if out-of-correspondence, apply friction brakes and flag a rollback condition.

#### 13.6.5 Rollback Prevention

The propulsion system will prevent vehicle motion in a direction opposite to that selected by the cab when a propulsion mode is selected. Additionally, the propulsion system will detect incorrect vehicle motion. See Section 4 Design and Performance Criteria for additional requirements.

#### 13.6.6 Cut-Out Control

Include provisions for each powered truck to be independently isolated from the propulsion control signals and the OCS supply:

1. With one truck cut out on a single vehicle, it will be possible to operate the vehicle in either direction over the whole alignment with no damaging effects.
2. If needed, a speed limit may be automatically applied when any truck is cut out (see Overspeed Protection, below).
3. All other systems will remain operational.

#### 13.6.7 Wheel Spin/Slide Detection and Correction

Provide a wheel spin/slide detection and correction system as an integral part of the propulsion control system:

1. It will meet the requirements of Section 4 Design and Performance Criteria.
2. Coordinate system with friction brake slide control.

#### 13.6.8 Overspeed Protection

The propulsion control system will include overspeed protection that limits vehicle speed to set values, up to but not exceeding maximum operating speed, by means of tractive effort and brake control. See the Speed Sensing Devices section, below.

1. Overspeed protection will function as follows:
  - a. As overspeed set point is approached: Limit propulsion effort as a function of speed.
  - b. At overspeed set point: Reduce tractive effort to zero.
  - c. At 3 km/h above overspeed set point:
2. Impose a MSB command.
3. The brake command will be resettable by moving the Master Controller to the MSB position at any speed below the overspeed set point.
4. Overspeed set point:
  - a. Initial: Set per values defined in Section 2, Design and Performance Criteria, Speed Requirements section.

- b. Changes: Setpoints will be adjustable by the City, up to and including the maximum operating speed in Section 2, Speed Requirements section.
5. Abnormal operating conditions: Overspeed set point and reset criteria may vary as deemed necessary to protect equipment in case propulsion or brake equipment is in failure mode or has been cut out, as Approved by the City.
6. Equipment protection: The propulsion system may impose a separate, non-user-adjustable, overspeed setting for equipment protection, set no lower than the vehicle design speed value in Section 4 Design and Performance Criteria.

#### 13.6.9 Adjustments for Wear

Adjustments will not be necessary to compensate for component wear, aging, and similar phenomena:

1. Provide compensation for a reference wheel diameter using software commands from Portable Test Units Specified.
2. Adjustments will be made in 1 mm (0.04 in) increments of wheel diameter, covering the full range between new and fully worn diameters.
3. Other required wheel size compensation will be automatic.
4. It will be possible to query actual wheel diameters for each axle/wheel on the TOD.

#### 13.6.10 Distance Signal

As required by system design, provide a distance signal with sufficient accuracy to the following systems Specified in Section 8 Communication Systems:

1. Automatic passenger information
2. Automatic passenger counting
3. Any other system as required.

### 13.7 System Components

#### 13.7.1 Traction Motors

AC traction motors will have the following basic design features:

1. Motor Type: Three-phase, squirrel cage induction motor, with welded or brazed copper cage and formed stator coils.
2. Duty: Thermally rated in accordance with the duty-cycle Specified in Section 2, Design and Performance Criteria.
3. Load Sharing: The motor characteristics will allow achievement of all performance requirements with wheel diameter differences of at least 0.6% for motors driven in parallel by the same inverter.
4. Motor Standard: IEC 60349.
5. Insulation:
  - a. Motor insulation: IEC 60085, Class 200 insulation system or better.
  - b. Motor stator coils: Vacuum pressure impregnated in the complete stator frame assembly.
6. Enclosure: Splash-proof or totally enclosed.
7. Mounting:
  - a. Each traction motor will be resiliently or rigidly mounted to the truck frame. Axle-hung motors are prohibited.
  - b. Unsprung mass of the motor-gear unit assembly will be kept to a minimum.
  - c. Provide safety straps, tabs, or hangers as required to retain the motor or gear in the event of mount failure.



8. Shaft Coupling:

- a. Provide a maintenance-free coupling arrangement between traction motor and gear-unit shafts.
- b. The coupling design and motor-gear unit mounting arrangement will be considered acceptable if no maintenance is required and coupling life exceeds drivetrain overhaul period.

9. Motor Design Speed:

- a. Equal to the vehicle design speed indicated in Section 2, at fully worn wheels.
- b. Based on the motor design speed, test the traction motor to the over-speed defined in IEC 60349-2.

10. Bearings:

- a. Type: Grease lubricated, NFL, antifriction bearings:

11. Grease cavities: Large enough to hold a five-year supply of lubricant.

12. Configurations are acceptable that use gear lubricant for the traction motor bearing at the pinion end.

- a. ABMA L10 rating life: Equivalent to 1,600,000 km (994,200 mi) of service, or greater.
- b. Inspection or service: None required except periodic lubrication.
- c. Prevent induced shaft currents and electrostatic discharges resulting from inverter switching pulses from damaging motor bearings as follows:

13. Provide insulated bearings, shaft grounding brushes, microfiber-type shaft grounding rings, or a combination of these measures.

14. Demonstrate that the proposed solution has been used successfully for a minimum of five years in a similar transit environment.

15. Motor and Rotor Balance:

- a. Motors will be dynamically balanced to meet the requirements of IEC 60349-2.
- b. Balancing will be accomplished by using metal weights, welded in place; or by drilling the rotor core.

16. Vibration: Meet the requirements of IEC 60349-2.

17. Noise: Motor will be free of objectionable windage and mechanical noises at all vehicle speeds and under all load conditions.

18. Markings: Terminals, leads, and motor frames will be clearly marked for positive identification.

19. Traction Motor Wiring and Electrical Connections:

- a. Cabling will minimize EMI:

20. As a minimum, provide a ground wire connecting inverter ground to traction motor ground, bundled with the three-phase cables.

21. There will be no other ground connection of this cable between inverter and traction motor.

- a. Size cables in accordance with NFPA 130, Section 8.6.3, Propulsion Motors.
- b. Connectors to motor leads and related hardware:

22. Quick-disconnect type.

- a. Rated for the peak voltages and currents present.

13.7.2 Gear Drive

Gear units will have the following basic design features:

1. Bearings: Provide anti-friction bearings throughout:

- a. Inspection or service: None required before a major gearbox overhaul.
- b. ABMA L10 rating life: Equivalent to minimum 1,600,000 km (994,200 mi) of service.

- c. External bearing shaft seals will be the labyrinth type, with supplemental sliding contact seals, or Approved equal, if necessary to keep high velocity splashed water from entering the gear units.
2. Lubrication:
  - a. Oil lubricated: Gear unit will have sufficient baffles, dams, and passages to ensure adequate flow of lubricant to bearings and gears under all combinations of acceleration, speed, direction, load, and environment.
  - b. Moisture: Prevent infiltration into the lubricant from all sources.
  - c. Oil replenishment: Maximum rate of one quart for every 160,000 km (99,400 mi).
  - d. Filling and draining:
3. Provide openings with removable plugs located for easy access.
4. Plugs will be of a type or be located to prevent damage by obstacles on the track and the resultant loss of lubricant.
5. Plugs will be secured by lock wires, lock tabs, or other Approved means to prevent loosening in service.
6. Filler plug: Opening will be arranged to give an indication of oil level and prevent overfilling.
7. Drain plugs: will have magnetic particle collectors.
8. Maintainability and Life:
  - a. Accessibility: Provide inspection covers on the gear housing that are accessible, removable, oiltight, and airtight for visual inspection of the gears.
  - b. Inspection or service before a major overhaul: None requiring disassembly. See Section 2, Scheduled and Preventative Maintenance section, for the minimum operating miles to the first major overhaul.
  - c. Life: Minimum 1,600,000 km (994,200 mi).

### 13.7.3 Resistors

#### *Dynamic Brake Resistors*

Comply with the following:

1. Capacity: Sufficient to enable full power dissipation by convection cooling during operation at MSB over the City alignment up to and including AW3 passenger loading:
  - a. Assume no regeneration into the line.
  - b. Do not consider air speed in estimating resistor cooling for resistor designs.
2. Cooling: Either convection-air ventilated or forced-air ventilated:
  - a. Forced-air cooling is acceptable only if the inverter cooling air is used.
  - b. Standalone resistors will be convection cooled.
  - c. In either case exhaust air and radiated heat from the resistors will be routed to prevent damage to nearby equipment and overhead contact wires.
3. Location: Roof mounted.
4. Resistor grid:
  - a. Resistor type: Edge wound ribbon, flat wound ribbon, or stamped sheet metal types.
  - b. Application design: Conform to NFPA 130, Section 8.6.5, Propulsion and Braking System Resistors.
  - c. Standard: Design and test per IEC 60322 requirements for double-insulated applications, except both insulation levels will be rated at the basic insulation level.
  - d. Grid expansion: Make provisions to prevent warping.
  - e. Maximum active element temperature under Specified operating conditions will be limited to the manufacturer's recommendation.

5. Protection:

- a. Shield resistors from accumulation of snow and ice.
- b. Provide screens to protect resistors from persons working on the roof, physical damage (including that resulting from overhead vandalism) and fouling by debris. Screens will withstand all brake resistor temperatures without damage or distortion.

6. Material:

- a. Resistor elements, resistor frames, heat shields, screens, enclosures, and hardware will be stainless steel.
- b. All resistor components will be selected both for their thermal and mechanical properties and for corrosion resistance.
- c. Mounting and grid insulators will be designed for rail application and withstand weather, heat cycles, and vibration encountered in this application for the design life of the vehicle.

*Other Resistors*

Other power resistors will have power dissipation capability that is 50% greater than the maximum load to which they can be exposed under all Specified operating conditions.

**13.7.4 Contactors**

Comply with the following:

1. Minimize the use of contactors for propulsion control to the greatest possible extent.
2. Comply with contactor requirements in Section 9, Electrical Equipment.
3. Propulsion system contactors, in coordination with HSCB, will be capable of safely interrupting the maximum possible load current in the event of a malfunction.
4. Safe and continued operation will be possible upon reset after a malfunction.
5. Coordinate contactor rating and operation with circuit protection elements.

**13.7.5 Propulsion Line Filter**

Line filter(s) will conform to the requirements of Section 12 Electrical Equipment.

**13.7.6 Control Logic**

*General Requirements*

Propulsion system control will comply with the design requirements as Specified. Control logic units will comply with Section 7 and IEC 60571.

*Configuration*

Provide dedicated control logic units and logic power supplies for each propulsion system such that a failed system has no impact on others.

*Monitoring*

The control logic units will indicate status and perform fault recording as part of a comprehensive MDS in accordance with Section 7 :

1. Critical parameters: Continuously monitor motor currents, switching device currents, cooling air flow, and component temperatures.
2. Detection and response times: will permit detection and corrective action on a per unit basis before other protective devices, including the HSCB, react.

**Self-Tests**

The control logic will support two types of self-tests. The self-tests will be initiated automatically and manually through the PTU or TOD, as Approved by the City.

1. Low-voltage test: Checks the integrity of the control logic and the peripheral low-voltage circuits.
2. High-voltage test: Checks all high-voltage components of the propulsion system and identifies malfunctioning high-voltage components or components out of tolerance such as filter capacitor, filter inductor, or resistor. Refer to Section 12 Electrical Equipment, for additional input filter capacitor test result requirements.

**13.7.7 Static Power Devices**

Comply with the following:

1. Apply and install per manufacturer's recommendations.
2. Propulsion power semiconductor assemblies will be functionally grouped, keyed, and mounted in modular form to facilitate maintenance and easy removal.
3. Ventilation:
  - a. Forced air may be used where required to stabilize heat sink temperature but will not be used to ventilate the inside of the equipment cabinets.
  - b. Route cooling air through channels free of high voltage.
  - c. See also Section 12 Electrical Equipment, for equipment temperature management requirements.

**13.7.8 Line Contactor**

Provide a line contactor 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:

1. Type: Contactor will comply with Section 9, Electrical Equipment.
2. Operation: Coordinate with the high-speed circuit breaker (HSCB) described in Section 9.
3. Protection: Coordinate line contactor rating with inverter protection requirements.
4. Instantaneous inrush currents:
  - a. Provide a charging circuit to limit inrush current to acceptable values.
  - b. The charging circuit will not interfere with vehicle performance under conditions of intermittent line-voltage availability, as with an icy contact wire or pantograph bouncing.
  - c. See also the Line Filters section in Section 12 Electrical Equipment.

**13.7.9 Speed Sensing Devices**

Provide speed sensors to measure axle or wheel speeds:

1. Location: On the axles or wheel assemblies or incorporated as integral with traction motor or gearbox if higher resolution is desired.
2. Quantity: Sufficient to continue normal operation with one speed sensor failed on each powered truck.
3. Sensor type:
  - a. Active or passive magnetic pick-up type.
  - b. Optical encoders may be used only with City approval.
4. Sensor packaging:
  - a. The face of each speed sensor will be smooth with no protruding elements.
  - b. The sensor will be hermetically sealed in a stainless-steel case.

- c. The face will be encased in a seamless stainless-steel cover unless the sensor is guaranteed, and proven in service, to be immune to damage or inaccurate operation caused by continuous exposure to the intended lubricating fluids and temperatures.
5. Interchangeability: Speed sensor types and mountings will be identical between powered trucks and within the non-powered truck.
6. Mounting:
  - a. Mounting will not require mechanical adjustments.
  - b. The mounting method will be selected to guarantee that the speed-measuring device cannot indicate speeds other than the actual axle speed under all conditions except massive drivetrain damage.
7. Accessibility: All speed sensors will be easily accessible for inspection, adjustment, and replacement both with trucks attached to vehicles over maintenance pits; on jacks; and with trucks sitting by themselves on the floor.
8. Wiring:
  - a. Speed sensor wiring will be enclosed in conduit on the vehicle body and will be run to a terminal box that is located above the speed sensor location on the truck.
  - b. Speed sensors will be connected to the vehicle body by shielded wires terminated in waterproof multi-pin connectors.

### 13.8 Inverter Enclosures

Comply with the following:

1. Provide IP65 rated enclosures for inverter system control components, to prevent dirt and moisture from affecting the system performance.
2. Provide ventilation where necessary as follows:
  - a. Semiconductor heat sinks, line filter chokes, brake resistor and contactors, if they are designed to cut power.
  - b. Openings to the atmosphere will be screened and filter protected.
  - c. Filter elements will prevent snow and water from entering the enclosure.
  - d. Filters will have a replacement interval greater than two years.

### 13.9 Painting

Comply with the following:

1. Traction motors and gear reducers: Same paint as Specified for the truck, applied by either the manufacturer or the Contractor.
2. Requirements: See Section 19 Materials and Workmanship.
3. Color: See Section 6 Interior and Exterior Appointments.

### 13.10 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

13-1 Propulsion System Design Package:

1. Propulsion and drive system configuration
2. High-voltage system and grounding schematics
3. Primary power and traction motor cabling
4. Outline drawings of major components
5. Cooling air requirements, filtering, and blowers
6. Manufacturer, part number, and ratings of power semiconductors
7. Line reactor details
8. Filter capacitor details
9. Overvoltage and overcurrent protection concept

13-2 Inverter Design Package:

1. Data sheets and a layout drawing

13-3 Propulsion System Run Time Simulations:

1. Verification of the thermal capacity of the propulsion equipment under the Specified duty cycle.
  - a. Input assumptions.
  - b. Ambient temperature assumptions.
  - c. Level of braking assumed on extended downgrades in degraded modes.
  - d. Speed/time/distance plots of the vehicle on the City alignment.
  - e. Temperature predictions (or actual test results) for all equipment, including motor windings, brake resistors, inverters, brake chopper device junction temperatures, and similar.
2. Normal duty cycle:
  - a. Perform at AW3 loading over the City alignment.
  - b. Show traction motor, IGBT, and brake resistor duty cycles.
  - c. All simulations will use distance as the x-axis and will indicate, at a minimum, all station stop locations.
3. Abnormal duty cycle:
  - a. Selected abnormal duty cycle.
  - b. Perform run time simulation showing traction motor, IGBT and brake resistor duty cycles for the abnormal duty cycle.

13-4 Traction Motor Design Package:

1. Tractive effort curves as a function of rpm, including as a minimum the following signals:
  - a. Torque
  - b. Output power
  - c. Phase voltage

- 1 d. Phase current
- 2 e. Efficiency
- 3 f. Stator frequency
- 4 g. Slip frequency
- 5 2. Outline drawings of major components
- 6 3. Insulation process information
- 7 4. Data sheets with sufficient information to confirm that all Specified requirements are satisfied,
- 8 such as the following:
- 9 a. Nominal values of signals listed in Item 1, above.
- 10 b. Peak values of signals listed in Item 1, above.
- 11 13-5 Gear Drive Design Package:
- 12 1. Outline drawing and data sheets
- 13 2. Traction-gear drive coupling
- 14 13-6 Brake Resistor Design Package:
- 15 1. Data sheets
- 16 2. Resistor outline drawing
- 17 3. Resistor grid and frame drawing showing electrical isolation and protective screens.
- 18 13-7 Control Logic Design Package:
- 19 1. Description of vehicle control logic functionality, including a functional block diagram of the
- 20 application program
- 21 2. Interfaces with the vehicle data bus and hard-wired control signals
- 22 3. Diagnostic features
- 23 4. Self-test capabilities
- 24 13-8 Interface with Friction Brakes Design Package:
- 25 1. Description of the interface between the propulsion system control logic and friction brake
- 26 controls
- 27 13-9 Fault Monitoring Design Package:
- 28 1. Description of the propulsion system fault monitoring scheme and response performance that
- 29 supplements the MDS CDRL in Section 7 Electronic Controls, Software, and MDS.

## Section 14 Carbody

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## 14.1 General

### 14.1.1 Scope

These requirements apply to all vehicle structural elements above the trucks, including articulation joints and related structures, and equipment mounting points, but exclusive of any composite body cladding panels, if used, except as noted.

### 14.1.2 Configuration

Configure vehicle as Specified in Section 4 Design and Performance Criteria.

1. Body sections: Articulated and semi-permanently coupled together with articulating joints to form a single operating vehicle.
2. Vehicle structures: Construct according to the methods and requirements below.
3. Clearance: Design vehicle and attached equipment to produce Specified wayside clearances for the Specified track profiles, and Specified vehicle/truck clearances, except for stops attached to the vehicle body for limiting truck movement.
4. Weight: Optimize the vehicle-body structure for minimum weight.

### 14.1.3 Materials

Comply with the following:

1. Vehicle structures: Aluminum, HSLA steel, stainless steel, or a combination of these materials.
2. Vehicle non-structural exterior elements: May be FRP or similar service-proven materials.
3. For specific material and painting requirements, see Section 19.

### 14.1.4 Venting and Drainage

Provide venting and drainage throughout the vehicle body to prevent build-up of condensation:

1. Vent enclosed structural cavities.
2. If subject to rusting or oxidation, treat in accordance with the paint and coating requirements of Section 16, Materials and Workmanship.

### 14.1.5 Definitions

The following definitions apply to terms used in this Section:

#### *Crash Energy Management (CEM)*

A design technique that enhances crashworthiness. CEM seeks to control the load path into the vehicle-body structure and to absorb the energy with components that are outside the occupied volume.

#### *Failure*

The complete separation of a member such that it can no longer perform its intended function—the rupture point on the stress-strain curve.

#### *Load Factor*

A number by which the actual or Specified load is multiplied in computing the calculated stress. The load factor will include all applicable safety factors.

*Margin of Safety (MS)*

$$MS = \frac{\text{Allowable Stress}}{\text{Calculated Stress}} - 1$$

The calculated stress will include the applicable load factors. MS will be a minimum value, but a positive number.

*Permanent Deformation*

A member is considered as having developed permanent deformation if one of the following conditions is met:

1. The minimum yield strength as published by ASTM for the Specified material and grade is exceeded.
2. For materials or grades not covered by an ASTM specification, the minimum yield strength as guaranteed by the manufacturer is exceeded.
3. 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% offset method will be used to determine yield strength.

*Ultimate Load Carrying Capacity*

The maximum load that a member can support before it completely fails as a column.

14.1.6 Verification of Design

Verify the design as follows:

1. Perform required analyses.
2. Perform tests on the finished vehicle in accordance with Section 15, Testing, to verify conformance of vehicle structures with Specification requirements and requirements of the Contractor's design and validate the design analysis.

14.2 Structure Arrangements

14.2.1 General

Comply with the following:

1. Design portions of the roof, side frame, and underframe to form a girder to carry Specified static and dynamic loads.
2. Select type and thickness of material to be used to maximize strength and reliability, minimize weight, and produce the desired appearance.
3. Incorporate tie down points into the vehicle to secure the vehicle for shipment and for body straightening after an accident.

14.2.2 Front End

*Front End Frame Structure*

Comply with the following:

1. Provide a front-end frame structure consisting of the following:
  - a. Partial height collision posts at the approximate one-third points (horizontal plane) of the end frame (but in any case, maximum 915 mm (36 in) apart) welded to the top and bottom of the end sill.
  - b. Structural corner posts at each extreme vehicle body corner welded to the top and bottom of the end sill.
  - c. 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.
2. The design will accommodate a wide, single-piece windshield that maximizes operator field of view and complements the Approved appearance.
3. Crashworthiness:
  - a. Securely weld the above elements to the end frame sheathing to resist telescoping in collisions, such that the connection can support the ultimate strength of the members and supporting structure.
  - b. Provide equivalent anti-telescoping and crashworthy elements at the articulation joint and support structure.

Alternative structural arrangements with equal or better performance may be proposed, with appropriate supporting technical justification, for the City's approval.

*Anticlimber*

Provide anticlimbers at each end of the vehicle that comply with the following requirements:

1. Location: Extended laterally over the full width of the vehicle front end frame.
2. Connection: Welded or bolted to the end sill.
3. Width: Sufficient to engage the anticlimber of an opposing vehicle under the worst horizontal track curves.
4. Height and Configuration:
  - a. Such that opposing anticlimbers of like vehicles and other rail vehicles sharing the route engage over the full range of vertical vehicle-body motions.
  - b. Where necessary to accommodate interoperability with multiple types of rail vehicles, provide additional anticlimber engaging adapters that meet the same requirements as those Specified for the anticlimber.
5. Jacking pad: Provide under the center of each anticlimber.
6. Cover: Frangible plastic to cover the anticlimber ribs and produce a visual impression like an automotive bumper. It will not deter engagement of anticlimbers in a collision.

*Front End Enclosure*

Design the front end to deflect, to the extent possible, pedestrians, cyclists, and road vehicles that may be struck by a rail vehicle:

1. Enclose the front end, below the anticlimber, with a full-width, smooth, rounded enclosure, designed for optimized crash compatibility. Some, or all, of the enclosure may form the cladding for the optional energy-absorbing bumper, below, if provided.
2. Continue front end enclosure to meet the side body and skirts such that there is no visible gap except a flexible element, if required to accommodate the optional energy-absorbing bumper, if provided.
3. If the optional energy-absorbing bumper is not provided, comply with the following:
  - a. The portion of the front-end enclosure below the anticlimber will be separate from that which encloses the cab, and replaceable without disturbing the cab enclosure or side skirts:
  - b. The front portion will be hinged to provide access to the coupler, by swinging upward. The design will include latches or other mechanisms to positively retain the cover in both the raised and lowered positions without rattling or movements while in service.
  - c. Assistance for raising the front portion will be provided by hydraulic assist, counterweights, or similar, to allow a fifth-percentile female to raise and lower the cover with ease.
  - d. The front and side portions will have sufficient structural strength and extent to withstand impacts with pedestrians, bicycles, and similar without damage, and prevent some from entrapment under the vehicle.
4. Design with ground clearance as low as feasible; maximum 254 mm (10 in).
5. Coordinate the front-end enclosure with the anticlimber cover and coupler access cover or optional energy-absorbing bumper, if provided, to comply with design requirements and produce an overall aesthetically pleasing appearance.

**14.2.3 Floor**

*General*

Design and construct the floor to meet applicable noise, vibration, and strength requirements in the TS.

*Floor Structure*

Comply with the following:

1. Transverse beams: Provide to transmit vertical floor loads to side sills and for support of floor panels.
2. Longitudinal beams: Provide a continuous side sill and support members.
3. Floor panels:
  - a. Material: Phenolic composite floor panels or Approved equal.
  - b. Support: Attach to the floor beams, end sills, side sills, body sills (if used), and body bolsters, depending upon location.
  - c. Transverse joints: Locate over structural members.
  - d. Insulation: Provide elastomeric tape between panel and metal structure.

*Floor Profile*

Design floor to be slightly higher at the center than the Specified height at doorways to allow water to drain to the outside. See Section 4 Design and Performance Criteria, for floor height at the doorways.

*Floor Fire Requirements*

Design floor to withstand Specified fire requirements and fire performance tests Specified in Section 15, Testing. If an alternate floor design is proposed, submit the following:

1. Detailed design of the proposed floor
2. Detailed description of the proposed standard
3. Evidence of compliance to the standard
4. Evidence that the proposed floor design yields safety to passengers and the operator equal to a floor compliant with the standards Specified in Section 18 in the event of a vehicle fire.

*Sub-Floor*

Provide a sub-floor (floor pans) below the floor beams throughout the length of the vehicle:

1. Design: Will not permit the entrance of water into the vehicle body.
2. Material: Stainless steel.
3. Thickness: Minimum 0.5 mm (0.02 in).
4. Assembly: Weld to bottom flanges of floor beams and to draft sills, end sills, side sills, and body bolsters. Riveting of floor pans will be allowed only if sealing of the pan can be guaranteed for the life of the vehicle.
5. Seams and edges: Permanently watertight and fireproof.

If clearances prohibit the application of the subfloor pan at locations, alternative designs may be proposed that produce the Specified fire barrier properties.

*Floor Insulation*

Comply with the following:

1. Fill the space between the floor and subfloor with insulation in accordance with Section 14, Interior and Exterior Appointments.
2. If clearances yield less than normal separation between the subfloor and floor panels, alternative designs may be proposed that produce the Specified thermal and acoustic insulation requirements.

**14.2.4 Roof**

*General*

Construct the roof of carlines, purlines, and roof sheathing covering the entire roof area. Alternative design maybe proposed for review and Approval by the City.

*Roof Fire Requirements*

Design roof to withstand the fire performance tests Specified in Section 15, Testing. If an alternate roof design for fire safety is proposed, submit the following:

1. Detailed design of the proposed roof
2. Detailed description of the proposed standard

3. Evidence of compliance to the standard

4. Evidence that the proposed roof design yields safety to passengers and the operator equal to a roof compliant with the standards Specified in Section 15 in the event of a vehicle fire.

#### *Roof Equipment*

Comply with the following to accommodate roof-mounted equipment:

1. Provide framing members and structural wells for support of roof-mounted equipment.

2. Provide equipment wells with adequate drainage for the worst-case environmental conditions described in Section 4 Design and Performance Criteria.

3. Provide roof equipment, including wiring and pipe work, to present a clean and simple appearance when viewed from above.

#### 14.2.5 Articulation

Comply with the following:

1. Articulation:

a. Considered an integral part of the vehicle body, including during testing required by the TS.

b. will produce a stable connection between vehicle-body sections and maintain each body section upright on level tangent track.

2. Articulation Bellows: Cover on the inside as an integral part of the interior finish.

3. Maintenance Access: Articulation components that require periodic service, inspection, and maintenance will be easily accessible either from the passenger compartment, side of the vehicle, or bottom of the vehicle at inspection pit.

4. Friction Material:

a. If the articulation uses friction material for rotation, it will have adequate life over a scheduled heavy maintenance interval but not shorter than 12 months.

b. Material will provide a coefficient of friction as constant as possible so that turning at curves is smooth and consistent over time without excessive flanging of the adjacent truck.

#### 14.2.6 Jacking Pads and Hoists

Provide each vehicle-body section with jacking pads at structural points to sustain jacking loads:

1. Features: Non-slip, easy to reach.

2. Location: Consider jack placement, derailment clearances, and similar factors arising when jacking the vehicles in the shop and in the field with modern portable rerailing equipment.

3. Asymmetrical jacking: Clearly indicate limitations of any body-section in maintenance and rerailing instructions, such that cosmetic damage, deformation, or dislocation does not occur.

#### 14.3 Shrouds and Skirts

##### 14.3.1 Roof Shroud

Roof shroud (if provided):

1. Aesthetics: Consistent with vehicle body styling.

2. Strength: Sufficient for worst case combination of Specified wind and vehicle design speed.



3. Design: Shroud roof-mounted equipment so that, when viewed from the side, the vehicle will have unbroken lines at top and bottom.

4. Material: HSLA steel, aluminum, or FRP complying with Section 16, Materials and Workmanship.

5. Attachment: Secure to roof structure using mechanical fasteners removable using ordinary tools.

#### 14.3.2 Skirts

Comply with the following:

1. Skirt Locations:

a. Sides of the vehicle to enclose trucks, tow bar, open spaces that may be accessible by pedestrians along the right of way.

b. On the sides between trucks if the vehicle structure does not cover these areas

2. Specific Location Requirements:

a. Skirts of high-floor areas below end sill: Carry around corners and down sides of vehicle to blend with line of bottom of vehicle in low floor area.

b. Skirts of low floor areas: Form a uniform lower edge with bottom of vehicle body.

c. Skirts in vicinity of trucks: May be modified to accommodate turning.

d. Coordination with Front End Enclosure: Design skirts to comply with the Front-End Enclosure section, above.

3. Design: Removable, not load bearing members.

4. Material: HSLA steel, aluminum, or FRP complying with Section 16.

5. Appearance:

a. Skirts: Integral part of vehicle body.

b. Ventilation openings: If required, in harmony with overall vehicle aesthetic design.

6. Repair: Skirts at ends and corners will be readily repairable following minor collisions.

7. Attachment where access is not required:

a. Provide standard threaded fasteners, removable with common hand tools, or Square Key.

b. Sufficient to hold the skirts firmly in place so they are rattle-free during vehicle operation and last the life of the vehicle.

8. Attachment where access is required:

a. Design such that removal is not necessary for equipment access or maintenance.

b. For easy access to trucks, skirts over trucks will be hinged, lift-assisted, and removable by sliding the moveable portion off hinge pins.

c. Provide quick-release closures of truck-access panels.

d. Sufficient to hold the skirts firmly in place so they are rattle-free and last the life of the vehicle.

## 14.4 Structural Design Requirements

### 14.4.1 General

Base the structural design on the following:

1. Proven rail vehicle techniques and elements
2. Structural static, dynamic, and fatigue loads encountered in revenue service.
3. Specified loads, load factors, deflections, and crashworthiness requirements
4. Passive safety design concepts for vehicles in ASME RT-1, Section 3, Interoperability.

### 14.4.2 Interoperability

#### General

As a minimum, comply with interoperability requirements of ASME RT-1. These include:

1. Requirements for anticlimber and coupler interface (where applicable), and leading end structure, intended to mitigate damage in case of engagement between rail vehicles of the same or different types operating on the same routes.
2. Requirements for rail vehicles operating in urban environments, intended to cause the vehicle to deflect struck objects from its path; and minimize entrapment, override, and penetration of automobiles and light trucks.

#### Energy Absorbing Bumper (Optional)

Provide a bumper designed to minimize damage, to the extent possible, to struck pedestrians, cyclists, road vehicles, and other rail vehicles:

1. Bumper style: Wraparound, continuous or segmented with separate front and corner/side segments, with corner/side segment designed to reduce damage in corner collisions.
2. Minimum bumper coverage: Full width of the vehicle and wrapped around sides, as approved by the City.
3. Minimum bumper width (in vertical direction): 457 mm (18 in)
4. Mounting height: Maximum 203 mm (8 in) from TOR to bottom of bumper.
5. Energy absorbing mechanism: Self-restoring and capable of absorbing collision energies between two streetcars at speeds of minimum 8 km/h (5 mph) with no structural damage
6. Stroke before anticlimber contacts struck vehicle or object: 100 mm to 150 mm (4 in to 6 in)
7. Cladding: Cushioning and aesthetically pleasing, matching front end enclosure colors and materials
8. Maintainability: Attached with quick release pins or other similar mechanism to allow easy and quick replacement following a collision
9. Vertical Stability: will withstand the anticlimbing load requirements.
10. Coupler access: will have hinges and hydraulic assist to allow the bumper and cladding to be raised by a single person. Include latches or other devices to retain bumper in the raised position. Raising and latching of the bumper must not contact or mar other portions of the vehicle.

*City-Specific Requirements*

The City's streetcars will share the alignment with existing streetcars and will operate in an urban environment with road vehicles. At a minimum, anticlimber height and arrangement will be designed to be fully compatible with existing Portland Streetcar vehicles.

*14.4.3 Crashworthiness*

*Design – CEM Option*

Comply with the following:

1. Design the vehicle-body structure in accordance with ASME RT-1 crashworthiness requirements and crash energy management (CEM) principles per Table 2, Structural Load Requirements for Streetcars:
  - a. Design the structure with minimum two sequential energy absorption zones, Zone 1, and Zone 2, as defined in ASME RT-1.
  - b. Collapse will not commence until the end sill compression load has been exceeded, except for the energy absorption in Zone 1.
  - c. The requirements of the Energy Absorbing Bumper section, above, if provided, and the Safety Bars section in Section 11, Truck Assemblies, are considered to satisfy ASME RT-1, Table 4, Crashworthiness for Streetcars, Item 1, Collision Scenario 1 - low-severity impact scenario, for the CEM Option.
2. Demonstrate compatibility with existing vehicles under the scenarios Specified in this Section.
3. Subject to approval by the City, European standards such as EN 15227 may be proposed, if it can be shown that results are essentially equivalent to ASME RT-1 and achieve structural compatibility with the existing vehicles.
4. Quasi-static or dynamic tests on the various structural elements may be required to validate the analysis and show the actual energy absorbed by the elements during crushing, in accordance with Section 18, Testing, or ASME RT-1 Section 10.4, Crash Energy Management Tests, depending on the availability of validated models matching the Specified design.

*Crashworthiness Analysis*

Demonstrate performance of the crashworthiness design features:

1. CEM Option: Collision between two like vehicles:
  - a. Simulation conditions (two simulations): ASME RT-1 Section 9.3, Crashworthiness Analysis, for the following:
    - New vehicle into new vehicle
    - New vehicle into existing vehicle
  - b. Vehicle closing speed: ASME RT-1 Table 4, Crashworthiness for Streetcars, Collision Scenarios 1 and 2, for the following:
    - New vehicle into new vehicle
    - New vehicle into existing vehicle
  - c. Acceptance criteria: ASME RT-1 Section 9.3, Crashworthiness Analysis, and Table 4, Crashworthiness for Streetcars.

*Crashworthiness Analysis Interactive Review*

The City may, at its discretion, require that models and results be reviewed during live interactive sessions with the engineers who performed the crashworthiness analysis, three weeks after each submittal.

1. At these sessions, give the City full access to the model input and output, and use of the software on a computer.
2. Give access to view the crushing simulation on the computer.

**14.4.4 Vertical Design Load Strength Requirements**

*Static Load*

Design a completely equipped vehicle body to carry the maximum vehicle loading of weight AW4 distributed uniformly along the vehicle, less truck weight or running gear weight. Stresses will not exceed the following:

1. 65% of the guaranteed minimum material yield strength; and
2. 65% of the buckling strength, and no loss of local stability

*Fatigue Load*

For fatigue-critical joints, structural details, and connections including bolted joints, determine allowable fatigue stress according to the requirements of the following standards and handbook:

1. AWS D1.1/D1.1M
2. AWS D1.2/D1.2M
3. AWS D1.3/D1.3M
4. AWS D1.6/D1.6M
5. AWS Welding Handbook requirements for dynamically loaded structures
6. Other recognized standards, as Approved, for connections not covered by Items 1 to 5 above.

For each joint design, the static stress at the AW2 load will be less than the mean stress that determines the allowable fatigue limit. The fatigue stress range will be calculated at AW2 loading times a dynamic factor.

The dynamic factor will be as determined by the Contractor but will be minimum plus or minus 20% under constant amplitude loading. The fatigue limit will be established for 10 million cycles. The fatigue stress range will not exceed the allowable range(s) in items 1 to 6 above for a given joint detail.

**14.4.5 End Sill Compression Load**

*General*

The end sills will 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.

*CEM*

Comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 2, End sill compression.

**14.4.6 Coupler Anchorage**

*Coupler Anchor Compression Load*

Comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 3, Coupler anchorage compression load, as applicable to the Specified coupler.

*Coupler Anchor Tensile Load*

Comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 5, Coupler anchorage operational tensile load and towing loads, as applicable to the Specified coupler.

**14.4.7 Collision Posts**

*Design*

Comply with the following:

1. Collision posts will be continuous, closed, cross-sections through the end sill, extending from the bottom of the end sill to the structural shelf.
2. Design the posts and/or supporting structures in the end frame such that when the post is overloaded, the initial failure begins as bending or buckling in the structure.
  - a. Primary connections between the collision post and other structure will not fail before the ultimate strength of the post itself is reached; failure will occur in the post.
  - b. Ultimate failure will not be in any connections, the underframe, or roof structure, and will not occur by shearing or fracturing of any member.
3. If the post is designed to support more than the Specified load, then the supporting structure must be strong enough to support the increased bending capacity of the posts. The posts will fail before the supporting structure.

*Collision Post Shear Load*

CEM: The minimum ultimate shear strength of each collision post will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 6, Collision post shear load.

*Collision Post Load*

CEM: The capacity of each collision post will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 7, Collision post load.

**14.4.8 Corner Posts**

*Design*

Comply with the following:

1. Corner posts will be continuous, closed, cross-sections and extend full height from the underside of the end underframe to the roof rail.
2. The connections of the posts to the supporting structure, and the supporting structure itself, will be strong enough to develop the bending capacity of the posts.
  - a. Primary connections between the corner post and other structures will not fail before the ultimate strength of the post itself is reached; failure will occur in the post.
  - b. Ultimate failure will not be in any connections, the underframe, or the roof, and will not be by shearing or fracturing of any member.
3. If the posts are designed to support more than the Specified loads, then the supporting structure must be strong enough to support the increased bending capacity of the posts. The posts will fail before the supporting structure.

*Corner Post Shear Load*

CEM: The ultimate shear strength of each corner post will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 8, Corner post shear loads.

*Corner Post Load*

CEM: The capacity of each corner post will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 9, Corner post loads (elastic design loads).

**14.4.9 Structural Shelf**

Comply with the following:

1. Design:

a. Provide a horizontal structural shelf below the windshield connecting the tops of the collision posts to each other and to the corner posts.

b. The outer ends of the structural shelf will be supported by the corner posts.

2. Capacity: Comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 10, Structural shelf.

**14.4.10 Side Wall**

*Side Wall Load at Side Sill*

Side sill and supporting structures will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 11, Side wall load, at side sill.

*Side Wall Load at Belt Rail*

Belt rail (at the lower side window edge) and supporting structures will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 12, Side wall load, at belt rail.

**14.4.11 Articulation Joint and Anticlimber Loads**

1. CEM Option: Resist vertical and longitudinal loads developed over the collision scenarios in the Crashworthiness Analysis section, above, per the requirements above.

**14.4.12 Floor Load**

Meet the following conditions for a fully equipped vehicle with a vehicle weight of AW4 evenly distributed:

1. Floor panels will deflect maximum 1/250 of the shortest span between supports, up to a maximum of 4.3 mm (0.17 in).

2. Floor beams will deflect maximum 1/250 of the span between supports.

**14.4.13 Roof Load**

All parts of the roof structure and walkways will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 13, Roof, concentrated load, as might be applied by maintenance personnel walking on the roof carrying tools and equipment.

**14.4.14 Truck-to-Vehicle-Body Attachment**

Comply with the following:

1. Trucks (or running gear): will be raised with the vehicle unless intentionally detached.

2. Attachment structure: Stresses will not exceed 50% of yield with the truck or running gear hanging from the body.

3. Attachment Strength:

- a. CEM Option: The structural connection of the truck (or running gear) to the vehicle body will comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 14, Truck-to-Carbody attachment, or Approved alternative standard.

14.4.15 Equipment

*Equipment Loads*

Comply with the following requirements for design of equipment attachments:

1. Scope: Underfloor, roof, and interior equipment, any portion of the equipment, equipment boxes, equipment hangers, standby supports, safety hangers, and the vehicle body supporting structure.
2. Design load: At a minimum, comply with ASME RT-1, Table 2, Structural Load Requirements for Streetcars, Item 15, Equipment attachments, or Approved alternative standard.

Equipment within an equipment box:

1. Not required to meet the above criteria if it can be shown that the equipment will not penetrate the walls of the equipment box when exposed to these load levels.
2. The equipment box will 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.

*Equipment Fasteners and Supports*

Comply with the following requirements for the support of equipment enclosures:

1. Fastenings will 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.
2. Equipment weighing more than 12 kg (26 lb.) will not be supported by threaded fasteners in tension or shear unless they are provided with an unstressed secondary support.
3. Equipment will not be supported by bolts in holes tapped in the structural elements of the vehicle. However, it is permissible to use tapping plates in accordance with Section 19 Materials and Workmanship.
4. For bolts used to support equipment, the minimum diameter will be 10 mm (3/8 in).
5. Underfloor equipment will be mounted on rails, hangers, brackets, or support structure such that the equipment rests on the top side of the support member and thus does not rely solely on bolted connections for mechanical integrity.
6. Waivers of these requirements may be requested for enclosures that weigh maximum 12 kg (26 lb.) or are agreed to be crushable, such as terminal boxes, or where the arrangement is service proven, as defined in Section 1, General Topics and Definitions.

14.4.16 Jacking and Hoisting Loads

For design purposes, the vehicle will comply with the following:

1. Symmetrical Jacking:
  - a. Loading condition on each jack point:
    - Vertical load: Static, AW0, with a load factor of 2; combined with

- Horizontal load: 10% of the vertical load applied in any horizontal direction.
- b. Result: No permanent deformation of any vehicle-body structure.
- 2. Diagonal Jacking:
  - a. Scope: Vehicle-body jacking pads, jacking sockets, and supporting structure. Diagonal jacking must be considered for each jack pad and socket adapter.
  - b. Loading condition: Empty vehicle with trucks (AW0 condition), under the load imposed by the diagonal jacking.
  - c. Result: No permanent deformation.

The stress analysis will include an analysis of the jack pads, jack sockets, their connections to the vehicle body, and the immediate supporting vehicle structure under symmetric jacking and the worst case of diagonal jacking.

The same load factors as above will apply for hoisting.

#### 14.4.17 Steps

If provided, steps will be designed to support one person as follows:

1. Load: 135 kg (298 lb.) per 305 mm (12 in) of tread
2. Load factor: 2

The resulting stresses in any part of the steps assembly, and its supporting structures, will not exceed the yield strength of the material.

#### 14.4.18 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 will be minimum 2.5 times the natural frequency of the secondary suspension.

### 14.5 Stress Analysis

#### 14.5.1 Purpose

Stress analyses will be used to design the vehicle structures in compliance with the requirements of the TS and to obtain the lightest-weight vehicle consistent with those requirements.

#### 14.5.2 General

Comply with the following:

1. The Approved stress analysis is a prerequisite for approval of the structural test procedures and structural drawings required by the TS and will be used as an aid in determining strain gauge locations for use during testing.
2. During the design and manufacture of the vehicles, update the input to the stress analysis to reflect the as-built configuration of the structure.
3. For any portion of the proposed design that is based on a service-proven vehicle, data may be furnished from previous tests, historical data from operations, or stress analyses as required to satisfy the corresponding portion of these requirements.



**14.5.3 Stress Analysis Content**

Include the following as a minimum:

1. Show the calculated stresses, allowable stresses, and margins of safety for all elements for all Specified loading conditions.
2. Include calculations of stresses in joints, joint elements, and other important elements.
3. Calculate the elastic stability of plates, webs, and flanges for members subject to compression and shear.
4. Prototype and test critical connections that cannot be adequately analyzed to demonstrate compliance with the requirements of the design and the TS.
5. If stainless steel is used, consider the variation in the stainless-steel compression modulus with stress in calculating compressive stability of stainless-steel members.
6. See the Contract Deliverables Requirements List (CDRL) section, below, for detailed requirements.

**14.5.4 Initial Stress Analysis**

The initial stress analysis will require temporary assumptions as to configuration and weights. If the initial design changes due to manufacturing considerations or other factors, revise and resubmit the stress analysis.

**14.5.5 Buckling Analysis**

Calculate the buckling strength of structural framing members. Include each member that was found to have a calculated compressive stress greater than or equal to 35% of material yield strength in any of the analyses.

**14.5.6 Finite Element Analysis (FEA)**

As part of the stress analysis, perform a linear-static finite element analysis (FEA) of the complete vehicle body.

1. Purpose: To show that the vehicle body design meets the requirements of this Section.
2. FEA software: Perform analysis using a recognized computer program such as NASTRAN, ANSYS, ABAQUS, or Approved equal.
3. Non-linear static analysis:
  - a. Perform if FRP skin is used and the material and/or the connection between the material and the supporting structure exhibit non-linear properties.
  - b. This may be instead of linear static FEA, or a local analysis in addition to a global static analysis.
4. Interactive City Review:
  - a. The City may, at its discretion, require review of FEA models and results during live interactive sessions with the engineers who performed the FEA, three weeks after each submittal.
  - b. At these sessions, give the City full access to the FEA model input and output, and use of the software on the computer used for the analysis.
  - c. Provide access to view the simulation on the computer.

14.5.7 Validation of Linear Elastic Analysis

Perform Vehicle-Shell Structural Type Tests in accordance with Section 15, Testing, to confirm the accuracy of the analysis:

1. For each test required for Vehicle-Shell Structural Type Tests in Section 15, compare the vehicle-body structural test measured results with the corresponding stress analysis analytical results.
2. Tabulate and submit this information with the vehicle-body structural test reports for each test, as required in Section 18 .
3. The test and analysis results will correlate within the following ranges:
  - a. Longitudinal deflections: Within +/- 10%
  - b. Vertical deflections: Within +/- 10%
  - c. Stresses: Within +/- 20%

14.6 Contract Deliverables Requirements List (CDRL)

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Component ratings: Top level components, and ratings of other components if requested.

14-1 Jacking Pad Design Package:

1. Drawing showing locations of jacking pads for both maintenance and re-railing equipment.
2. Details of vehicle-body inserts, if provided, sufficient to enable the City to procure adapters for portable jacks.

14-2 Roof Shroud Design Package:

3. Drawing showing side and end views as mounted on vehicle.
4. Drawing showing details of roof shroud construction, materials, and attachment methods.

14-3 Skirt Design Package:

1. Drawings showing side and end views as mounted on vehicle, with ventilation openings, if used.
2. Drawing showing details of skirt construction, materials, and attachment methods.
3. Drawing showing details of skirts over trucks, including hinges, lift-assist mechanism, and removal method.

14-4 CEM Option: CEM and Collision Survivability Plan:

1. Submit maximum 30 calendar days after NTP.
2. The report will include the requirement of ASME RT-1, in Sections 8 and 4, to present the design strategy that defines the specific features to meet the required zones of energy absorption.
3. Include the CEM testing plan, or waiver justifications.

14-5 CEM Option: Crashworthiness Analysis Report:

1. Submit a minimum of 60 calendar days before starting manufacture of structural parts.

- a. The report will demonstrate that the crushing of the vehicle body is stable.
- b. Include sufficient analysis to demonstrate compliance with the Specified requirements.
- c. Organize the report and furnish sufficient detail so that the City’s representative can readily follow the theory and its application to this vehicle.
- d. Include the same reference information, such as drawing numbers, material properties, references for formulas, and buckling coefficients, as required in the Stress Analysis Report CDRL.
- e. Include the following:
  - i. Animations of the time-dependent, large-deflection analysis:
    1. Format: Compatible with one of the current commonly available video formats.
    2. Content: Sufficient detail, view directions, and magnifications to review the behavior and stability of the following:
      - a. Energy absorption elements
      - b. Frangible elements
      - c. Non-crushable structure inboard of the crush zones
      - d. The vehicle body as a whole
  - ii. Description of the model in sufficient detail to show that the model is appropriate for this application, including as a minimum the following:
    1. Descriptions of the elements and restraints
    2. The conditions of the simulation
    3. The output of the simulation shows that relevant Specification requirements have been met, including force-displacement plots.
  - iii. Table for non-crushable structure inboard the crush zones:
    1. Show locations where the MS is less than 0.20, with a discussion of the results.
    2. There will be no permanent deformation in this area of the structure.
  - iv. References for formulas, calculation procedures, buckling coefficients, material strengths, and other physical and mechanical properties that appear in the report.
    1. If a cited reference is not readily available to the City, furnish the following:
      - a. Reference; or
      - b. Copies of the pages that show the cited formula or data, and the pages that show the development and interpretation of the formula or data.

2. References will be in the English (USA) language:

a. If an English (USA) reference cannot be found, furnish an English (USA) translation.

b. Include both the original and the translation in the report.

v. Test reports required to verify the results of the analysis:

1. Include the entire test report, which will include the test procedure, raw data, reduced data, and a summary.

2. The City will determine the adequacy of the submitted test reports.

vi. Electronic input and output files.

14-6 Vehicle-Body Stress Analysis and Tests Plan:

1. Submit within 30 days after NTP.

2. Follow the general requirements of the Stress Analysis Report.

3. This Plan must be submitted and Approved before approval of the Stress Analysis Report.

4. Update and resubmit whenever the Plan for the analysis and testing of the vehicle body is revised, but not more often than monthly.

5. With each revision submit detailed revision notes that explain each change and indicate where changes were made in the report because of the change.

6. Include the following:

a. Table including the Specification subsection or standard met, load case number, load, and criteria.

b. Outline of the procedure the Contractor will use to analyze and test the design of the vehicle body.

c. Listing of load conditions to be used during analysis and test, with load magnitudes, supports, and points of application.

d. Description of the analysis to be used for each load condition.

e. Structural sketch of the vehicle body, showing sheathing thickness, framing member locations and shapes, and the materials and thicknesses of each. Define methods of joining.

f. Diagrams of load applications and supports.

g. Procedure for analyzing the static and fatigue capability of FRP side skin and its connections, if used.

h. Table of material properties.

i. Description of major assumptions.

j. Description of how analysis results will be correlated with test results, as required in Section 15, Testing.

14-7 Stress Analysis Report:

1. Submit as follows:
  - a. Initial stress analysis report: Within 90 days after NTP.
  - b. Complete stress analysis report: Minimum 60 days before starting manufacture of any vehicle body structural parts.
  - c. Revisions: Any time the design, and/or the stress analysis plan is updated but not more than monthly.
2. With each revision, include detailed revision notes that explain each change and indicate where changes were made in the report because of the change.
3. General Requirements:
  - a. The final submitted and Approved Stress Analysis Report will be for vehicles in as-built configuration.
  - b. Certify that analysis and calculations have been reviewed and checked before submitting report.
  - c. Follow procedure outlined in Vehicle-Body Stress Analysis and Tests Plan.
  - d. Report will demonstrate that structure satisfies requirements of Contractor's design and the TS.
  - e. The report will be sufficiently complete and analysis sufficiently accurate for the City to use report to design repairs during life of vehicles.
  - f. Organize report in a logical way such that content can be easily found by the City's reviewer. Furnish sufficient detail so the City's reviewer can readily follow the theory and its application to this vehicle.
4. Include the following:
  - a. Sections that organize the material into logical units.
  - b. Consecutive page numbering.
  - c. Table of Contents Listing each section with page number on which it starts.
  - d. Manual analysis: Each page will be initialed by analyst and checker, and include the following:
    - Date
    - Revision level
    - For revisions, include revision letter with revision date and initials of analyst and checker.
  - e. Computer-generated analysis: Each page will be initialed by checker and include the following as a minimum:
    - Page number
    - Date
    - Revision level

5. Include the following drawings:
  - a. Approved structural sketch of the vehicle body showing structural elements and their connections (submitted with the Vehicle Body Stress Analysis and Tests Plan, above).
  - b. Framing and miscellaneous drawings:
    - 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
6. In drawings, or body of the analysis, indicate materials and weights of all components.
7. In body of analysis, include the following:
  - a. References for formulas, calculation procedures, buckling coefficients, material strengths, fatigue strengths, and other physical and mechanical properties where these items appear in the stress analysis:
    - If a cited reference is not readily available to the City, furnish the reference or copies of the pertinent pages. In addition to the pages that show the cited formula or data, include the pages that show the development and interpretation of the formula or data.
    - References will be in English (USA). If an English reference cannot be found, furnish an English translation. Include both original and translation in report.
  - b. Algebraic statement of formulas and equations before related calculations are performed. Define terms, and state values and units to be applied to these terms.
  - c. Units for each quantity.
  - d. Diagrams displaying, for each load case, loads applied externally to the vehicle body and points of support.
  - e. Analysis showing compliance with each design load and condition, as required by Section 3.4, Structural Design Requirements.
  - f. Detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing, with a summary of the results.
  - g. Table showing locations where MS is less than 0.20, along with design or operating conditions (loads) that cause the stresses.
  - h. Reference to elements including, but not limited to the following:
    - Side sill
    - Body sills (if used)
    - End sill
    - Anticlimber

- 1           • Draft sills
- 2           • Tow bar support.
- 3           • Side frame rails
- 4           • Side frame posts
- 5           • Transverse and longitudinal sections at doorways
- 6           • Body bolster
- 7           • Floor and floor beams
- 8           • Collision posts
- 9           • Corner posts
- 10          • Structural shelf
- 11          • Articulation end frame
- 12          • Roof structure
- 13          • Equipment supports.
- 14          • Connections between structural elements
- 15          • Any FRP skin and bonded connections used.
- 16          i. Tabulation or diagram of calculated deflections of vehicle body under full vertical loading and
- 17             under combined vertical and compression loads Specified in:
  - 18           • Section 3.4.4, Vertical Design Load Strength Requirements.
  - 19           • Section 3.4.5, End Sill Compression Load; and
  - 20           • Section 3.4.7, Collision Posts.
- 21          j. Analysis of critical and highly loaded connections, as required in Section 3.4.4, Vertical Design
- 22             Load Strength Requirements, showing joint is stronger than weakest member being joined.
- 23          k. Analysis of the strength of connection of trucks to vehicle body, including calculated vertical
- 24             and horizontal connection capacities.
- 25          l. Analyses of the vehicle-body structure under:
  - 26           • Torsional loading resulting from diagonal jacking described in Section 3.4.16, Jacking and
  - 27            Hoisting Loads; and
  - 28           • Torsional loadings resulting from anticipated normal operations.
- 29          m. Tabulation of Contractor's selection of:
  - 30           • Allowable fatigue stresses, with sources; and
  - 31           • Assumed applied fatigue stress ranges for structural members and connections that are
  - 32            critical in fatigue, and for FRP skin and its connections if used.

- n. Table showing engineering properties of each grade and temper of each material used in vehicle structure:
  - Include material designation, yield strength, ultimate strength, elongation, Young's modulus for tension, and compression and shear elastic moduli.
  - For each, use minimum-guaranteed values for grade and heat treatment of material used, from the TS.
  - Do not include in the table materials, grades, or tempers not used in vehicle body construction.
- o. Table showing geometric properties, such as area and section moduli.
- p. Table(s) showing minimum static and fatigue strengths of single and multiple spot welds:
  - Give values for each material, temper, weld size, and thickness combination used in vehicle body.
  - Include source of data.
- q. Test reports if tests are conducted to furnish necessary data. Submit the entire test report, which will include test procedure, raw data, reduced data, and summary.

**14-8 Equipment Support Stress Analysis Report:**

1. Submit a minimum of 60 calendar days before starting manufacture of any vehicle body structural parts.
2. Include a stress analysis of equipment support for equipment weighing over 91 kg. Stress analyses for support for items weighing less than 91 kg may be requested for review at the City's discretion.
3. In addition to stress analysis, include the following:
  - a. Detailed drawings of equipment support.
  - b. Outline drawings and weights of equipment.
  - c. Material lists for all components and fasteners.

**14-9 FEA Model Report:**

1. Submit within 90 days after NTP.
2. Submit and receive approval of FEA model before performing FEA analysis.
3. Include the following:
  - a. Element mesh
  - b. Assumptions
  - c. Plots with legends showing input data such as loads, boundary conditions, area properties, and material properties.
  - d. Key to symbols and colors
  - e. Boundary reaction forces of the shell at AW0
  - f. Input file on electronic media



4. Each revision includes detailed revision notes that explain each change and indicate where changes were made in the report because of the change.

5. Upon completion of final design, update FEA Model to represent final configuration of structure.

14-10 FEA Report:

1. Submit a minimum of 60 days before starting manufacture of any vehicle body structural parts.

2. Submit FEA Report after receiving approval for FEA Model and performing complete analysis.

3. In addition to the items required for this submittal, include those items required for the FEA Model submittal.

4. Upon completion of final design, update FEA Report to represent final configuration of structure.

5. Each load condition submittal will include diagrams of areas of mesh refinement, assumptions, input data, reaction forces, and a table to show static equilibrium.

6. For input and output files, number each page and clearly label columns of data on each page using terms, symbols, abbreviations, and units defined in the analysis report.

7. Prepare color plots showing the following:

a. Deflections in all three axes separately plotted and imposed over the deflected shape.

b. Von Mises, or other Approved failure criteria, depending on the material.

c. Maximum and minimum principal stresses

d. Direction of maximum and minimum principal stresses

e. Meshing accuracy index

f. Maximum and minimum values and values that are greater than 80% of Specified maximum value.

g. Triad showing direction of global axes.

h. For plots at high magnification, the key to a plot showing structure to an extent sufficient to orient high-magnification plots.

8. Furnish enough plots for each load case to see the stresses in all areas of the vehicle body, with special attention given to the following components:

a. Side sill

b. Body sills (if used)

c. End sill

d. Anticlimber

e. Draft sills

f. Tow bar supports.

g. Side frame rails

h. Side frame posts

i. Transverse and longitudinal sections at doorway

- 1           j. Body bolster
- 2           k. Floor and floor beams
- 3           l. Collision posts
- 4           m. Corner posts
- 5           n. Structural shelf
- 6           o. Articulation end frame
- 7           p. Roof structure
- 8           q. Equipment supports.
- 9           r. Connections between structural elements
- 10        9. Show in detail areas with an MS less than 2.0.
- 11        14-11 FEA Input and Output Data on Electronic Media:
- 12           1. Submit FEA input and output data on electronic media, and if requested by the City, hard copy.
- 13           2. Obtain approval from the City for proposed media type before submitting.
- 14           3. Resubmit each time the file is changed, but not more often than monthly.
- 15           4. Fully configured input data files must be submitted before final approval of the stress analysis
- 16           required by this Section.

## Section 15 Trucks

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## 15.1 General

### 15.1.1 Scope

This Section specifies the design and functional requirements of the truck assembly, which includes truck frame and suspension components, wheels and axles, and other components defined below.

Gear boxes, motors, wiring, and brake system components are physically part of the completed truck assemblies but are not included in this Section, except that mechanical interfaces requiring welding or drilling on the truck frame will be considered part of the truck.

### 15.1.2 General Requirements

Comply with the following:

1. Supplier experience: The trucks will be designed, and the truck frames manufactured by a supplier that has designed and manufactured the same trucks previously for the vehicle offered:
  - a. Adaptations are limited to changes in dimensions, materials, or procedures necessary to comply with the TS.
  - b. The trucks will have operated in the same or more unfavorable climatic conditions over track meeting FRA Class 4 requirements, and at the same or higher maximum operating speed.
2. Vibration and noise: The trucks will minimize resonant vibrations when in operation. Surface contact between truck components, except suspension stops, will be made through service-proven, non-metallic materials selected to impede the transmission of vibration and noise.
3. Speeds: Trucks will operate safely at all speeds from zero up to vehicle design speed, as indicated in Section 4 Design and Performance Criteria, and produce the Specified ride quality at all speeds up to the maximum operating speed indicated in Section 4 Design and Performance Criteria, over the entire range of wheel wear and vehicle loading.

## 15.2 Design Requirements

### 15.2.1 Wheelbase

Truck wheelbase: 1,780 to 1,910 mm (70 to 75 in).

### 15.2.2 Interchangeability

Powered trucks will be interchangeable among every vehicle provided under this Contract, without modification. Non-powered trucks, if provided, will be interchangeable among every vehicle provided under this Contract, without modification.

### 15.2.3 Wheel Machines

Wheel truing: Provide suitable adapters and fixtures to permit wheel truing on City's wheel machines.

### 15.2.4 Clearance Requirements

The complete truck assembly will clear the vehicle body and vehicle-body-mounted equipment by minimum 12 mm (0.5 in). All truck parts, except wheels and track brakes, will clear the plane of the top-of-rails by minimum 50 mm (2 in).

These clearance limits will be met when full allowance is made for the most unfavorable combinations of the following:

1. Wheel tread or flange wear.
2. Static and dynamic primary and secondary spring deflection.
3. Primary and secondary suspension failure.

4. Static and dynamic suspension stop deflection, including possible wear of the suspension stops to the condemning limit.
5. The full Specified range and worst-case combination of horizontal and vertical curves.
6. Other possible movements of the trucks and associated parts, including those caused by the maximum excursions of truck-mounted parts.

#### 15.2.5 Truck Removal

Provide a design that allows for the following:

1. There will be clear and direct access from the side or under the vehicle to all mechanical, electrical, pneumatic, hydraulic, and other connections necessary for trucking and de-trucking.
2. All such connections will be operable with common hand tools.

### 15.3 Suspension System

#### 15.3.1 General Requirements

Truck suspension will consist of a primary and secondary suspension system. The vehicle body will be supported on secondary suspension. The suspension system will:

1. Produce stable operation at all defined speeds.
2. Produce Specified ride quality.
3. Retain and locate the vehicle body relative to the truck centerline, such that Specified clearances and platform interfaces are achieved under all normal conditions.
4. In the case of suspension failure, limit the lateral vehicle-body motion and maximum change in floor height over the loading range from AW0 to AW4, such that the following parameters are satisfied:
5. Safe operating requirements.
6. Clearance requirements.
7. Prevention of interference between the doors and wayside loading platforms during door opening.

#### 15.3.2 Primary Suspension

Comply with the following:

1. Primary suspension: Elastomeric elements in compression.
2. Vertical resonance frequency: Maximum 12 Hz.
3. Longitudinal spring rate:
  - a. Maximum 1600 kg/mm (89,595 lb./in)
  - b. Select such that the requirements of the TS are met.
  - c. Will permit the axles to align properly (absent squealing or hunting) in curves.

#### 15.3.3 Secondary Suspension

Comply with the following:

1. Secondary suspension system: Coil springs or elastomeric springs, dampers, and related hardware.
2. Design: will keep the vehicle body aligned laterally and longitudinally with the truck centerline under all forces expected in rail service.
3. Stable operation and ride quality: Augment springs with dampers and other components as necessary to comply with the TS.

15.3.4 Dampers

Provide vertical and lateral dampers:

1. Type: Hydraulic
2. Service life: Minimum 10 years
3. Orientation: Comply with manufacturer's recommendations, as installed on trucks, and detail in the maintenance manuals

15.3.5 Suspension Stops

Provide lateral, longitudinal, and vertical suspension stops with replaceable elastomeric cushions:

1. Function: will not engage under normal operations but will limit maximum vehicle-body and truck motions under maintenance or suspension failure conditions.
2. Performance: Dimensions and developed forces will limit motion to within clearance requirements.
3. Vertical suspension stops: May be incorporated into vertical dampers or other suspension elements.

15.3.6 Wear Adjustment

The truck design will allow for vertical mechanical adjustment of the primary or secondary suspension to compensate for maximum wheel wear and wear or settlement of other truck parts:

1. Adjustments will be made with standard shop maintenance equipment.
2. Adjustments will not impair the operation of the truck.
3. Adjustment at any level will not cause the vehicle to exceed the Specified dynamic envelope.

15.3.7 Load Compensation Sensors

The truck will incorporate the load sensors and other devices necessary to meet the load compensation requirements Specified in this Section and Section 4 Design and Performance Criteria.

Transducers will not be mounted to the truck frame or bolster.

15.4 Truck Frame and Bolster

15.4.1 General Requirements

Comply with the following:

1. Truck type: Inboard frame, to facilitate wheel tire replacement, or outboard frame.
2. Truck frame and bolster design:
  - a. Service-proven.
3. Fabrication: By welding, casting, or a combination of the two.
4. Drainage: Provide where pockets or partially enclosed spaces exist so that no moisture collects anywhere within the truck frame and bolster.
5. Accessibility: Threaded fasteners, adjustment points, and structurally critical locations will be accessible for inspection and work using conventional means and tools.

15.4.2 Connection

Comply with the following requirements for connection between vehicle body and trucks:

1. Positive and safe mechanical connection such that the trucks can be raised with the vehicle body without disengaging any part of the suspension system.
2. Strength of the connection will comply with Section 3, Vehicle-Body Structure.
3. See Truck Removal section, above.

## 15.5 Journal Bearings

Comply with the following:

1. Type: Grease lubricated, tapered or spherical roller bearings.
2. Application: There will be no sliding surfaces involved in the method of retaining the journal bearings in their proper positions.
3. Inspection or service: None requiring disassembly before a major truck overhaul.
4. ABMA L10 rating life: Minimum 1,600,000 km (994,194 mi) at AW3 vehicle weight with the shock and impact loads typical of rail vehicle service.
5. Service-proven: For use in a similar rail vehicle.

## 15.6 Wheels

### 15.6.1 Description

Comply with the following:

1. Type: Resilient wheel with a steel tire and steel center (hub).
2. Tire material: Comply with ASTM A551/A551M Class DHT.
3. Maintainability: Tire will be replaceable by bolted connections and will not require pressing off any axle components.
4. Rating: The wheel and tire assemblies will be rated by the manufacturer for continuous operation at vehicle weights up to and including AW4.
5. Wheel Diameter and Wear: See Section 4 Design and Performance Criteria, for requirements.

### 15.6.2 Conductive Path to Rail

Comply with the following:

1. Function: The wheel assembly will serve as the interface for electrically connecting the vehicle to the running rails for the following purposes:
  - a. Safety ground.
  - b. Return of propulsion and auxiliary current.
  - c. Shunting of signal system track circuits from rail-to-rail.
2. Capacity: Sufficient to conduct Specified currents via minimum three external shunts per wheel, between hub and tire.
3. Current path: Ensure that journal bearings are isolated from shunting currents.
4. Shunting Resistance:
  - a. Full length axle wheelset: Maximum 0.01 ohm, measured from tire tread to tire tread.
  - b. Stub axle wheelset: Maximum 0.05 ohm, measured from tire tread to tire tread, including wheel, tire, and axle assemblies, ground brushes and cables, and all connections.
  - c. Wheel tread to axle/stub axle: 0.005 ohm.
  - d. Measurement: See Section 18 Vehicle and Systems Testing, for resistance routine tests.

## 15.7 Axles

Comply with the following:

1. Axles will withstand static and dynamic stresses expected in revenue service:
  - a. Standards: European standards EN 13103 for non-powered axles, EN 13104 for powered axles, or other railway-specific axle design standards as Approved by the City.
  - b. Dynamic loads for axle design: Minimum in accordance with the Fatigue Design section, below.



2. Axle fatigue life: Meet the minimum service life requirements of Section 4 Design and Performance Criteria.

## 15.8 Wheel and Axle Assembly

Comply with the following:

1. Assembly:
  - a. Fit wheels, bearings, and ground brush ring to the axle by pressing or mounting.
  - b. Fit tolerances and pressing forces will be as recommended by the equipment manufacturers.
2. Records:
  - a. Furnish pressure graphs of all gear coupling, disc hub, grounding ring, journal bearing, and wheel-to-axle pressings.
  - b. The graphs obtained for the wheel pressing will meet the requirements described in AAR RP-631 (AAR MSRP, Section G-II), Section 2.3, "Wheel Mounting Press Practices," subsection 2.3.5, and Standard RP-633, alternative standards or work instruction may be proposed, as Approved by the City, including the following figures:
    - i. Figure 4.19, Identification of wheel fit pressure diagram
    - ii. Figure 4.20, Constructing and using a typical wheel mounting template.
    - iii. Figure 4.21, An example of an ideal mount
    - iv. Figure 4.22, Example of an acceptable amount
    - v. Figure 4.23, Example of an acceptable mount
    - vi. Figure 4.24, Example of a misfit where the final tonnage is not concise.
    - vii. Figure 4.25, Example of a misfit whose peak tonnage exceeds the minimum tonnage.
    - viii. Figure 4.26, Example of a misfit where tonnage does not build up to the 75% fit line.
    - ix. Figure 4.27, Example of a misfit caused by an obstruction or by excessive positive taper.
    - x. Figure 4.28, Example of a misfit indicating an alignment problem.
3. Wheel and axle assemblies will be fully interchangeable and will be interchangeable between powered trucks and non-powered trucks, if provided.

## 15.9 Track Brake Support

Comply with the following:

1. Track brakes will be supported from the journal bearing housings.
2. The track-brake support arrangement will maintain positive lateral alignment of the track brake with the running rail.
3. Track brake forces will be transmitted to the truck frame as near to the top-of-rail as practical to minimize moment imposed on the track-brake unit.

## 15.10 Safety Bars

Comply with the following:

1. Purpose: To deflect pedestrians or foreign objects and prevent them from being run over by the trucks.
2. Location: At the outboard ends of trucks:
3. Dimensions:
  - a. Width: 1700 mm (66 in), or the lateral extent of truck components, whichever is greater

- b. Height: 150 mm (6 in)
4. Mounted Clearance:
  - a. Maximum: 100 mm (4 in) to top of rail when all truck parts are new
  - b. Minimum: 50 mm (2 in) for the worst-case combination of conditions Specified in the Clearance Requirements section, above
5. Strength: will withstand a horizontal force of 2200 kN (500 lbf) applied at the center.
6. Maintainability: Arrange and mount for replacement with common hand tools.

#### 15.11 Flange Lubricators

Comply with the following:

1. End trucks: Equip with wheel flange lubricators for wheels on the lead axle, or other configuration as Approved by the City.
2. Center truck (if provided): Equip with wheel flange lubricators on at least one wheel on both sides of the truck.
3. Location: Install each lubricator such that it provides friction modifier material between the flange of the wheel and the rail.
4. Material: Applicator components will be stainless steel.
5. Interchangeability: Lubricator sticks and applicators used for the end and center trucks will be identical.

#### 15.12 Design Calculations

##### 15.12.1 Design Loads

###### *Maximum Load Variation*

The truck frame and all truck parts will be capable of withstanding the maximum load variation imposed by the forces acting on the frame, in addition to the loads identified elsewhere in the TS. Truck parts include the following:

1. Motor
2. Gear unit
3. Friction and track brake equipment supports.
4. The basis for determining maximum load variation will include forces resulting from the following:
  5. Passenger load
  6. Track shocks and forces
  7. Motor torque
  8. Friction brakes
  9. Track brakes
10. Any possible combination of these forces when operating under all possible conditions on track meeting the minimum requirements of 49 CFR 213 Class 4 track.

###### *Static Strength Design Condition*

The static strength design condition for the truck frame and bolster will be based on the truck's share of a design load weight equal to the AW4 weight minus the weight of the truck.

###### *Vertical Load*

The minimum vertical load on the truck will be the truck's share of the design load, augmented by the weight transfer affects such as tractive effort reactions.

#### Longitudinal Load

The minimum longitudinal load, applied at the center of gravity of the vehicle, will be the maximum possible instantaneous braking effort (friction and dynamic plus track brake) with AW4 loading and 50% adhesion.

#### Lateral Load

The minimum lateral load, applied at the center of gravity of the vehicle, will be that developed at vehicle overturning.

#### Accessory Loads

Accessory loads, such as those from brake units, track brakes, and traction motors, will 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.

#### 15.12.2 Maximum Allowable Stresses

Under the above load conditions, the maximum stresses at any location in the truck frame and bolster will not exceed 50% of the yield strength of the material.

Exception: Local zones greater than allowable will be reviewed on a case-by-case basis if it does not affect the overall stability of the truck. Based on this review, the City will determine the acceptability of these areas.

#### 15.12.3 Fatigue Design

The fatigue design of the truck frame and bolster will be based on the above conditions with a design load equal to the AW2 weight minus the weight of the trucks. Loads on the truck will be as follows:

1. Vertical load: The mean vertical load will be the truck's share of the design load; the vertical load will vary about the mean vertical load by plus or minus 25%.
2. Lateral load: will 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.
3. Longitudinal load: will vary between 15% of the mean vertical load acting towards one end of the truck and 15% of the mean vertical load acting towards the other end of the truck.
4. The lateral and longitudinal loads will act as if they were applied at the center of gravity of the vehicle body at AW2 with resulting vertical loading applied to the bolster or truck frame as appropriate.
5. Accessory loads: will vary between plus or minus 100% of their maximum steady-state values:
  - a. Motor under maximum braking torque; and
  - b. Brake unit tractive effort reaction under MSB application with minimum 50% adhesion; plus
  - c. Maximum track brake tractive effort load.
6. Loads will be applied with the phasing to produce the worst possible stress combination. Under these conditions, stresses will not exceed the allowable fatigue values.

#### 15.12.4 Fatigue Allowable Stress Levels

Fatigue allowable stress levels for truck materials will not exceed the following:

1. Published endurance stress values for smooth, flat, tension-tension specimens; or
2. Recent Contractor tests with sufficient individual tests to establish the endurance stress value for 95% survival at the 84% confidence level, as defined in ISBN: 978-0871700148, ASM Metals Handbook, 9<sup>th</sup> Edition, Volume 8: Mechanical Testing, "Fatigue and Fracture," pages 695-720.

(Note that this is a description of the statistical treatment of the fatigue data; the Contractor is responsible for finding or developing data to establish the fatigue properties.)

3. Fatigue allowable stress levels for welded connections will not exceed the following:
4. Requirements of AWS D1.1/D1.1M for dynamic structures; or
5. Contractor tests of the specific connection establishing its endurance stress (load) value for 95% survival at 69% confidence level.

#### 15.12.5 Non-U.S. Standards

Standard EN 13749, or other standards, may be permitted at the discretion of the City as a basis for design conditions of the trucks, if it is shown that the truck design conditions will aim to produce a truck that meets the more severe track conditions, speeds, and truck weights in the U.S.

However, the requirements for strength of the truck-to-vehicle-body connection Specified in Section 14 Carbody, may not be modified or waived.

#### 15.12.6 Stress Analysis

##### Scope

Comply with the following:

1. As a minimum, the stress analysis will consist of an FEA of the global structure and a classical analysis of all connections, supplemented as necessary by manual or computerized calculations.
2. Perform a stress analysis of the end truck frame and bolster and the center truck assembly. Show the calculated stresses, allowable stresses, and margins of safety for all elements for all Specified loading conditions.
3. Update the analysis as the truck design proceeds.
4. Perform a separate analysis of welds and welded connections on the finished truck frame, including welds attaching brackets, studs, and holders for truck accessories.

##### Service Proven Design

The Contractor may submit data from previous tests, historical data from operations, or stress analysis, as required above, to satisfy the corresponding portion of these requirements, only for those portions of the proposed designs that meet each of the following conditions:

1. Based on a service-proven truck, as defined in Section 1, General Topics and Definitions.
2. Fabricated by the same manufacturer at the same manufacturing facility.
3. Approved by the City.

##### Testing

The information derived from the stress analysis will be used to determine strain gauge locations and other criteria for truck tests (see Section 18 Vehicle and Systems Testing).

#### 15.13 Truck Painting

Paint all truck components except components specifically excluded below, in accordance with Section 19 Materials and Workmanship. See Section 6 Interior and Exterior Appointments, for paint color.

The following truck-related items will not be painted:

1. Wheels
2. Axles
3. Elastomeric parts
4. Grease fittings
5. Linkages

6. Threads used for adjustments.
7. Electrical equipment
8. Wearing surfaces

#### 15.14 Serial Numbers

Provide permanent identification for each component as follows:

Truck frame:

Serial number plate: Permanently attached and located in a conspicuous place.

Figure size: Minimum 20 mm (0.8 in) high.

Wheels: Mark according to ASTM A551/A551M or other Approved standards body.

Hubs: Mark according to AAR M-107/M-208 or other Approved standards body.

Axle: Mark with information required by AAR M-101, or other Approved standards body.

Other truck components: Serialize as required in Section 19, Program Control and Quality Assurance.

#### 15.15 Contract Deliverables Requirements List (CDRL)

##### 15.16 CDRL Detail

Submit the following in accordance with Section 2 Program Control, Deliverables and Quality Assurance.

Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

##### 15-1 Truck Design Package

##### 15-2 Truck Clearance Design Package:

1. Drawings showing truck clearances under the Specified worst-case conditions, with sufficient detail to demonstrate that Specified clearances have been achieved.

##### 15-3 Truck-to-Vehicle-Body Connection Design Package:

1. Calculations demonstrating vehicle-body-to-truck connection strength meets requirements of Section 3, Vehicle-Body Structure.
2. Instructions for de-trucking and re-trucking on flat tracks with portable jacks, including diagrams.
3. Details of lifting tools provided for de-trucking and re-trucking, if required by design.

##### 15-4 Suspension Design Package

##### 15-5 Journal Bearings Design Package:

1. Data sheet on proposed bearing type.
2. Journal bearing L10 life calculation.
3. Sufficient data to demonstrate that the proposed bearings are service proven.

15-6 Axle Strength Design Package:

1. Submittal will be furnished by the axle manufacturer.
2. Proposed material specification and manufacturing requirements per AAR M-101, EN 13261, or equivalent standard.
3. Strength calculations for axles:
  - a. Load diagram.
  - b. Static and dynamic stress calculations for the axles that show, at a minimum, the maximum value of stresses to which the axles are expected to be subjected in service.
4. Fatigue life calculations:
  - a. Prediction of axle's fatigue life using cumulative damage (or other Approved) calculation method.
  - b. Consideration of effect of bending loads induced by the presence of restraining rails in the axle bending fatigue stress calculations.

15-7 Wheel-Axle Assembly Design Package:

1. Axle press fitting procedures for all components pressed onto the axle.
2. Pressure graphs:
  - a. Gear coupling, disc hub, grounding ring, journal bearing, and wheel-to-axle pressings.
  - b. Before submitting, confirm that graphs are within the limits recommended in the AAR's Wheel and Axle Manual, as required by this Section.

15-8 Flange Lubricator Design Package:

1. Data sheets on lubricator sticks and applicators.

15-9 Truck Stress Analysis and Testing Plan:

1. Truck Stress Analysis and Testing Plan must be Approved before submittal of Truck Stress Analysis Report.
2. Contractor's chosen static and fatigue allowable values, whether published or test values.
3. Outline of the procedure to be used to analyze and test the design of the truck.
4. Table of loads to be used for static analysis and test, with load magnitudes and points of application.
5. Derivation of the static loads to be applied.
6. Table of loads to be used for fatigue analysis and test, with load magnitudes, points of application, and phasing.
7. Derivation of the fatigue loads to be applied.
8. Diagrams of load applications.
9. Table of allowable stress levels.

15-10 FEA Model Package:

1. Submit and receive approval of the FEA Model Package before performing the FEA and submitting the Truck Stress Analysis Report.

2. FEA input data on electronic media as Approved by the City.
3. Element grid, assumptions, and input data, such as loads, section properties, boundary conditions and material properties.
4. Boundary reaction forces of the truck under its own weight.
5. Key to symbols and colors.
6. Format:
  - a. Number each page, and clearly label columns of data on each page.
  - b. Define terms, symbols, abbreviations, and units.

15-11 Truck Stress Analysis Report:

1. Submit after receiving approval for the Truck Stress Analysis and Testing Plan and the FEA Model Package.
2. Submit before truck frame static load test and fatigue endurance test.
3. Format:
  - a. Include a Table of Contents.
  - b. Number each page, and clearly label columns of data on each page using terms defined in the analysis.
4. Include the following as a minimum:
  - a. Structural diagram (layout) of the truck frames and bolster showing member locations and shapes and indicating the material and thickness of each.
    - i. Completely define the methods of joining, including AWS D1.1/D1.1M weld classifications for fatigue for all welds.
    - ii. Clearly show connections between the truck, bolster, and vehicle body.
  - b. Diagrams displaying external loads and supports applied to the truck frames and bolster.
  - c. Summary of the results of calculations of stresses in all members:
    - i. Show in a separate table the locations where calculated stress levels equal or exceed 85% of the allowable stress criteria Approved by the City in CDRL 11-8, Truck Stress Analysis and Testing Plan, along with the design or operating conditions (loads) that cause them.
    - ii. Calculated stresses will be supported, where available, by the results of actual tests of trucks of identical design.
  - d. Analysis of all critical connections of the truck frames and bolster major structural elements under all Specified loading conditions.
  - e. For the truck frame and bolster members that are fatigue critical, include a tabulation of the Contractor's selection of allowable truck frame and bolster static and fatigue stresses and assumed applied fatigue stress ranges. Allowable stress levels will be substantiated by the Contractor's test data or by citing published sources.

- f. Critical welds including, 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.
- g. Table showing the engineering properties of each grade and temper of each material:
  - i. Include the material designation, yield strength, ultimate strength, elongation, Young's modulus for tension and compression, and shear elastic moduli.
  - ii. In each case, use minimum-guaranteed values from the TS for the corresponding grade and heat treatment of the material.
- 5. FEA portion of the report:
  - a. FEA output data on electronic media as Approved by the City.
  - b. Element grid, all assumptions, and all input data, such as loads, section properties, boundary conditions and material properties.
  - c. Color plots showing the following:
    - i. Deflections in all three axes separately plotted and imposed over the deflected shape.
    - ii. Von Mises, or other Approved combination stresses
    - iii. Maximum and minimum principal stresses
    - iv. Direction of maximum and minimum principal stresses
    - v. Meshing accuracy index
    - vi. Locations of strain gauges, shown on plots of the FEA truck and bolster mesh with dimensions

15-12 FEA Input and Output Data:

- 1. In addition to submitting FEA input data with the FEA Model Package, submit the input files each time the files are changed, but not more often than monthly.
- 2. In addition to submitting FEA output data with the Truck Stress Analysis Report, submit the output files each time the files are changed.
- 3. Submit on electronic media as Approved by the City.
- 4. Criteria for final approval of the Truck Stress Analysis Report include submittal of the fully configured input data files.
- 5. Each revision will be accompanied by detailed revision notes that explain each change and indicate where changes were made in the report because of the change.

15-13 Welding Analysis Report:

- 1. Fatigue classifications of each weld according to AWS D1.1/D1.1M.
- 2. Drawings of truck welding locations, or FEM mesh plots with the welding locations indicated, with the AWS classification indicated.

15-14 Service Proven Design:

- 1. For a service-proven truck, submit data from previous tests, historical data from operations, or stress analysis.
- 2. Include a summary stating specifically what portions of the submittal requirements are intended to be satisfied by the submitted material.



## Section 16 Brake Systems

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## 16.1 General

### 16.1.1 Scope

Provide a spring-applied, hydraulic-release friction brake system. The friction brake system includes disc brakes, disc brake actuators, calipers, track brakes, sanders, electronic control units, hydraulic pressure control unit, and related components.

### 16.1.2 Configuration Options

Comply with the following:

1. Control: Friction brake controls may be independent or embedded in the propulsion system.
2. Load-Weigh System: Equipment and controls may be part of the friction brake system.

### 16.1.3 System Description

Friction braking will be arranged as a physically and functionally independent system for each truck on the vehicle. The friction disc brake system will perform the following basic functions:

1. Perform service and emergency braking in the event of dynamic brake failure.
2. Perform emergency braking with the assistance of dynamic brakes, track brakes and sand.
3. Act as a parking brake system.
4. Supplement dynamic braking on a per powered-truck basis, to provide the requested service braking efforts in all cases where dynamic braking is not providing the requested efforts.

### 16.1.4 Performance Requirements

Comply with the following:

1. See Section 4 Design and Performance Criteria, for brake performance requirements, and performance related to sanding.
2. The friction brake system will have the thermal capacity to operate continuously with the duty cycles Specified in Section 4 Design and Performance Criteria.
3. Complete disc brake release will be achievable at all vehicle speeds down to zero, and under the worst-case combination of LVPS or battery voltage, reservoir fluid level, accumulator charge, and ambient temperatures.

### 16.1.5 Power Sources

All friction brake equipment will operate from the vehicle's low-voltage dc power system, except as may be permitted below.

### 16.1.6 Audible Noise

The disc brake rotor, caliper, and pad assembly will not emit audible squeal, chatter, or other undesirable sounds.

## 16.2 Components

### 16.2.1 Configuration

Comply with the following:

1. For through-axles, provide at least one brake disc and caliper per axle. For stub axles, provide one brake disc and caliper per wheel.
2. Provide two track brakes for each truck.
3. Provide sanding on each truck.

16.2.2 Disc Brake Rotor and Hub

Comply with the following:

1. Type: Split disc, retained by bolted connection. Non-split disc maybe proposed where installed outside of the truck frame, as Approved by the City
2. Durability: will resist warping and cracking due to thermal stress resulting from the Specified duty cycle.
3. Wear indication grooves: Provide on both edges of each disc brake rotor to indicate the minimum allowable thickness.

16.2.3 Actuators and Calipers

Each disc brake rotor will be equipped with a spring-applied, hydraulic-release brake actuator:

1. Each caliper will act as a parking brake by removal of hydraulic pressure.
2. The brake actuator will include an automatic slack adjustment feature, which will compensate for brake pad and disc rotor wear as well as assure drag-free running.
3. Brake actuators will be mounted to floating calipers designed as follows:
  - a. To follow the disc brake rotor regardless of lateral disc brake rotor motion.
  - b. To accommodate all other relative motions between the disc brake rotor and the caliper to maintain full brake pad engagement with the disc brake rotor, and prevent binding, accelerated wear, or damage to truck or brake components.
4. Actuators and calipers will be interchangeable:
  - a. Powered truck: Among all powered truck axles.
  - b. Non-powered truck: Among all non-powered truck wheel-axle assemblies.

16.2.4 Brake Pads

Brake pads and holders will be designed for quick pad replacement without disassembly of the caliper unit. Brake pads will be interchangeable among all axles of the same type.

16.2.5 Hydraulic Pressure Control Units (HPCU)

*General*

Provide each truck with an independent hydraulic pressure control unit (HPCU):

1. It will include the following:
  - a. Hydraulic fluid reservoir and accumulator
  - b. Motor-driven pump
  - c. All necessary control valves and pressure transducers
2. Function: will control hydraulic pressure to the brake calipers in response to commands from the brake control units.
3. Location: Adjacent to their respective trucks, in an area protected from dirt, dust, wheel splash, and unusual heating conditions, such as cooling air outlet from propulsion equipment or radiant heat from brake discs, to prevent damage.
4. Mounting: Onto the vehicle structure, via resilient mounts.

*Reservoir and Accumulator*

Provide accumulator hydraulic storage capacity as follows:

1. Sufficient to allow at least three EB applications after loss of hydraulic pump power:
  - a. Assume accumulator hydraulic volume is at its normal minimum level at the time of power loss.

- b. Brake application and release will be as follows:
  2. MSB level for an AW1 vehicle weight
  3. Brakes will be applied for at least 30 seconds per application and released for 2 minutes between applications.
  4. Normal brake modulation will be available.
  5. The required capacity will be available under all Specified environmental conditions.

#### Hydraulic Pump

Comply with the following:

1. Hydraulic pumps may be powered by the low-voltage dc system via brushless dc motors, or via three-phase induction motors powered from auxiliary inverter.
2. See Section 12 Electrical Equipment, for general electrical and failure management requirements.

#### 16.2.6 Pressure Transducers

Comply with the following:

1. Provide pressure transducers for control, feedback, testing, and the failure monitoring system. Pressure switches are not permitted, except as necessary to transmit system information to the MDS and TOD upon loss of electronic controls.
2. Transducers will be low drift, temperature compensated devices that operate for a minimum of five years without requiring calibration.
3. Transducers will be powered from isolated power supplies and will not interface directly with vehicle battery-level circuits.

#### 16.2.7 Parking Brake

Comply with the following:

1. The parking brake will be inherent in the caliper design. See this Section. Parking brakes will be controlled by application and release of the service brakes.
2. The parking brake control signal will be configured to release the parking brakes when energized.
3. A parking brake applied anywhere on a vehicle will inhibit propulsion and brake release indications.

#### 16.2.8 Disc Brake Cutout

Provide a means for manual release of the brakes from the side of the vehicle, or via other Approved methods, as follows:

1. One hydraulic cutout per truck.
2. Individual mechanical cutout for each caliper.

#### 16.2.9 Track Brakes

Comply with the following:

1. Performance: The electromagnetic track brake system will be effective at all speeds from vehicle design speed down to zero speed, over all conditions of curves and grades.
2. Environmental:
  - a. Track brakes will be fully watertight.
  - b. Coils will be enclosed in a non-magnetic, corrosion-resistant case with coil voids filled to form a hermetically sealed unit.
3. Mounting:
  - a. Track brake forces will be transmitted to the truck through bonded rubber elements.

- b. The City will consider track brake mounting that enables quiet operation but does not require rubber elements.
4. Rail Contact: Wear surfaces will be smooth and will not wear grooves or ridges in the rail head throughout the life of the track brake shoe.
5. Maintainability:
  - a. If it is necessary to remove the track brake to renew the rubber elements, they will be applied to the track brake assembly rather than the truck.
  - b. Track brake shoes and the pole filler material will be readily replaceable.
  - c. Make provision for adjustment to maintain proper clearances.
6. Clearance:
  - a. Track brakes will not interfere with track, wayside, or truck components under all normal conditions and combinations of wear.
  - b. In the area between the railhead and 51 mm (2 in) above top of rail, the track brake will not extend laterally beyond the wheel-tire cross section with fully worn track-brake shoes.
7. De-energized state:
  - a. The track brake will be suspended above the rail by springs and will be located laterally by resilient stops.
  - b. Track brake motion while suspended will not produce audible noise under any normal operating condition.
  - c. Vertical clearance above top of rail, when de-energized, will be maintained under all loading conditions.
8. Electrical:
  - a. Coils will be electrically isolated from grounds and will be terminated in a built-in two-pin connector or other Approved connection.
  - b. The track brake will include a freewheeling diode.
  - c. Connection to vehicle wiring will be via flexible cable with waterproof connectors at both ends.
  - d. Provide a separate track brake contactor and circuit breaker for each truck.
  - e. Tripped or open track brake circuit breakers will cause annunciation of a friction brake fault and will be logged in the MDS.

#### 16.2.10 Electronic Control Unit (ECU)

Unless control is via the propulsion system, provide an independent friction brake ECU for each truck. Comply with Specified electrical requirements and Section 7 Electronic Controls, Software, and MDS.

### 16.3 Controls

#### 16.3.1 General

The friction brake system will include microprocessor-based controls (Braking Control Unit, or BCU) on a per-truck basis:

1. Each BCU will independently read master controller and other signals from the controlling cab and the propulsion controls. The BCU will calculate and apply the requested brake effort.
2. Each BCU will connect to the vehicle data network, transmit system status, and perform fault logging.
3. If friction brake controls are embedded in the propulsion ECU, then similar friction brake status and fault logging will be provided within the propulsion system design.

4. Emergency braking will be caused directly by hard-wired signals from the Cab Console to all brake control valves, track brake contactors, and sanding controls, and will not be processed by the BCU, except for monitoring purposes.

#### 16.3.2 Dynamic Brake Interface

A dynamic brake signal from the propulsion system will be used by each BCU to modulate disc brake effort in response to the dynamic braking effort on that truck, such that the requested brake effort is produced regardless of the status of dynamic braking:

1. The propulsion and friction brake suppliers will jointly determine the characteristics of this signal.
2. If the disc brake control logic is within the propulsion system, the propulsion control ECU will calculate the required disc braking effort to produce the requested level of effort within Specified tolerances.

#### 16.3.3 Load Compensation

Comply with the following:

1. The friction brake system will use the signals from the load measuring system on each truck to adjust disc brake efforts according to passenger load, on a per truck basis.
2. In the event the load compensation signal is not within the allowable range, the system will default to the value of the nearest healthy truck and notify the operator through the MDS system.
3. The friction brake system may include the equipment and controls for the load measuring system and may send processed load signals to the propulsion system.

#### 16.4 Disc Brake- Propulsion System Interlock

Comply with the following:

1. Interlock the disc brake system with the propulsion system such that propulsion is removed if any disc brake remains applied on any truck for more than a designated time after the application of propulsion.
2. Initial setting: 7 seconds.
3. Time value: Adjustable in software and optimized during vehicle testing.

#### 16.5 Sanding System

Comply with the following:

1. Sander type:
  - a. Pneumatic with integral compressors. Separate compressors may be considered by the City for approval as an alternative. The compressor will be oil-less and maintenance-free except for input filter cleaning.
  - b.
2. Control:
  - a. Automatic application:
3. Sand will be automatically applied during emergency braking and during severe wheel spins or slides.
4. Sanding will be interlocked with the no-motion detection circuitry and disabled below the no motion detection point.

5. Manual application: Possible only if a vehicle direction is selected but will not be interlocked with the no-motion detection point.
6. Electrical:
  - a. Power source: Low-voltage dc system for all sander functions, including heaters and compressors.
  - b. Circuits: Feed sanders for each truck from a separate circuit breaker, which will also function as the sander cutout switch.
  - c. Friction brake fault: Annunciate on tripped or open breaker.
7. Sand boxes:
  - a. Quantity: Eight
  - b. Location: Suitable to feed sand to each wheel of powered trucks, as Approved by the City.
  - c. Material: Stainless steel or aluminum
  - d. Capacity: Minimum 15 liters (4 gallons) per box
  - e. Configuration: Slope sandbox bottom towards the floor outlet with the slope angle greater than the angle of repose of the sand, such that all sand in the box can be dispensed
  - f. Environmental protection:
8. Seal to prevent moisture and debris ingress.
9. Heat to keep sand dry from condensation.
10. Filling:
  - a. Sight gauge: Provide one for each sandbox, visible from inside vehicle, to indicate sand level. Alternative solutions maybe proposed for Approval by the City.
  - b. Filling portal: Arrange sandbox to permit easy filling from inside or outside vehicle.
11. Output:
  - a. Through piping or hose selected and arranged to permit the free flow of sand to the nozzles under all conditions of environment and truck motions
  - b. Tees, elbows, or other restrictive fittings will not be used.
12. Sanding nozzles:
  - a. Fastened to the truck frame.
  - b. Shaped and located to deposit sand directly in front of and as close as possible to the wheel/rail contact point of each leading wheel of powered trucks for both directions of operation.
  - c. Designed to reject water caused by wheel splash.
  - d. will not clog under any Specified environmental conditions.
13. Flow rate: Approximately 0.45 kg/min (1 lb./min), adjustable by shop personnel by minimum +/- 25% of the nominal setting.

## **16.6 Contract Deliverables Requirements List (CDRL)**

Submit the following in accordance with Section 19, Program Control and Quality Assurance. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.

### **16-1 Friction Brake System Design Package:**

1. Description of friction brake system

2. Details of parking brakes
3. Description of EB application
4. Hydraulic fluid specifications
5. Details of truck cut-out and mechanical brake release
6. Outline drawings and mounting of major components.
7. Hydraulic system schematics

16-2 Track Brake Design Package:

1. Data sheets on track brake components with sufficient detail to demonstrate that Specified requirements have been satisfied.
2. Outline drawings of overall system
3. Illustrations demonstrating how to replace track brake shoes, pole filler material, and bonded rubber elements.
4. Illustrations demonstrating how to adjust and maintain proper clearances.

16-3 Friction Brake Control Design Package:

1. Hardware and software functional description, including all interfaces and their interdependencies.
2. If friction brake control is accomplished by propulsion equipment, demonstrate that sufficient information from the friction brake supplier is furnished on the following:
  - a. Friction brake physical and electrical characteristics
  - b. Transfer functions
  - c. Network communications
  - d. All other aspects necessary to achieve Specified performance.
3. Interfaces with propulsion system
4. Hardware design description

16-4 Friction Brake Run Time Simulations:

1. Verification of the thermal capacity of the brake equipment under the Specified duty cycle.
  - a. Input assumptions.
  - b. Ambient temperature assumptions.
  - c. Level of braking assumed on extended downgrades in degraded modes.
  - d. Speed/time/distance plots of the vehicle on the City alignment.
  - e. Temperature predictions (or actual test results) for all equipment, including brake discs, pads, and similar.
2. Normal duty cycle:
  - a. Perform at AW3 loading over the City alignment.
  - b. Show traction disc and pad duty cycles.
  - c. All simulations will use distance as the x-axis and will indicate, at a minimum, all station stop locations.
3. Abnormal Duty cycle:



- 1                   a. Selected abnormal duty cycle.
- 2                   b. Perform run time simulation showing traction motor, IGBT and brake resistor duty cycles
- 3                   for the abnormal duty cycle.
- 4 16-5 Sanding System Design Package:
- 5       1. Data sheets on system components
- 6       2. Outline drawings of overall system
- 7 16-6 Friction brake redistribution scheme:
- 8       1. For EB and slide controlled braking
- 9       2. During dynamic brake failure (if applicable)

## Section 17 Coupler

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## 17.1 General

### 17.1.1 Purpose

Provide coupling devices to allow one vehicle to tow or push another vehicle under emergency conditions.

### 17.1.2 Description

The coupler system will be an automatically- or manually operated, storable unit with resilient draft gear, presently in use on similar vehicles for the same purpose.

### 17.1.3 Compatibility with Existing Vehicles

The coupler must be mechanically compatible with the City's existing vehicle fleet for towing or pushing.

## 17.2 Geometry

The coupler system will permit vehicles to operate over track profiles Specified in Section 4 Design and Performance Criteria, including the following conditions, without damage or stress outside the system design limits:

1. Worst-case combination of horizontal and vertical curves, superelevation, track wear, and track misalignment.
2. Variations between adjacent vehicles resulting from uneven loading, wheel wear, maximum suspension travel, and suspension failure.

## 17.3 Mechanical Coupler

### 17.3.1 Coupler Head

Comply with the following:

1. Purpose:
  - a. Acts as the connecting mechanism between two couplers.
  - b. Includes devices necessary to safely lock coupler heads together when coupled.
2. Shape:
  - a. Allows for vertical and lateral misalignment between coupler heads.
  - b. Allows self-alignment with the mating coupler when the couplers are brought together during a coupling operation.
3. Coupling:
  - a. Manual coupling: Mechanism will be engaged by inserting a pin, throwing a latch, or similar manual process; or
  - b. Automatic coupling: Coupler heads may latch automatically.

### 17.3.2 Lateral Stops

Provide lateral stops as follows:

1. Purpose: To positively limit lateral coupler swing and prevent damage to the vehicle-body structure and other equipment if the vehicle is operated with the coupler unstowed.
2. Strength: Sufficient to withstand the impact loading of the coupler, without damage, when it is accelerated from one stop to the other, at the maximum lateral acceleration possible on the Specified right of way.
3. Failure: Design the stop to fail before the structure to which it is attached.
4. Maintainability: Bolted to the vehicle structure to facilitate replacement after accident damage.

**17.3.3 Strength**

Comply with the following:

1. The coupler, coupling mechanisms, and draft gear will be capable of withstanding buff or draft loads of not less than 133% (or tested to 110%) of the maximum forces experienced during coupling, towing, or pushing, with no permanent deformation.
2. The coupler assembly strength will be sufficient to meet the towing requirements and operational requirements Specified in Section 4 Design and Performance Criteria.

**17.3.4 Draft Gear and Anchorage**

Comply with the following:

1. Draft gear:
  - a. Rubber cushioning: Provide in both buff and draft.
  - b. Resilient mounting: Provide in the vertical direction to maintain nominal coupler height above top of rail.
2. Supporting device at coupler anchor point:
  - a. Will maintain coupler and draft gear assembly at the Specified coupler height above top of rail.
  - b. Will allow a means of vertical height adjustment of the coupler head to compensate for vehicle and coupler variations and wear.
3. Coupler assembly mounting: will be bolted to the vehicle structure under the cab floor.

**17.3.5 Coupler Storage**

When not in use, the coupler will fold or retract under the vehicle behind a removable or hinged cover:

1. Operation: The storage mechanism will permit a maintainer to manually deploy and stow the coupler with minimal physical effort.
2. Operating position lock:
  - a. Provide a device to lock the coupler into its operating position, and to release the coupler for storage.
  - b. The device may be integral to the coupler mechanism, or a separate device. If separated, it will be stowed on the coupler.
3. Stowed position lock: Retain the coupler assembly rigidly in its stowed position to prevent movement due to vehicle motion.

**17.4 Electrical Connections**

Provide a connector, wiring, and related hardware for a temporary electrical connection for communication between vehicle cabs.

1. The connection may be made manually or automatically.
2. The arrangement will allow for all coupler motions without damage to connectors or wiring.
3. The connectors and wiring system will be watertight and meet the multi-pin connector requirements of Section 16, Materials and Workmanship.
4. Provide a watertight cap to protect the connector when not in use. The cap will be retained by chain, lanyard, or similar device when not applied.

**17.5 Contract Deliverables Requirements List (CDRL)**

Submit the following in accordance with Section 17 Coupler. Include the following in each design package, if applicable, in addition to specific items listed below for each CDRL number:

1. Detail drawings: Top level assemblies, and other drawings if requested.
2. Functional description
3. Control schematics
4. Component ratings: Top level components, and ratings of other components if requested.
5. Software functional descriptions: Include top level control parameters and values.

**17-1 Coupler Design Package:**

1. Operating Description: Narrative describing how to deploy, couple, uncouple, and store coupler assembly.
2. General Arrangement Drawings: Show coupler components with dimensions
3. Detail Drawings: Include details of the draft gear, folding or storing mechanism, coupler head, and latching mechanism.
4. Material Properties:
  - a. Indicate the material used for each component, unless indicated on Detail Drawings.
  - b. Furnish data on properties of each material used.
  - c. Include coatings, lubrication requirements, and similar.
5. Strength Analysis:
  - a. Furnish sufficient information to demonstrate that the Specified strength requirements have been met.
  - b. If available, manufacturer's test data may be used for this purpose.
6. Electrical Connections:
  - a. Detail drawings with manufacturer's part numbers for standard parts.
  - b. Include connector material details.

## Section 18 Vehicle and Systems Testing

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18.1 General

18.1.1 Scope

Test the vehicle and all its components to verify compliance with Contract-Specified design, performance, reliability, and maintainability requirements:

1. Perform tests Specified in this Section as indicated unless specifically waived by the City.
2. Perform tests on production components without modification or special preparation.
3. Material test requirements may also appear in Section 19 .
4. Other test requirements may appear in other sections of the TS.

18.1.2 Equivalent Testing

Perform the tests included in this Section on equipment designed specifically for this Contract, unless equipment is accepted by the City as an existing, proven design:

1. Evidence of satisfactory completion of prior tests, as determined by the City, may be sufficient to meet the requirements of this Section, although certain tests must be performed regardless of prior testing.
2. The following will disqualify existing tests:
  - a. Design or material changes have been made to the items under test.
  - b. The items are produced in a different facility.
  - c. The requirements are different.
  - d. Reports of such equivalent testing are dated more than five years before NTP for this Contractor.

18.1.3 Witnessing and Notification

Comply with the following requirements:

1. The Contractor will be present at each Specified test.
2. Minimum 30 days before each test, notify the City in writing of the date, time, and location of the test.
3. The City may, at its option, witness all tests.

18.1.4 Test Classifications

The required tests are categorized as follows:

1. **Type Tests** will be conducted to demonstrate compliance with design requirements at operating and environmental extremes, and the TS.
  - a. These tests will be performed on selected production components, systems, and completed vehicles, at the highest level of assembly that will allow demonstration of design compliance.
  - b. Type tests are limited to the number of units needed to demonstrate design compliance, typically one or two.
2. **Routine Tests** will be conducted to demonstrate that each unit produced operates within Specified limits and is in compliance with the requirements of the TS.
  - a. These tests will be performed on each component, system, or vehicle included in the Contract.
  - b. Routine test requirements may vary from an inspection and functional demonstration for a simple component to full dynamic tests of a vehicle.
  - c. These tests are performed at ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation.

18.1.5 Test Procedures

Prepare and submit a detailed test procedure for each test described in the Master Test Plan (MTP), and for other tests conducted by the Contractor in connection with its own Quality Assurance program:

1. For each test procedure, include the following identifying information:
  - a. The number of the CDRL that will be satisfied by the test.
  - b. Each Specification section number relevant to the system or component under.
2. Submit with each test procedure the forms to be used to record data during the test. Include the following:
  - a. Step-by-step format for data reduction
  - b. Formulae used in deriving the format.
  - c. Criteria for acceptability
  - d. Justification for the criteria set forth.
3. Submit each detailed test procedure minimum 30 working days before the planned date of the test to allow the City to review and approve the procedure.
4. A test will not occur, and results are not considered valid, until approval of the test procedure by the City.

18.1.6 Test Reports

Submit test reports that follow the format of the test procedure.

1. Include the following in each test report:
  - a. The same identifying information required for the test procedure.
  - b. A description of the test
  - c. All raw data collected in the test.
  - d. All data reduction forms.
  - e. Summary of the results
  - f. Signature fields for individual conducting the test and witness, if applicable
2. Include test reports of routine tests in the appropriate Vehicle History Book.

18.2 Testing and Inspection Requirements

18.2.1 Insulation Testing

When an insulation test is Specified to be performed, comply with the requirements of IEEE Std 16, Section 5.9, Insulation Testing.

18.2.2 Non-Destructive Testing and Inspection

Where Specified or required, perform the following:

1. Magnetic Particle Testing: Perform in accordance with ASTM E709, using wet fluorescent particles. Inspections will be by personnel certified to NAS 410.
2. Dye Penetrant Inspection: Perform in accordance with ASTM E165/E165M, using fluorescent dye.
3. Radiographic Inspection: Perform in accordance with ASTM E94.
  - a. Castings: Use ASTM E446 reference radiographs.
  - b. Cast-weld designs: Use ASTM E390 reference radiographs.

18.3 Component Type Tests

18.3.1 General

Comply with the following:

1. Perform type tests at the manufacturer's facilities unless indicated otherwise in the TS.

2. Tests will demonstrate that the components or set of components are likely to meet Specified requirements when installed on the vehicle.
3. To the extent practical, test conditions will replicate worst case operating conditions of the application, such as ambient temperatures, voltage ranges, and other applicable conditions.
4. If, after the City's approval of a component type test, there are changes to product, design, production process, materials, or location of manufacture, another type test will be performed. The scope of the subsequent type test will be at the sole discretion of the City.

#### 18.3.2 Flammability, Smoke Emission, and Toxicity Type Test

Test all materials supplied for the vehicle to verify compliance with the flammability and smoke emission performance requirements of Section 16, Materials and Workmanship:

1. Flammability and smoke emission: Perform testing in accordance with NFPA 130, Chapter 8, Vehicles, and verify that test results meet the performance criteria of NFPA 130, Chapter 8.
2. Toxicity:
  - a. Test all material used in vehicle construction for toxicity, except materials used in small parts that would not contribute significantly to fire propagation, smoke, or toxic gas generation (such as knobs, rollers, fasteners, clips, grommets, and other small parts).
  - b. Perform tests in accordance with BSS 7239 or Bombardier Specification SMP 800C.
  - c. Materials will not exceed the toxic gas release limits Specified in Section 16.
3. If the quantity of a particular material is such that it would not contribute significantly to a fire, a waiver may be requested from testing for this material.

#### 18.3.3 Paint Performance Type Test

Test the final painted or powder coated surface on the first component of the production run to the following criteria:

1. Hardness: Perform pencil hardness tests according to ASTM D3363.
  - a. The acceptable range is between H and 2H, based on the average of ten readings taken from typical surface locations.
  - b. To avoid a destructive test of a vehicle's surface that would require the tested surfaces to be repaired, the use of a test structure for this test may be proposed for consideration.
2. Adhesion: Perform test using an Elcometer pull-off adhesion gauge.
  - a. Tested surfaces will achieve a minimum rating as furnished by the paint manufacturer.
  - b. To avoid a destructive test of a vehicle's surface that would require the tested surfaces to be repaired, the use of a test structure for this test may be proposed for consideration.
3. Thickness: Perform non-destructive testing to verify final dry film thickness.
  - a. The minimum and maximum dry film thickness will be within the recommended criteria furnished by the paint manufacturer.
  - b. Dry film thickness beyond the manufacturer's recommendations will not be accepted.
4. Paint Cure: Perform a solvent rub test per ASTM D5402.
  - a. The test procedure requires a minimum of 50 double finger rubs with a cloth wetted in acetone or methyl isobutyl ketone to the painted surface.
  - b. Paint color must not transfer to the cloth.
  - c. After 72 hours, the painted surface must retain all original characteristics such as gloss and hardness.
5. Surface Appearance:
  - a. Make a visual inspection of vehicle surfaces for uniform gloss and no visible orange peel effect.

- b. Using a DOI meter, take measurements at multiple locations.
- c. Verify that average readings comply with Specified limits in Section 14, Interior and Exterior Appointments.
6. Repeat tests during production on vehicles randomly chosen by the City if it appears that there are quality issues.

#### 18.3.4 Fiberglass Reinforced Plastic (FRP) Type Test

Test FRP coupons trimmed from production parts:

1. Perform a visual examination for porosity, voids, and other imperfections visible in the cross section.
2. Verify compliance with the strength requirements Specified in Section 16, Materials and Workmanship. Tests will be performed by an independent laboratory. Condition test specimens in accordance with ASTM D618.

#### 18.3.5 EMI/EMC Component Type Tests

Test each component containing electronics to verify compliance with the TS:

1. Testing will be performed by a qualified test laboratory.
2. Perform tests in accordance with EN 50121-3-2.
3. Perform each individual emissions and immunity test cited in EN 50121-3-2 as applicable to the specific subsystem/component.
4. For immunity tests, develop detailed definitions of IEC 50121-1 Performance Criteria A and B applicable to each individual subsystem/component and include in the respective test procedures, including signals to monitor and acceptable signal change boundaries.

#### 18.3.6 Heater Type Tests

##### *Cab Heater(s)*

Perform a type test demonstrating that heaters meet requirements for heat and defrosting as Specified in Section 10 HVAC, and do not exceed maximum surface temperature.

##### *Floor Heater*

Comply with the following:

1. Perform a type test demonstrating that heaters have the required capacity, as calculated, without exceeding maximum Specified surface temperature.
2. The test will mimic the actual vehicle installation, including any limits on airflow, such as seats installed over the heater enclosure.

#### 18.3.7 AC Traction Motor Type Test

Perform a type test in accordance with a mutually acceptable method from IEC 60349-2 to determine the characteristics and efficiency of the traction motor.

#### 18.3.8 AC Auxiliary Motor Type Test

Perform an IEC 60349 type test for one of each type of ac auxiliary motor to demonstrate its capabilities and power rating:

1. Include a temperature-rise test.
2. Test each model at its continuous rating.

**18.3.9 Traction Gear Unit Type Test**

Subject unit to a 100-hour test, and mount with torque load simulation. Alternatively, submit 100-hour test data and gear tooth contact verification data, previously run on identical gear units:

1. The load cycle for the 100-hour test will consist of a maximum power motor and brake cycle repeated to simulate a typical load cycle in revenue service on the City alignment.
2. The test will subject the units to conditions that are more severe than would occur under the most extreme operating conditions, by increasing the torque by 20%.
3. If two motors are controlled in parallel, the torque load will include the effects of uneven torque distribution due to wheel diameter differences, as Specified, in the Traction Motors section.
4. Include the following as a minimum:
  - a. Check and record gear tooth mesh and tooth pattern before the test.
  - b. Start the test with the unit at a temperature from 15 degrees C to 32 degrees C (59 degrees F to 90 degrees F). A fan or other device may be used so that in-service air flow conditions in driving direction are simulated.
  - c. Measure temperature rise in the oil sump. Maximum temperature will not exceed the gear oil supplier's recommendations consistent with the life between oil changes, as stated in the Contractor's maintenance manuals.
  - d. Measure the bearing temperature.
  - e. Reverse the direction of rotation every successive 5 hours until the 100-hour test is completed.
5. During the 100-hour test, perform noise and vibration tests to verify compliance with requirements of Section 2, Design and Performance Criteria:
  - a. Take vibration and sound level readings at such intervals as necessary to verify compliance with the TS.
  - b. Monitor for any drippage or seepage from the unit.
6. After completion of the test, perform the following:
  - a. Check the oil for contamination or metal particles.
  - b. Disassemble the gear unit and examine all parts.
  - c. Check and record gear tooth mesh and tooth pattern.

**18.3.10 Auxiliary Power Supply Type Test**

Perform tests per the type test requirements of IEC 61287-1:

1. Consider the Specified design requirements, environmental ranges, and supply voltages and demonstrate that the equipment complies with the TS.
2. The acoustic noise measurement test will demonstrate compliance with Section 4 .
3. The temperature rise test will be designed to test the system for the worst-case heat loadings for the following:
  - a. Maximum rated output current at the lowest operational input voltage.
  - b. Lightest possible load, at the highest operational input voltage.

In addition, perform a 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.

### 18.3.11 Low-Voltage Power Supply and Battery Charger Type Test

1. Perform tests based on the type test requirements of IEC 61287-1:
2. If two LVPS units are used on the vehicle, perform tests using two units. Run the tests below with both units connected as on the vehicle, and with one unit connected as if the other unit is disabled.
3. Acoustic noise measurement test: Take sufficient noise measurements to demonstrate compliance with Specified requirements.
4. Temperature-rise test: Include the following test conditions in addition to requirements of the standard:
  - a. Sufficient duration to allow all critical elements to stabilize in temperature.
  - b. Input voltage at the upper limit of the Specified operating range, and at rated output current and voltage.
  - c. 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.
  - d. Cycling OFF and ON by interruption of the source voltage supply external to the unit under test at short durations, when connected to its rated load.
  - e. Starting into an open circuit multiple times in succession.
  - f. Starting into a short circuit multiple times in succession.
  - g. Starting while connected into an overload at 120% of rating. The overload will then be removed, and the unit will automatically attain rated output voltage.
  - h. Pass Criteria: Temperature rises over ambient will be within Contractor's limits as stated in the test procedure.

In addition, perform a test to demonstrate compliance with Specified regulation and ripple requirements, monitor output voltage and output voltage waveforms with an oscilloscope at operating points representing the full range of conditions for delivery of rated output voltage and for routine current limit operation.

If more than one LVPS is used in normal operation, demonstrate equal load share and dynamic stability with both units connected during the above tests.

### 18.3.12 Truck Frame Type Test

#### General

Perform a static load test and a fatigue endurance test. Select test loads and conditions that will demonstrate conformance to the TS.

#### Test Set Up

Set up the static load and fatigue tests as follows:

1. Apply minimum 75 rosette strain gauges to the truck frame and bolster at locations of expected high stress and other areas of interest:
  - a. Type: SR-4 or other Approved strain gauges specifically suitable for the application.
  - b. Location: Based on the stress analysis and the Contractor's experience, subject to the direction of the City.
  - c. Calibration: In accordance with manufacturer's instructions for material being measured.
  - d. Temperature compensation: Apply to the gauges.
2. Use a load cell at each point of load application.
3. Use deflection gauges during the static load test to monitor vertical and lateral deflection of the truck frame.



### Static Load Test

#### Test Purpose:

1. To verify that the maximum allowable static stresses selected by the Contractor do not exceed the maximum expected static loads.
2. To verify the predictions of the finite element analysis.
3. To simulate as closely as possible the actual loading conditions to which the truck will be subjected in service, by using appropriate methods and points of test load application and reaction.
4. Test Steps:
  5. Load the truck and bolster twice, with complete release of the load between applications.
  6. Apply test loads as follows:
    - a. Vertical load: The truck's share of completed vehicle weight plus an AW4 passenger load minus the weight of the truck.
    - b. Lateral load: Load developed at vehicle overturning.
    - c. Longitudinal load: The maximum possible instantaneous braking effort (friction and dynamic plus track brake) and 50% adhesion at the wheels at AW4 load.
    - d. Lateral and longitudinal loads will act as if they were applied at the center of gravity of the completed vehicle plus an AW4 passenger load.
    - e. Accessory loads, such as brake units, track brakes, and traction motors will represent maximum steady state conditions. For example, maximum motor torque and brake unit weight, and maximum brake unit reaction and motor weight.
    - f. All loads will be applied to produce the worst stress conditions on the truck.
  7. Measurements During Test:
    8. Re-zero strain gauges after the first load application and record and report the offset from zero.
    9. Take all required data during both load applications.
    10. Record all load cells simultaneously with all strain gauges.
  11. Test Results:
    12. The truck will be compliant with the TS if all the following are met:
      - a. Maximum stresses calculated from strain readings in any gauge during the second load application do not exceed 50% of the material's yield stress.
      - b. Indicated residual strains following removal of the second loading do not exceed the maximum error resulting from the accuracy of the instrumentation.
      - c. There are no permanent deformations, fractures, cracks, or separations in the truck.

If any of the above criteria are not met, the truck design will be corrected and the truck retested at the Contractor's expense, and this process will continue until these criteria are met.

### Fatigue Test

Test Purpose: To demonstrate that the truck has adequate fatigue strength under dynamic loading.

#### Pre-Test Non-Destructive Testing:

1. Perform a magnetic particle test or dye penetrant inspection on the test unit for cracks and other defects that might impair the performance of the truck during the test.
2. Perform tests or inspection in accordance with the Non-Destructive Testing and Inspection section, above.
3. Record the defects found, and if required, repair using an Approved procedure.
4. Document the type, size, location, and repair of each defect by photographs and drawings.
5. Test Steps:
  6. Subject the truck frame and bolster to minimum 2 million cycles of dynamic loading.

7. Apply the following loads in accordance with the Fatigue Design section in Section 11, Truck Assemblies, except that loads will be based on the completed vehicle:
  - a. Vertical load
  - b. Lateral load
  - c. Longitudinal load
  - d. Accessory loads
8. Select the phasing of the loads such as to produce the worst-case stresses at critical locations.
9. Post-Test Non-Destructive Testing:
10. At the conclusion of 2 million cycles, perform a magnetic particle or dye penetrant inspection for cracks.
11. The post-test inspection procedure will duplicate the pre-test inspection procedure.

**Test Results:**

1. The truck will be compliant with the TS if all the following are met after 2 million cycles:
  - a. Stresses calculated from strains measured at critical locations do not exceed Contractor-selected fatigue allowable included in the test procedure.
  - b. This stress range will be within the allowable fatigue endurance limit for non-redundant structures obtained from one of the following:
2. AAR M-1001 (AAR MSRP Section C-II), Section 7.4, Material Properties – Fatigue Properties of Members and Details.
3. AWS D1.1/D1.1M; or
4. The Contractor's own tests if more appropriate and conservative.
  - a. Following removal of all loads, indicated residual strains at strain gauges on principal structural elements do not exceed the maximum error resulting from the accuracy of the instrumentation.
  - b. There are no permanent deformations, fractures, cracks, or separations in the truck.
5. If cracks are found during the post-test non-destructive testing that were not present before the test, or cracks have propagated from original recorded dimensions, correct the design, and rerun the test from the beginning with a new test specimen.
6. Redesign and retest will continue until these criteria are met.
7. Test Unit Disposal: The truck and bolster that undergo this test will not subsequently be used on a production vehicle and will be permanently marked or destroyed.

**18.3.13 Traction Inverter Type Test**

Perform traction inverter type tests on a production unit, per the type test requirements of IEC 61287-1. These tests will confirm compliance with all aspects of the Specified design requirements, environmental ranges, and supply voltages.

**18.3.14 OESS Component Type Test**

Perform a type test on a production unit, including all parts of the OESS as Specified in this Section.

1. Comply with IEC 61287-1 and IEC 62928.
2. The test shall confirm compliance with all aspects of the Specified design requirements, environmental ranges, and supply voltages.

## 18.4 Vehicle-Shell Structural Type Tests

### 18.4.1 General

Test Purpose: To show that the critical portions of the vehicle-body structure comply with the TS and ASME RT-1.

1. Test Specimen: The first vehicle shell.
2. Conduct all structural tests on the same specimen.
3. The test shell will be structurally complete, consisting of all shell sections with the articulation joints installed, but excluding nonstructural items that would obscure structural members from view or interfere with performance of the test, as described in ASME RT-1.
4. Simulate equipment by equivalent weights at the respective locations, in accordance with ASME RT-1 and the Approved test procedure.
5. Vertical load test only:
  - a. Doors: All side doors on one side of the vehicle will be installed:
6. Doors will be complete with operators, thresholds, sealing, and weatherstripping.
7. Door equipment will be production equipment installed in accordance with production drawings and procedures.
  - a. Bridgeplate: Installed on one side of the vehicle.
8. Bridgeplate will be complete with operators and thresholds.
9. Bridgeplate equipment will be production equipment installed in accordance with production drawings and procedures.
10. Test Schedule: Tests will not begin until the drawings, stress analyses, and test procedures have been Approved.
11. Failures: Broken welds will be jointly inspected by the Contractor and the City to determine if the failure is the result of weld quality or stress. Areas exhibiting buckling will also be examined to confirm elastic behavior, as appropriate.

### 18.4.2 Test Set Up

#### General

Comply with ASME RT-1 requirements for Proof Load Tests or the Approved test procedure. At a minimum, the procedures will describe the following:

1. The general test setup, fixtures, tooling, and method of loading.
2. All load application points including dimensions for the position and distribution of loads, where appropriate.
3. Details of the supports and boundary conditions.
4. Load cell, gauge locations, including locational dimensioning of gauges.

#### Strain Gauges

Apply calibrated strain gauges to the vehicle structure:

1. Quantity:
  - a. Vertical load tests: Minimum 300
  - b. End-compression load tests: Minimum 300
  - c. Collision and corner post load tests: Minimum 100
  - d. Diagonal jacking tests: Minimum 300
2. Type:
  - a. Rosette, bonded resistance, SR-4; or other Approved gauges suitable for the application.

- b. 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.
- c. Gauges used on FRP will be appropriate for that material.
3. Location:
  - a. Based on the Contractor's experience, the stress analysis, and the City's recommendations.
  - b. Place half the gauges in areas where the stress may be critical and the other half in locations to validate the stress analysis.
  - c. Gauges may be used for more than one test if located on the structure appropriate to more than one test, but the required number of readings must be taken for each test.
4. Calibration and temperature compensation: In accordance with manufacturer's instructions for material being measured.

#### *Deflection Gauges*

Apply calibrated deflection gauges to the vehicle structure:

1. Quantity:
  - a. For each section, five gauges to measure the side sill vertical deflection, except for the post test on the cab section must have these gauges.
  - b. At both ends of the vehicle shell, two total, one at each side sill corner to measure longitudinal deflection.
  - c. Between each section, four total, one at each corner to measure longitudinal deflections.
  - d. For each section, four gauges total, one at each corner on the side sills to measure transverse deflections.
  - e. For the collision and corner post load tests additional gauges to measure the longitudinal deflection of the posts at five locations on the post.
  - f. For the diagonal jacking test additional gauges to measure the vertical deflection at the jacking pads.
2. Type: Displacement transducers with enough stroke to measure 1.25 times the deflection predicted by the FEA.
3. Measurements: will be taken to the nearest 0.25 mm (0.01 in).
4. Location:
  - a. As noted above.
  - b. Based on the Contractor's experience, the stress analysis, the City's recommendations, and verification that the loading condition remains safe.
5. Calibration and temperature compensation: In accordance with manufacturer's instructions.

#### *Load Cells*

Apply calibrated load cells:

1. Quantity: Sufficient to measure the input load and the reaction loads.
2. Type: Load range of 1.25 times the applied load or expected reaction load.
3. Location: At all load and reaction points.
4. Calibration and temperature compensation: In accordance with manufacturer's instructions.

#### *18.4.3 Vertical Load Test*

Test Purpose: To confirm the ability of the vehicle-body structure and articulation joints to resist the static and fatigue loads Specified in Section 3, Vehicle-Body Structure, Vertical Design Load Strength Requirements section.

1. Test Setup: Comply with the Approved test procedure.
2. Test Load: See Vertical Design Load Strength Requirements section in Section 3, Vehicle-Body Structure.
3. Test Steps:
4. Apply test load to the specimen in four increments:
  - a. Increment one: Equal to the complete, ready-to-run vehicle-body weight (complete vehicle minus trucks).
  - b. Increment two: Add load such that total load is equal to AW2 passenger load.
  - c. Increment three: Add load such that total load is equal to AW3 passenger load.
  - d. Increment four: Add load such that total load is equal to AW4 passenger load.
5. Unload the specimen in the same increments that it was loaded, in reverse order.
6. Door operation during test:
  - a. At each increment of test load, open and close doors electrically by means of the operators.
  - b. In case of failure to operate at the prescribed speed or any indication of binding, take corrective action to the vehicle structure, or door arrangement, and repeat the vertical load test in its entirety.
7. Bridgeplate operation during test:
  - a. At each increment of test load, extend and retract bridgeplate electrically by means of the operators.
  - b. In case of failure to operate at the prescribed speed or any indication of binding, take corrective action to the vehicle structure or bridgeplate, and repeat the vertical load test in its entirety.
8. Measurements During Test:
9. Measure and record vehicle-body vertical and longitudinal deflection, load cell readings, strains, and flatness of side skin on the vehicle-body shell with each test load applied:
  - a. Plot vertical deflections to verify linearity.
  - b. Plot 10 highest strain values to verify linearity.
  - c. Visually inspect for deformation.
10. Measure and record the opening and closing time of each door leaf.
11. Measure and record the extend and retract time of bridgeplate.
12. Test Results: The vehicle will comply with the TS if results comply with ASME RT-1 Test Criteria and Approved test procedure criteria for this test with the following exceptions and additions:
13. Referenced loads are in accordance with Section 3, Vehicle-Body Structure.
14. Vertical deflection: Variance not more than +/- 5%.
15. Strain readings: Variance not more than +/- 5%.
16. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis before starting the test program.
17. Vehicle-body side-sill deflection is maximum 9 mm (0.4 in) under a load equal to the passenger load of AW4, as measured from the datum line drawn from the transverse center line of the vehicle-body bolster at the truck through the transverse centerline of the articulation joint.
18. Vehicle-body vertical and longitudinal deflections measured at the side sill during the test at AW2, AW3, and AW4 agree with the analysis calculated deflection within +/- 10%.
19. The side doors open and close at all test loads at speeds and operating force levels as required without binding.
20. The bridgeplate must extend and retract at all test loads at speeds and operating force levels as required without binding.

**18.4.4 Compression Load Test**

Test Purpose: To confirm the ability of the vehicle-body structure and articulation joints to resist the compression loads Specified in Section 3, Vehicle-Body Structure, in the End Sill Compression Load section.

1. Test Setup: In accordance with ASME RT-1 or the Approved test procedure.
2. Test Load: See End Sill Compression Load section in Section 3, Vehicle-Body Structure.
3. Test Steps:
4. In accordance with ASME RT-1 and the Approved test procedure, with the following exceptions:
  - a. Apply the load in increments of 25, 50, 75, 87.5, and 100% of Specified full load.
  - b. Reduce the load to maximum 2% of full load after each step, but not less than necessary to hold the test article firmly in the fixture.
5. Measurements During Test:
6. Measure applied and reaction forces using an independent load cell.
7. Take strain gauge and deflection readings at each load increment and at each relaxation of load.
8. Test Results: The vehicle will comply with the TS if all the following are met:
9. The vertical deflection of each side of the test structure is within plus or minus 10% of the value determined by the analysis.
10. Vertical deflection readings plotted against load do not vary by more than plus or minus 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.
11. Strain readings plotted against load do not vary by more than plus or minus 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.
12. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis before starting the test program.
13. Following removal of the maximum test load:
  - a. Residual vertical deflection between bolsters does not exceed 1.0 mm (0.04 in).
  - b. Residual horizontal deflection between ends does not exceed 1.0 mm (0.04 in).
  - c. Indicated residual strains at strain gauges on principal structural elements do not exceed the maximum error resulting from the accuracy of the instrumentation.
14. There are no permanent deformations, fractures, cracks, or separations in the vehicle structure or in the vehicle-body sheathing.

**18.4.5 Collision Post and Corner Post Load Tests**

Test Purpose: To confirm the ability of the collision posts, corner posts, and associated supporting structures to resist the elastic design loads Specified in ASME RT-1 Table 2, Structural Load Requirements for Streetcars.

1. Test Steps: In accordance with ASME RT-1 and the Approved test procedure, with load applied in accordance with Table 2.

Test Results:

1. 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 near the point which represents the measured deflection at maximum load.
2. 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 near the point which represents the measured deflection at maximum load.

3. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis.
4. Indicated residual strains at strain gauges on principal structural elements following removal of the maximum loading do not exceed 50 microinch/in.
5. There is no permanent deformation, fractures, cracks, or separations in the vehicle structure.
6. Failures: Broken welds will be jointly inspected by the Contractor and the City to determine if the failure is the result of weld quality or stress.

#### 18.4.6 Crash Energy Management (CEM) Tests

Conduct CEM tests in accordance with ASME RT-1, Section 10.4, Crash Energy Management Tests, and as agreed by the City to validate the CEM design and verify the Crashworthiness Analysis simulations of Section 3, Vehicle-Body Structure. Include the CEM testing plan, or waiver justifications, as part of the CEM and Collision Survivability Plan CDRL, Specified.

#### 18.4.7 Diagonal Jacking Test

##### Test Setup:

1. Load the vehicle shell to its AWO weight.
2. Hang trucks (or an equivalent weight) from the body bolsters.
3. Support the vehicle shell symmetrically at the minimum number of jack pads and placement necessary to support the vehicle safely.

##### Test Steps:

1. Lower the jack that, when lowered, subjects the vehicle-body structure to worst-case diagonal loading:
2. Lower in five equal increments until the load on the jack is 10% of its original value.
3. Reverse the procedure until the load on the jack is returned to its original level.
4. Repeat the test using the vehicle jack socket adapters.
5. Measurements During Test: Record all gauge and load cell readings at each increment of jack position.
6. Test Results: The vehicle will comply with the TS if all the following are met:
7. Maximum stresses calculated from strain readings in any structural element do not exceed the allowable stresses Approved as part of the stress analysis before the start of the test program.
8. Strain readings plotted against load do not vary by more than plus or minus 5% from a straight line (linear) deflection curve, with one end point at the origin (no load) and the other at the point that represents the measured deflection at maximum load.
9. The vertical deflection of each side of the test structure is within plus or minus 10% of the value determined by the analysis.
10. Following return to original level, indicated residual strains at strain gauges do not exceed the maximum error resulting from the accuracy of the instrumentation.
11. There are no permanent deformations, fractures, cracks, or separations in the vehicle structure.

#### 18.4.8 Validation of Linear Elastic Analysis

##### *Measured vs. Analytical Values in Test Procedures and Test Reports*

Test Procedures and Test Reports: For detailed requirements, see the Contract Deliverables Requirements List (CDRL) section, below.

Test Procedures: For analytical strain (or stress) values at selected strain gauge locations, not less than 50% of the total gauges, insert values obtained from the stress analyses required in Section 3, Vehicle-Body Structure.



Test Reports:

- For test report tables that require calculated percent difference between analytical and measured values, it is defined as follows:

$$\text{Percent Difference} = \frac{\text{Measured} - \text{Analytical}}{\text{Measured}} \times 100$$

where

*Measured* = the value obtained from strain gauges or other instruments during testing

*Analytical* = the value obtained through calculation

Results

The percent difference between the measured and analytical values will be as follows:

- Minimum 75% of selected measurements recorded: Within 15%.
- Remaining 25% of selected measurements recorded:
  - Percent difference more than 15%, and measured value greater than or equal to 35% of yield strength of material: Prepare a detailed explanation of the reasons for the excessive variance.
  - Percent difference not within the above-Specified tolerance:
- Revise the stress analyses, update the finite element model, and re-run all.
- Repeat the process until the percent difference is within the Specified tolerance.
- Recalculate all manual analyses using data from the finite element analysis using the corrected values.
- Revise and resubmit the stress analysis report in accordance with Section 3.
- All results from re-analysis will meet the requirements of the TS and, if they do not, the design will be corrected.

## 18.5 System Type Tests

### 18.5.1 General

The following system type tests will be performed by the Contractor, or under its direction, to demonstrate conformance to the requirements of the TS.

### 18.5.2 Floor and Roof Assembly Fire Performance Type Test Requirements

Test the floor and roof assemblies (structural):

- Test Setup: In accordance with NFPA 130 Section 8.5, Fire Performance
- Test Steps: In accordance with ASTM E119
- Fire Exposure Duration: 15 minutes for low floor vehicles, in accordance with NFPA 130 Section 8.5, Fire Performance
- Test Results: In accordance with NFPA 130 Section 8.5, Fire Performance

### 18.5.3 Propulsion Combined Type Test

- Perform a laboratory test on one set (truck) of propulsion equipment, including OESS:
- Scope: Include motors, inverter, brake resistor, protection devices (i.e., HSCB), logic, controls, and master controller.
- Test Setup:
  - The physical layout of vehicle components and cabling for this test will simulate actual vehicle conditions as much as possible and will be Approved by the City.
  - Simulate vehicle inertia with a dynamometer that uses flywheels or programming of a motor generator.



- c. Simulate vehicle resistance by means of a motor-generator.
4. Test Results:
  - a. Demonstrate that the propulsion functions properly and meets Specified requirements before installation on the vehicle.
  - b. Demonstrate compliance with the conductive emission requirements in Section 2, Design and Performance Criteria.

#### 18.5.4 Friction Brake System Type Test

Perform a type test on the complete friction brake system and all components:

1. These tests may be included with the propulsion system laboratory tests.
2. Use a dynamometer to confirm braking capability, thermal capacity, response, and wear rates.
3. Testing will include hot and cold retardation, wet and dry retardation, actuation energy storage, and control response.

#### 18.5.5 Door System Type Test

Perform a type test on one door, door operator, control, and sensitive edge of each type of door:

1. The door will be assembled as a unit for the test.
2. The test fixture used will accurately represent the actual vehicle body and installation.
3. Include an accelerated life test of 1.5 million cycles for one complete set of door equipment.

#### 18.5.6 Bridgeplate System Type Test

Comply with the following, in addition to requirements for the Door System Type Test, above:

1. Perform a type test on one bridgeplate and bridgeplate operator, and controls.
2. Door and bridgeplate equipment will be assembled as a unit for the test.
3. In addition to the accelerated life test of doors, include 250,000 cycles for the bridgeplate equipment.

#### 18.5.7 Unitized HVAC System Type Test

##### *General*

Perform a type test on one self-contained HVAC unit of each type, complete with all controls:

1. The test will confirm air flow, water elimination, heating capacity, cooling capacity, controls, extreme operating conditions, unit noise, vibration, and power consumption.
2. Test setup will be according to ANSI/ASHRAE Standard 37, including instrumentation accuracy and tolerances requirements.
3. Record all data required by ANSI/ASHRAE Standard 37 using an appropriate data acquisition system.

##### *Air Flow Test*

Test Conditions:

1. Ambient room temperature of 20 degrees C.
2. Interior room temperature of 20 degrees C.
3. "Dry" evaporator coil.

Test Steps:

1. Adjust the fresh air flow to comply with the requirements of Section 7, Heating, Ventilating, and Air Conditioning.
2. Adjust the return air flow such that total air flow is in accordance with the required design value.

3. Measurements During the Test:

4. Use the flow measurement device described in ANSI/ASHRAE Standard 37 and related standards for measurements of the total/supply air.

5. Use the flow-hood type instrument for measurements of the fresh air.

Test Results: The fresh air flow and total air flow will comply with the requirements of Section 7 and manufacturer's design parameters.

*Scan Test*

Test Conditions:

1. Expose temperature control components to the temperature environments they will experience on the vehicle.

2. The use of test switches or potentiometers to control the unit independent of the temperature sensors is not permitted.

Test Steps:

1. Simulate actual operation to the extent possible by slowly varying the temperature in the test rooms, as appropriate for the control system, to reflect natural temperature lags.

2. Cycle the simulated vehicle interior and ambient temperatures through the operating range of the temperature sensors.

3. Verify all points of temperature control on temperature rising and temperature falling.

4. Measurements During the Test:

5. Instrument the simulated vehicle interior and ambient rooms with temperature measuring devices to determine when various control switching points are reached.

6. Connect the contactor coils to the event recorder or other suitable recording instrumentation to determine which contactors are picked up to verify control response.

Test Results: Malfunction of the system or components at any temperature constitutes a failure of the test.

*Control Stability Test*

Comply with the following testing requirements:

1. Under steady state operation at design conditions, vary the low-voltage power supply voltage between the limits allowed by Section 9, Electrical Equipment, to show the effect of such change.

2. Shut down and restart the system while the control voltage is at its minimum value.

*Cooling Capacity*

Verify cooling capacity at the design criteria conditions as Specified, using the methodology of ANSI/ASHRAE Standard 37:

1. In addition to test "A", select one of the secondary applicable test methods "B" from Table 1 of the Standard.

2. Verify the efficiency of the unit's mixed air plenum design:

a. Perform the cooling capacity verification test using the normal multi-streamed airflow configuration with the outside air (fresh air) intakes open to the design exterior ambient air condition and the return air stream open to the design interior air condition, balanced to achieve the design air proportions.

b. Significant degradation of performance will not be present when operating in this actual configuration.

- c. Verify and finalize the design of the mixing plenum before proceeding with the remaining sections of the unit type test.
- d. Record the data, after conditions are stabilized, in 10-minute intervals for 1 hour.

#### *Maximum Operating Conditions*

Perform a system functional test as follows:

1. Test Conditions:
  - a. Conduct test with the following temperatures:
    - i. Ambient condition: DB and WB Maximum Operating Conditions temperatures, as Specified.
    - ii. Recirculated air to evaporator: 24 degrees C (75 degrees F) DB and 60% relative humidity.
  - b. Conduct test at nominal supply voltage.
2. Test Steps:
  - a. Operate the unit under the conditions above.
  - b. At the end of 1 hour of operation, momentarily stop the system and then restart.
  - c. The system will continue to function properly with all components safe from malfunction. There is no capacity to be met.
3. Measurements During Test:
  - a. Record all data every 5 minutes during steady state operation.
  - b. Record each condenser motor's temperature rise during the test and verify that it is within the motor manufacturer's motor-winding insulation and heat rise and overheat-protection design ratings.
4. Test Results:
  - a. Successful test: Continuous operation of the system at these conditions for 1 hour without shutdown due to high pressure, modulation, circuit breaker trip, compressor motor overload, or any device failure.
  - b. Test Failure: A shutdown or capacity modulation for any reason while operating at these conditions.

#### *Modulation Pressure Switch Test*

Demonstrate capacity modulation capability as follows:

Test Conditions: Perform the test at ambient temperatures above Maximum Operating Conditions, as Specified.

Test Steps: As the condenser outlet air dry bulb temperature rises, allow the system to cycle by pressure transducer or modulation pressure switch.

Measurements During Test:

1. Record the frequency of pressure switch cycling.
2. Record all system pressures and temperatures.

Test Results: A successful test consists of 1 hour of continuous operation of the system without shutdown due to high pressure, cutoff, circuit breaker tripping, compressor motor overload, or any device malfunction.

*High-Pressure Cut-Off Switch Test*

Test Steps:

1. Upon conclusion of the modulation-pressure switch test, slowly increase the condenser air temperature above the Maximum Operating Conditions DB temperature, as Specified, to achieve a discharge pressure slightly below the high-pressure switch trip point.
2. The system will operate a minimum of 1 hour continuously at this condition without operation of the high-pressure cut-off device, while maintaining the interior mixture conditions defined in the section above, Maximum Operating Conditions.
3. Following this, slowly raise the condenser/fresh air ambient to the point when the high-pressure cutoff switch activates and shuts off the system.
4. Repeat this test four times.
5. Measurements During Test: Record pressures and temperatures of the pressure-switch cutoff and reset conditions.

*Low Temperature Operation Test*

Test Conditions: Perform the test at air temperature entering evaporator coil based on the following mixture:

1. Recirculated air at 22 degrees C (72 degrees F) DB and 50% relative humidity.
2. Ambient conditions determined from the control chart to be 1 K (1.8-degree F) higher than the compressor lock-out point.
3. Test Steps: After attainment of the Specified temperature conditions, operate the unit continuously for a period of 4 hours.
4. Measurements During Test: Record the data every 10 minutes (or more frequently) during steady state operation.
5. Test Results: During the test, the unitized air-cooling system will operate without damage to the equipment and without the formation of ice or frost on the evaporator coil or piping.

*Insulation Efficiency and Condensate Carry-Over Test*

Test Conditions: Ambient and evaporator entering air temperature at 27 degrees C (81 degrees F) DB, 24 degrees C (75 degrees F) WB.

Test Steps:

1. Operate the unit continuously for a period of 4 hours at the Specified conditions.
2. Verify that the condensate drains function properly.

Test Results: During the test, there will not be condensate carry-over downstream of the condensate collection system.

*Refrigerant Sample Test*

Have a sample of refrigerant analyzed for contaminants by an Approved laboratory in accordance with AHRI Standard 700:

1. The sample will be taken from the air conditioning system of the tested unit.
2. Maximum allowable levels of contaminants will comply with AHRI Standard 700 with the following exceptions:
  - a. Moisture level of up to 45 ppm maximum.
  - b. High boiling residue may be as high as 5%.

*Abnormal Heating Condition, Restricted Air*

Test Conditions: Maintain ambient temperature at approximately 21 degrees C (70 degrees F) with the following conditions:

1. System heaters activated independent of the thermostat.
2. Air conditioning compressor not operating.
3. Air flow switch bypassed.

Test Steps:

1. Slowly restrict the mixed air inlet so that heater unit temperature rises 1 K (2 degrees F) per minute (not faster) until the high-limit switch cycles off.
2. Ease the restriction to the point where the high-limit switch stays closed.
3. Continue the heating test to simulate a dirty filter condition.
4. Operate the system until a steady condition is reached.

Test Results: The test is considered successful if the following criteria are met:

1. The back-up protection did not activate during the test.
2. The temperature inside the unit did not cause damage to the equipment and components.
3. There was an absence of smoke and odors.
4. The high-limit switch opened at the design set point +/- 6 K (11 degrees F).

*Abnormal Heating Condition, No Air*

Test Conditions:

1. Maintain ambient temperature at approximately 21 degrees C (70 degrees F).
2. The air conditioning compressor will not be operating, and the air flow switch will be bypassed.

Test Steps:

1. Apply power to the heaters with no air blowing over the heaters.
2. The system will operate as the high-limit switch cycles.

Test Results: The test is considered successful if the following criteria are met:

1. The back-up protection did not activate during the test.
2. The temperature inside the unit did not cause damage to the equipment and components.
3. There was an absence of smoke and odors.
4. The high-limit switch opened at the design set point +/- 6 K (11 degrees F)

*Back-Up Protection Test*

Test Conditions:

1. Maintain ambient temperature at approximately 21 degrees C (70 degrees F).
2. The air conditioning compressor will not be operating.
3. Bypass the high-limit switch and air-flow switch before applying power to the heaters.

Test Steps:

1. Energize the heaters and observe the activation temperature of the back-up protection device.
2. Measurements During Test: Measure and record the equipment interior temperatures minimum once per minute from the start until recorded temperatures start decreasing.

Test Results: The test is considered successful if the following criteria are met:

1. The temperature inside the unit did not cause damage to wire, electrical components, motor, or unit insulation.
2. There was no visible smoke.
3. There was no detectable odor.
4. The back-up protection device opened at the design set point +/- 6 K (11 degrees F).

#### *Start-up Current Draw*

Record the start-up current-draw profile (current versus time) characteristics of the unit under the following conditions:

1. Design cooling conditions
2. Maximum operating cooling conditions
3. For these tests the data-sampling rate will be maximum 10 ms.

#### *Shock and Vibration Test*

Perform random vibration, simulated long life vibration, and shock type testing of the HVAC equipment under test, in accordance with IEC 61373:

1. Perform routine tests prior to and following the shock and vibration testing to verify that there is no degradation in HVAC equipment performance due to the testing.
2. Evaluate damage that occurs during any portion of the test for potential design changes, if required, and then correct. Following the appropriate corrective action, repeat the test prior to performing the subsequent test(s).

#### *Water Eliminators Test*

Test Steps: Conduct the water test of the HVAC unit per requirements of Watertightness Routine Tests section, with the design air flow, including required fresh air.

Test Results: At the conclusion of the test, there will be no evidence of moisture in the ducts downstream of the water excluding features and fresh air filters will be dry.

#### *HVAC Noise Test*

Noise tests the HVAC equipment to verify compliance with the Specified noise limits of Section 2, Design and Performance Criteria. Comply with applicable noise testing requirements in this Section.

#### *18.5.8 Communication System Type Test*

Before shipping the first vehicle's communication equipment, perform a functional laboratory test:

1. The test will include one complete vehicle set of equipment.
2. The testing will verify compliance with the TS and design.

### *18.6 Vehicle-Level Type Tests at Contractor's Facilities*

#### *18.6.1 General*

Perform vehicle-level static and dynamic type tests on the first fully assembled vehicle to confirm that the overall vehicle design complies with the TS:

1. In general, perform static tests at the Contractor's facilities or at other Specified facilities and dynamic tests at the City's facilities. The City will consider allowing some tests, or subsets of these tests to be performed at the Contractor's facilities.
2. Perform a complete, orderly, and comprehensive test of each vehicle system to verify systems integration and the proper operation of each system, whether specifically described below or not.

18.6.2 Vehicle-Level Type Static Tests at Contractor's Facilities

*General*

*Horn and Bell Type Test*

Test the horn and bell, as mounted on a completed vehicle, to demonstrate compliance with Specified requirements. Test horn and bell at both ends of the vehicle.

*Jacking Type Test*

Perform a jacking test to demonstrate compliance with the Specified jacking requirements.

*Ducting Watertightness Type Test*

Water test the fresh air and electric equipment ventilation intake ducts in the vehicle roof to determine the effectiveness of the water-excluding features of the duct work:

1. Run ventilating fans at full speed.
2. At the conclusion of the test, there will be no evidence of moisture in the ducts downstream of the water excluding features.

*Air Leakage Type Test*

Perform an air leak smoke bomb test to confirm positive internal vehicle-body pressurization:

1. Seal all openings related to ventilation during the test.
2. Pressurize the interior to a minimum of 125 Pa.
3. Evaluate apparent leaks and implement a fleetwide correction.

*Air Balance Type Test*

Perform an air balance test to verify conformance with the requirements of Section 10 :

1. Perform with "dry" evaporator coil condition.
2. Measure and record the volumes of fresh, recirculated, and exhaust air, and the total volume of air delivered by the circulating blowers.
3. Measure and record the conditions of the air (degrees C DB, degrees C WB, and barometric pressure).
4. The blower motor current, voltage, power consumption, and speed will conform to the HVAC manufacturer's design data and motor specifications.
5. Measure and record interior pressurization.
6. Adjust as necessary to conform to the requirements of Section 10 .

*Vehicle HVAC System Type Test*

Test the vehicle HVAC system to verify compliance with the requirements of Section 10 , with assistance from the HVAC unit manufacturer.

Test Setup:

1. This test may be conducted in a climate room, or in an enclosed facility, such as a paint booth, where the "ambient" temperature and humidity requirements Specified in Section 7 can be achieved.
2. Use electric baseboard heaters and humidifiers to simulate the passenger, sensible and latent, and solar loads inside the vehicle.

Test Steps:

1. Expose the vehicle to high ambient temperature condition Specified in Section 7 for minimum 6 hours, without HVAC system operation ("soaking period").

2. Following the soaking period, perform a pull-down test, and measure the time required to reach the required vehicle interior temperatures and stabilize, for information.
3. Include a cooling test at the design conditions of Section 7 and the cooling tests required in the Unitized HVAC System Type Test section, above, except simulate actual interior passenger and solar loads inside the vehicle, instead of regulating the return air temperature.
4. After stabilizing for each test condition, record the temperatures every minute for 30 consecutive minutes to determine temperature swing as the HVAC equipment cycles.
5. The test will also verify proper operation of HVAC equipment during cooling and heating operation.

**Measurements During and After Tests:**

1. Use data logging equipment to record temperature at a minimum of 30 locations throughout the vehicle, representative of seating and standing passengers, including operator's cab and articulation section.
2. Record all significant events and data (such as refrigeration and heating equipment cycling), with corresponding temperatures and pressures as applicable for each test.
3. After all tests have been completed, take samples of the refrigerant for analysis for contaminants by an Approved laboratory.

**Test Results:**

1. Vehicle interior temperatures will not exceed the temperature variation Specified in Section 7.
2. Refrigerant and compressor crankcase oil test results will conform to the requirements of AHRI Standard 700 with the following exceptions:
  - a. Moisture level of up to 45 ppm maximum.
  - b. High boiling residue may be as high as 5%.

*Door Operation Type Test*

Test the door system on the first vehicle to verify compliance with the requirements of Section 6, Passenger Doors:

1. Operate each door for 1,000 continuous, trouble-free cycles. If a door or door control fails before the test is completed, correct the fault, and start the test over from the beginning.
2. Independently test each door obstruction system, door sensitive edge, and additional Approved method to verify compliance with door obstruction detection requirements as Specified.
3. Measure door closing stall force during door closing at 50 mm (6 in) intervals along the width of the door opening, to verify compliance.

*Bridgeplate Operation Type Test*

Comply with the following, in addition to requirements for the Door Operation Type Test, above:

1. Test bridgeplate system to verify compliance with the requirements as Specified.
2. Operate each bridgeplate for 1,000 continuous, trouble-free cycles. If a bridgeplate, or bridgeplate control fails before the test is completed, correct the fault, and start the test over from the beginning.
3. Independently test each bridgeplate obstruction system to verify compliance with bridgeplate obstruction detection requirements as Specified.

*Light Intensity Type Test*

Take light intensity readings (without light from other sources) to verify conformance with the requirements as Specified.



*Communication Equipment Type Test*

PA System and APIS:

1. Verify that the PA and APIS systems are compliant as Specified.
2. Perform the following tests as a minimum:
  - a. Test the intelligibility of the PA and APIS systems in accordance with ANSI S3.2.
  - b. Test the PA automatic volume control.
  - c. Test the accuracy of the distance calculation of the APIS over the City alignment.

Intercom:

1. Verify that intercom systems comply with requirements as Specified.
2. Test both cab-to-cab and passenger emergency intercom intelligibility and functional requirements.

CCTV:

Verify that CCTV complies with the requirements as Specified.

1. Verify viewable areas within the interior and exterior, storage capacity, and functional requirements.

Event Recorder:

1. Verify that the event recorder complies with the requirements as Specified.
2. Test functional requirements and data storage and retrieval.

Automatic Passenger Counting (APC):

1. Verify that the APC system complies with the requirements as Specified.
2. Test accuracy for simulated unloading and loading of passengers.

TWC:

1. Verify that the TWC system complies with the requirements as Specified.
2. Test functional requirements, TWC Cab Control Panel, and transponder.

*Vehicle Data Network Type Test*

Conduct a test to verify that there is sufficient bandwidth in the vehicle network and communication systems network (communications and CCTV):

1. Activate all systems connected to the vehicle data network system.
2. Measure actual peak and average traffic levels.
3. Verify compliance with Specified traffic level requirements as Specified.

**18.6.3 Vehicle-Level Type Dynamic Tests at Contractor's Facilities**

*General*

Vehicle Type Dynamic Tests will generally be performed at the City's facilities. However, if the City's track facilities are not adequate to perform all required dynamic tests, perform those that require an alternate location at the Contractor's facilities or other facilities, as agreed with the City.

*Preliminary Vehicle-Level EMI/EMC*

Perform preliminary EMI/EMC testing on the first vehicle to demonstrate compliance with the emission limits Specified. Use the test procedure prepared for the vehicle-level type test of EMI/EMC at the City's facilities and perform portions of the test as suitable for the Contractor's test track.

## 18.7 Component Routine Tests

### 18.7.1 General

Each component will be routine tested by its manufacturer during production before installation at the vehicle manufacturing site. Each test of electrical equipment will include an insulation test.

### 18.7.2 Air Conditioning Unit Routine Tests

Perform the following tests:

1. Leak testing: Confirm compliance with refrigerant leak test requirements Specified.
2. Evacuation testing: Confirm compliance with evacuation test requirements Specified.
3. Air conditioning unit test:
  - a. Apply a heat load to both the evaporator and condenser coils.
  - b. Perform a complete functional test to verify capacity modulation, control points of pressure transducers or switches, and return air and fresh air thermostatic control points.
  - c. Record the following:
    4. Power consumption of motors
    5. Evaporator and condenser fan motor speeds
    6. System pressures and temperatures
    7. Applied loads to the evaporator and condenser
    8. System refrigerant charge
    9. Refrigerant condition (wet or dry)
      - a. Correct abnormal conditions and repeat the associated test.
10. Unit heat staging and function of overheat protection devices: Verify performance as Specified.
11. Insulation resistance and dielectric (high potential) tests: Performed by the manufacturer on each unit in accordance with the Insulation Testing section, above.

### 18.7.3 Motor Routine Test

Perform a routine test on each traction motor, ac auxiliary motor, and dc motor:

1. Perform in accordance with IEC 60349, as appropriate.
2. Dynamically test motor balance in accordance with IEC 60349.

### 18.7.4 Traction Gear Unit Routine Test

Each traction gear unit will be tested using the manufacturer's routine test. The test will include the following as a minimum:

1. Check gear tooth mesh alignment, backlash, and shaft endplay to verify that it is within the manufacturer's tolerances before the gear unit is operated.
2. No load operation at maximum operating speed equivalent vehicle speed for 10 minutes in each direction. Continuously monitor vibration produced by each gear unit and gear sump oil temperature.
3. Gear units that produce abnormal oil temperature or noise will be rejected.

### 18.7.5 Traction Inverter Routine Test

Perform a routine test on each traction inverter:

1. Test in accordance with IEC 61287-1 to verify compliance with the TS.
2. Test insulation per the Insulation Testing section, above.

18.7.6 AC Auxiliary Power Supply Routine Test

Perform a routine test on each auxiliary power supply:

1. Test in accordance with IEC 61287-1 to verify compliance with the TS.
2. Test insulation per the Insulation Testing section, above.

18.7.7 Low-Voltage Power Supply and Battery Charger Routine Test

Perform a routine test on each low-voltage power supply:

1. Test in accordance with IEC 61287-1 to verify compliance with the TS.
2. Test insulation per the Insulation Testing section, above.

18.7.8 Battery Routine Test

Perform a capacity test on 5% of the batteries supplied at the point of manufacture:

1. Test in accordance with IEC 60623, Section 4.2.1, Discharge Performance at 20 °C.
2. The test will be at the 5-hour rate, at 20 degrees C (68 degrees F) ambient temperature.

18.7.9 OESS Component Routine Test

Perform a routine test on each onboard energy storage system in accordance with IEC 61287-1 and IEC 62928 to verify compliance as Specified.

18.7.10 Friction Brake Routine Tests

Test each component and system that is part of the friction brake system. Perform the following tests:

1. Electrical and electronic assemblies:
  - a. Test insulation per the Insulation Testing section, above.
  - b. Perform functional test and certify performance in accordance with manufacturer's specifications and test codes.
2. Hydraulic pump unit: Perform a functional test and a capacity test.
3. Valves: Perform functional test and certify for performance in accordance with manufacturer's specifications and test codes.

18.7.11 Communication System Routine Test

Test each electrical and electronic assembly that is part of the communication system.

1. Test insulation per the Insulation Testing section, above.
2. Perform a functional test and certify for performance in accordance with manufacturer's specifications and test codes.

18.7.12 Truck Frame Welds Routine Test

Perform the following inspections in accordance with the Non-Destructive Testing and Inspection section, above:

1. Each production truck weld:
  - a. Perform magnetic particle or dye penetrant inspection.
  - b. Includes welds on the frame, bolster, and other primary structural members.
2. Critical welds:
  - a. Inspect by radiography or by section and etch.
  - b. Perform on the first and fifth production trucks, and thereafter 5% of the trucks chosen at random.
3. Cast trucks: Perform magnetic particle inspection on 100%.

4. If defects are found during sampling inspection, positively locate the beginning of such defects in previous truck frames and apply appropriate corrective action.

#### 18.7.13 Wheel Back-to-Back Routine Test

Measure each wheel-axle assembly to verify conformance with back-to-back distance requirements.

#### 18.7.14 Resistance Routine Tests

Perform test for each truck, isolating the other trucks during the test. Test must be performed by sending current through the circuit, not by using an ohmmeter.

1. Vehicle-Structure to Wheels Resistance Routine Test: Measure grounding system resistance between vehicle structure and wheels.
2. Propulsion System to Wheels Resistance Routine Test:
  - a. Measure grounding system resistance between the propulsion system return bus and wheels.
  - b. Test will be via the ground brushes separate from the safety ground system.
3. Wheel Shunt Resistance Routine Test:
  - a. Measure wheel-axle-wheel and wheel-axle-ground brush assembly to verify conformance to shunt resistance values Specified in Section 11, Truck Assemblies.
  - b. Measure values for each wheelset with other wheelsets isolated from the measurement.
  - c. Measure wheel tread to stub axle before installation, or with ground brush disconnected.

#### 18.7.15 TWC System Routine Test

Perform the following tests:

1. Insulation test: Perform on electrical and electronic assemblies per the Insulation Testing section, above.
2. Functional test: Certify for performance in accordance with manufacturer's specifications and test codes.

### 18.8 Vehicle-Level Routine Static Tests at the Contractor's Facilities

#### 18.8.1 General

After installation of components and systems on the vehicle, perform routine tests to verify that equipment functions as expected within the vehicle's nominal mechanical, electrical, and physical environments, and interacts with other systems correctly:

1. Perform tests for all equipment and systems on each vehicle at the Contractor's facilities prior to shipment, whether listed in this Section or not.
2. Each test will be in accordance with Specified standards or an Approved test plan.
3. All test plans must include procedures furnished by, or Approved by, the equipment manufacturer.
4. Where external inputs or signals are required for verification, such as for TWC, use test equipment furnished by the equipment supplier, or built to supplier specifications.
5. Where insulation testing is Specified, perform in accordance with the Insulation Testing section above.
6. Include test reports in each Vehicle History.

#### 18.8.2 Vehicle-Level Routine Functional Tests

Perform a functional test on each vehicle system to verify correct operation and integration with other vehicle systems. This is not intended to repeat component manufacturer's routine tests.

**18.8.3 Vehicle-Level Routine Wiring Tests**

Perform each test listed below after the wiring and equipment installation is complete. Confirm integrity of electrical insulation and connections:

**1. Wiring Continuity Checks:**

- a. Test each circuit to ensure continuity and correct polarity of equipment and devices.
- b. Check each frame ground and terminal connection for tightness.

**2. Insulation Resistance Test:** Conduct in accordance with the Insulation Testing section, above.

**3. Dielectric (High Potential) Test:** Conduct on each circuit in accordance with the Insulation Testing section, above.

**18.8.4 Watertightness Routine Tests**

*General*

Perform watertightness tests Specified below on each vehicle. Perform tests before installation of sound deadening material, thermal insulation, and interior finish.

*Vehicle*

Perform a complete watertightness test on all areas of the vehicle sides, ends, and roof, including doors and windows:

1. Spray water from nozzles maximum 1 meter from and aimed directly at the surface being tested.
2. Deliver a minimum of 26 liters per minute to each square meter of surface being tested, with minimum nozzle velocity of 25 meters per second.
3. Continue spray applications for 10 minutes before inspection for leaks begins and run continuously during the inspection.

*HVAC*

Conduct HVAC watertightness test as part of the vehicle watertightness test, with blowers operating.

*Equipment Enclosures*

During the test of the vehicle body, conduct the enclosure watertightness test on individual underfloor and roof-mounted enclosures required to be watertight:

1. Direct spray at the exposed sides and ends of the boxes as would normally occur during vehicle washing operations.
2. Direct spray as appropriate to simulate water spray from the wheels.

*Traction Motor Leads*

Water test traction motor lead connections. The water flow rate and velocity will be the same as for the vehicle water test.

**18.9 Vehicle-Level Type Dynamic Tests at the City's Facilities**

**18.9.1 General**

Perform these tests on the City alignment or at other facilities, as directed by the City.

Perform tests on the first or second vehicle.

1. Demonstrate compliance with performance Specified in Section 2, Design and Performance Criteria, and other sections of the TS for a fully assembled vehicle.
2. Make two runs in each direction for each dynamic test, as a minimum.

3. Select, with the City's concurrence, a suitable test segment:
  - a. Determine where each test will start, based upon right-of-way restrictions, grades, speeds, clearances, safety considerations, and other limitations at the City's facilities.
  - b. Locations will be such that the opposite direction test run is run over the same portion of the alignment.
  - c. Mark the start location for each test.
4. If the vehicle or apparatus fails to satisfy the Specified performance and design criteria, redesign the vehicle and retest. If modifications are necessary, they will be made on a fleetwide basis.

#### 18.9.2 Setup for Vehicle-Level Type Dynamic Tests

##### *Instrumentation*

Comply with the following for instrumentation:

1. Furnish proof of calibration for each instrument, traceable to a master at the national standards organization of the applicable country. All testing equipment used must be calibrated.
2. Use personnel familiar with the setup and function of instrumentation and equipped to handle troubleshooting the test setup in the field, to limit testing delays.
3. For vehicle type tests, instrument each vehicle with a Contractor-furnished multi-channel data acquisition system, which will produce a permanent test record (both electronically and hard copy):
  - a. The data acquisition system will be capable of interfacing with all major systems through a serial bus.
  - b. Wherever possible, applicable signals needed to verify vehicle performance will be obtained from the serial interface with the equipment in question instead of hardwiring to obtain the desired signals.
4. Provide all recorders, sensors, transducers, pickups, equipment racks, test wiring termination panels, calibration equipment, wiring, and inverters necessary to operate this instrumentation.
  - a. Test wiring termination panels will 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. Arrange so that calibration signals cannot be fed back into the monitored equipment.
  - b. Provide isolation amplifiers and voltage dividers to isolate the inside vehicle instrumentation wiring and equipment from high voltages. No exposed terminals with potential differences greater than 50 V will be permitted.
5. Instrumentation will be powered from the vehicle low-voltage dc power system.
  - a. The equipment will function over the Specified low-voltage dc power system voltage range Specified.
  - b. Internal combustion engines driving a generator or use of the vehicle inverter power will not be permitted.
6. The accuracy and response of the instrumentation will be sufficient to determine compliance with the TS.

##### *Channel Assignments*

For each test, permanently record the following channel assignments simultaneously:

1. Acceleration (positive and negative): The signal will be produced by an independent accelerometer:
  - a. Type: Inertial
  - b. Range: +/- 1g

- c. Acceleration/deceleration rates calculated by the propulsion or friction brake system will not be considered acceptable for this requirement.
2. Tractive effort: Each truck
3. Spin/slide system operation: Each truck
4. Brake cylinder pressure: Each truck
5. Brake disc temperature: On one powered-truck axle using thermocouples embedded in the brake pads.
6. OCS voltage
7. Total OCS current drawn by each vehicle.
8. Speed
9. Propulsion and braking trainline command signals (or multiplexed to a single analog channel)
10. Auxiliary inverter voltage and frequency outputs
11. An independent time base with one-second time intervals
12. Such channels as the Contractor feels necessary to record voltage transients.
13. Five spare analog and ten spare digital channels for additional signals that may be requested by the City.

#### *Measurement of Average Acceleration Rates*

Where performance requirements specify average acceleration rates, measure as follows:

1. Use the accelerometer and speed channels.
2. Determine the 90% point on the acceleration trace where the acceleration achieves its response time. (See definition of Time, Response, in Section 1, General Topics and Definitions.) Record the vehicle speed at that point. This is the entry speed.
3. Determine the elapsed time from the entry speed to the end speed (typically zero) of the test.
4. Calculate average accelerations: (Entry speed - End speed) / Elapsed Time.
5. Disputes over interpretation of recorded values and calculations will be resolved by the City.

#### *18.9.3 Propulsion and Braking Type Tests*

##### *Propulsion Tests*

Perform the following tests, under OSC and OEES, as a minimum:

1. Acceleration rates and balancing speed for five evenly spaced tractive effort commands, accelerating from a stop.
2. Time to travel 1 km (0.6 mi) from a standing start with a maximum power command.
3. Acceleration performance during the AW3 braking tests required in the following section.
4. Run the tests at AW0 and a second series of tests at AW2. Monitor braking during tests.

##### *Braking Tests*

Perform the following tests, under OCS and OEES, as a minimum:

1. MSB stops from 70, 50, and 25 km/h (43, 31, and 16 mph)
2. Minimum brake stops from 15 km/h (9 mph)
3. All-friction MSB stops from 70, 50, and 25 km/h.
4. All-friction minimum service brake stops from 15 km/h.
5. Emergency stops from 70, 50, and 25 km/h.
6. Tests designed to determine compliance of the track brake system with the TS
7. Run three series of tests:
8. At AW0
9. At AW2



10. At AW3

11. Before initiation of each friction-stop test, cool brake discs to a maximum of 120 degrees C (248 degrees F) as measured by thermocouples.

#### *Thermal Capacity Tests*

Demonstrate compliance with the Specified duty cycle requirements.

#### *Wheel Spin/Slide*

Demonstrate compliance with wheel spin/slide requirements using all power and braking modes.

Monitor the following signals during spin/slide testing:

1. Tractive effort command and effort delivered per inverter.
2. Pressure signals per truck
3. All wheel (or axle) speed signals on the spin/slide test vehicle

#### *Parking Brake*

Perform a parking brake system test. Demonstrate compliance with performance requirements by measuring the force required to move the vehicle with the parking brake applied.

#### *18.9.4 Emergency Towing Type Test*

Demonstrate that an operational vehicle can tow an inoperative vehicle over the entire City alignment.

#### *18.9.5 Ride Quality Type Test*

Perform ride quality tests according to ISO 2631 to demonstrate compliance with the Specified ride quality in Section 2, Design and Performance Criteria:

1. As a minimum, ride quality tests will consist of operating the vehicle at speeds of 40 and 70 km/h (25 and 43 mph) over track selected by the City under two load conditions: AW0 and AW1. Weights used to simulate AW1 will be provided by the Contractor.
2. Provide and monitor instrumentation capable of measuring and recording the expected magnitude of vertical, longitudinal, and lateral shocks and vibrations concurrently, with speed and event marker.
3. Locate sensing units that measure in the three translation directions on the vehicle floor above the intersection of the vehicle longitudinal center line and the following:
  - a. An end truck transverse center line
  - b. A center truck transverse center line
  - c. The center of one section of the vehicle between trucks
  - d. At three seat locations at the bottom of the seat, as determined by the City.
  - e. Clearly identify locations for acceleration measurements in the test procedures and obtain final approval from the City before starting testing.
4. Measure acceleration data over the frequency range of 0.5 Hz to 80 Hz.
5. Make ride quality measurements with fully functioning suspension systems with normal acceleration and braking levels in a simulated revenue service operation.
6. Acceptability of the ride quality will be determined by an analysis of the recorded rms accelerations and will meet the requirements as Specified.

#### *18.9.6 Noise and Vibration Type Test*

##### *General*

Perform sound level and vibration tests at AW0 vehicle weight, to demonstrate compliance with the Specified limits.



*Noise Testing*

Provide noise test equipment necessary to perform tests to verify compliance with Section 2. Perform sound measurement per the following:

1. Take sound measurements on welded rail at-grade, newly-ground, and where reflections from nearby walls, floor, or other equipment will not influence the directly radiated sound by more than 2 dB.
2. Ambient sound level will be minimum 10 dB below the sound level produced by the equipment being measured, when evaluated using the same scale or octave band.
3. Perform sound measurements using Type 1 sound level meters meeting current IEC or ANSI standards. Measure sound levels on the A scale (dBA), with slow meter response for stationary vehicle measurements, and with fast meter response for moving vehicle measurements.
4. Measure interior noise levels in accordance with ISO 3381.
5. Measure exterior noise levels in accordance with ISO 3095, with microphones placed 7.5 m (25 ft) from the track centerline, and 1.5 m (5 ft) above top-of-rail.
6. Test for each condition Specified in Section 2, Design and Performance Criteria.
7. Record the following:
  8. Description of sound level or vibration source being measured, including pertinent statistical information.
  9. Description of the environment where sound level or vibration source is measured, including a sketch showing source position.
  10. Operating conditions of sound level or vibration source during measurements
  11. Pertinent meteorological data
  12. Locations and orientations of microphones with respect to sound level source
  13. Equipment used for making measurements.
  14. Description and measurements of ambient sound levels
  15. Data obtained, including range of variation.
  16. Instrument settings, corrections, and calibration records

*Vibration Testing*

Perform vibration testing to demonstrate compliance a Specified:

1. Test in accordance with IEC 61373 to verify compliance with the Specified limits.
2. Confirm that the vehicle can operate without degradation of performance when subject to vibration and impacts encountered during normal service.

*18.9.7 EMI/EMC Vehicle-Level Type Tests*

Perform EMI/EMC testing on the City alignment:

1. Conduct tests with all wayside systems functioning, including but not limited to signals and TWC.
2. Demonstrate compliance with EMI limits Specified.
  - a. Validate results considering worst-case conditions to comply with the EMI monitor requirements Specified.
  - b. Worst case conditions will include all tolerances of the input filter, such as, but not limited to, loss of capacitance due to aging and worst-case location on the alignment.
3. Radiated Emission Testing: Perform in accordance with EN 50121-3-1, with the following qualifications:
  - a. Extend measurement range up to 6 GHz, with limits in the range 1 GHz to 6 GHz measured in accordance with EN 50121-3-2, Table 3, Emission - Enclosure port, at 10 m, with limits decreased according to this distance.

- b. Conduct measurements in the range 10 kHz to 150 kHz as cited in EN 50121-3-1 Annex C, Emission values for lower frequency range. To minimize impact of near-field effects and increase measurement certainty, Contractor may propose to carry out these measurements from a greater distance than that prescribed in EN 50121-3-1, with limits recalculated accordingly.
4. Conductive Emission Testing: Perform in accordance with UMTA-MA-06-0153-85-6 (NTIS PB88-136932), Method RT/CE02A, Conductive Emission Test, Vehicle, or Approved equal, with the following addition for the TWC system:
  - a. Test for electromagnetic compatibility with the TWC system, operating at frequencies Specified, or as communicated by the City.
5. Inductive Emission Testing: Perform in accordance with UMTA-MA-06-0153-85-8, (NTIS PB87-194379) Method RT/IE01A, or Approved equal, with the following addition for the TWC system:
  - a. Test for electromagnetic compatibility with the TWC system, operating at frequencies Specified or as communicated by the City.

#### 18.9.8 Equipment Settings for Vehicle-Level Routine Dynamic Test at the City's Facilities

Use vehicle-level type dynamic tests to determine equipment settings and calibrations for vehicle routine tests at the City's facilities:

1. Develop the following for a continuous range of passenger loadings from empty to fully loaded:
  - a. Torque vs. passenger load state, per powered truck
  - b. Brake cylinder pressure vs. passenger load state, per each unique truck braking configuration
2. Reference these relationships to evaluate vehicle-level routine testing of all other vehicles, which may then be tested without load during vehicle-level routine testing.

#### 18.10 Vehicle-Level Routine Static Tests at the City's Facilities

##### 18.10.1 General

Perform the vehicle-level routine static tests listed below on each assembled vehicle prior to the vehicle-level routine dynamic testing. In addition to the tests listed, repeat other vehicle-level routine static tests performed at the Contractor's facilities if requested by the City.

##### 18.10.2 Door, Operators and Controls

Test and adjust each door and its operating equipment:

1. Check the obstruction detection features for proper operation and adjust before the start of the cycling test. This feature will operate properly, without the need for readjustment, at the end of the cycling tests.
2. Operate each door a minimum of 100 consecutive, successful cycles. Initiate cycling through the control line.
3. Before and after the above cycling, verify proper forces for opening and closing on each door.
4. If a door or controls fail before completion of the test, document correction of the failure and restart the test from the beginning.
5. Make any necessary adjustments to ensure smooth functioning, attainment of the required speed of operation, and Specified operation of controls, signals, and interlocks.

18.10.3 Bridgeplate, Operators and Controls

Comply with the following, in addition to requirements for the Door, Operators and Controls Routine Test, above:

1. Test and adjust each bridgeplate and its operating equipment.
2. Check the obstruction detection features for proper operation and adjust before the start of the cycling test. This feature will operate properly, without the need for readjustment, at the end of the cycling tests.
3. Operate each bridgeplate a minimum of 100 consecutive, successful cycles. Initiate cycling through the control line.
4. Before and after the above cycling, verify proper forces for extending and retracting for each bridgeplate.
5. If a bridgeplate or control fails before completion of the test, document correction of the failure and restart the test from the beginning.
6. Make any necessary adjustments to ensure smooth functioning, attainment of the required speed of operation, and Specified operation of controls, signals, and interlocks.

18.10.4 Heating

Perform a functional test of the heating system by simulation of inputs with the PTU:

1. Demonstrate operation of the thermostatic control system by using the PTU.
2. Apply heat to the overhead heaters without air flow and cycle the high-limit control switch three times.
3. During the test, record power consumption and verify proper operation of all controls.
4. The test will be successful when the backup protection device is not activated.

18.10.5 Air Conditioning

Test the air conditioning system by simulating inputs with the Portable Test Unit (PTU):

1. Demonstrate operation of the thermostatic control system by using the PTU.
2. Verify the sequence of capacity modulation, as applicable, and system pump-down.
3. Record the system refrigerant charge and the refrigerant condition (wet or dry) in liquid sight glasses.
4. Correct abnormal conditions and repeat the associated test.

18.10.6 Headlight and Stoplight Adjustments

Aim and adjust the headlights and stop lights on each vehicle to meet the Specified requirements.

18.10.7 Friction Brake

Perform a functional test of the friction brake system. Tests will include the following, as a minimum:

1. Verification of brake cylinder pressure settings
2. Control and indicator verification
3. System leakage tests
4. Response to dynamic brake feedback signals
5. Functional test of the brake fault detection system

**18.10.8 Communication Systems**

Functionally test communication equipment and systems to verify conformance with Specified requirements. In addition, perform the following tests:

1. Test the PA system, APIS and each PEI for clarity (intelligibility) of voice transmission and reception.
2. Test APC to verify accuracy of the system.
3. Test the CCTV and exterior side view CCTV to verify proper positioning of cameras.
4. Test communication systems not tested at the Contractor's Facilities:
  - a. Radio
  - b. GPS
  - c. Vehicle Wireless Communication to Wayside
  - d. AVL
  - e. Traffic Light Priority

**18.11 Vehicle-Level Routine Dynamic Tests at the City's Facilities**

**18.11.1 General**

After completion of all vehicle-level routine static tests and vehicle-level type tests conducted at the City's facilities, perform the following vehicle-level routine dynamic tests on each vehicle at the City's facilities and on the City alignment. Successful completion of testing is a condition of Acceptance of each vehicle. Instrumentation for the vehicle-level routine dynamic tests will be as Specified for vehicle-level type dynamic tests, as Specified above.

**18.11.2 Joint Inspection**

Before starting dynamic routine testing, jointly inspect the vehicle with the City. Adjust, repair, or replacements as required for proper operation or as deemed necessary by the City.

**18.11.3 Vehicle Performance Test**

Demonstrate, by dynamic testing on the City alignment, that each vehicle's tractive power, dynamic braking, friction braking, and track braking systems meet the criteria used for the Vehicle Dynamic Type Tests.

Test the vehicles only at AW0.

If adjustments are required to obtain values corresponding to the required performance levels, adjust before formal delivery and note in the vehicle's history book.

**18.11.4 Burn-In Test**

Perform burn-in test:

Sequence: Perform after successful completion of the vehicle performance test.

Test:

1. Operate each vehicle a minimum of 1000 km (621 mi) on the City alignment in simulated revenue service.
2. Stop at each station and cycle the doors on both sides of the vehicle.
3. During the last 100 km (62 mi), there will be no failures, using the same criteria as that used for Reliability in Section 2, Design and Performance Criteria.

Retest: If a failure occurs in the last 100 km, correct the problem, and restart the 100 km portion of the test.

Successful completion is a condition of Conditional Acceptance of SCV.

## 18.12 Cooperation with the City and Other Systems

Assist the City as necessary in operation of the vehicle(s) for systems integration testing, including but not limited to interface with the Shop, OCS, substations, signal system, track, and wayside.

## 18.13 Contract Deliverables Requirements List (CDRL)

### 18.13.1 General Requirements

Comply with the following:

1. Type tests: Submit a test procedure and test report for each.
2. *Component routine tests: Submit the manufacturer's routine test procedure for each. Include routine test reports with the shipping documents or furnish separately to verify that the tests were performed successfully.*
3. *Vehicle level routine test: Submit a test procedure and test report.*
4. For CDRLs for which both a test procedure and a test report are required, submit test procedures and test reports using the appropriate CDRL number followed by "P" for procedure and "R" for test report, such as CDRL 15-12.P and CDRL 15-12.R.
5. For test reports where multiple vehicles are tested, submit a separate test report for each vehicle, and include the vehicle designator in the CDRL number, such as CDRL 15-41.R/302.
6. Submit the following in accordance with Section 19, Program Control and Quality Assurance.

### 18.13.2 CDRL Details

18-1 Master Test Plan:

Submit within 180 days after NTP.

1. Include each test, whether specifically referenced in this Section or located in another section of the TS.
2. Include a proposed schedule and location for each test.
3. Component Type Tests

18-2 Flammability, Smoke Emission, and Toxicity (FST) Type Test:

FST Type Test Procedures:

1. Assemble and submit materials and test procedures for all materials as one package.
2. Include a list of each material included in the package with a description of where each type of material is used.
3. For each material, include a list of the tests to be performed with the name of applicable testing standards.
4. Include pass/fail criteria for each material.
5. FST Type Test Reports:
6. Assemble and submit test reports for all materials as one package.
7. Include sufficient test result data to demonstrate compliance with toxic gas release limits of Section 19 Materials and Workmanship, and requirements of this Section.
8. State explicitly whether each material passed or failed each test.

18-3 Waiver of FST Type Testing:

Submit in writing as one package, including each type of material for which a waiver is requested.

Include the total weight of the material to be used, the location of the material and its distribution in the vehicle. Furnish flammability, smoke emission, and toxicity test reports for each material.

**18-4 Paint Performance Type Test:**

**Paint Performance Type Test Procedure:**

1. Include a list of each type of paint and powder used on the vehicle with its location on the vehicle and sufficient identifying information so that it can be cross referenced with the paint design package Specified in Section 16, Materials and Workmanship.
2. Include Specified test criteria.
3. Include step-by-step test procedures for each Specified test.
4. Paint Performance Type Test Report:
5. Submit as one package including test results for each type of paint and powder used on the vehicle.
6. Include sufficient test data to demonstrate compliance with the TS.
7. Indicate whether each type of paint or powder passed or failed each test.

**18-5 FRP Type Test Certificates:**

For each FRP item, furnish an independent laboratory test certificate stating that the production FRP material complies with the Specified strength requirements when tested in accordance with the standards Specified in Section 19 Materials and Workmanship.

**18-6 EMI/EMC Component Type Tests:**

**EMI/EMC Component Type Tests Procedure:**

1. Furnish a test procedure prepared by the qualified test laboratory conducting the test.
2. Procedure will include the testing standards used for each test.
3. EMI/EMC Component Type Tests Report:
4. Group all test reports into one submittal.
5. For each test, furnish the test report prepared by the qualified test laboratory conducting the test.
6. The test report will include sufficient test data to demonstrate compliance with the TS.

**18-7 Cab and Floor Heater Type Tests:**

**Cab and Floor Heater Type Tests Procedure:**

1. Include separate procedures for each type of heater.
2. Include step-by-step test procedures for each test necessary to demonstrate compliance with the TS.

**Cab and Floor Heater Type Tests Report:**

1. Include sufficient test data for each test to demonstrate compliance with the TS.

**18-8 AC Traction Motor Type Test:**

**AC Traction Motor Type Test Procedure:**

1. Include the agreed to IEC 60349-2 method for determination of the characteristics and efficiency and describe adaptations required for compliance with the TS.
2. Include step-by-step test procedures for each test necessary to demonstrate compliance with the TS.

**AC Traction Motor Type Test Report:**

1. Include sufficient test data for each test to demonstrate compliance with the TS.

18-9 AC Auxiliary Motor Type Test:

AC Auxiliary Motor Type Test Procedure:

1. Include a list of motors to be tested.
2. Include a list of each test to be conducted.
3. Include step-by-step procedures complying with the Specified standard.

AC Auxiliary Motor Type Test Report:

1. Include test data and a statement of pass or fail for each test in accordance with the Specified standard.

18-10 Traction Gear Unit Type Test:

Traction Gear Unit Type Test Procedure:

1. Include the criteria and calculations used to determine the conditions to which the unit will be subjected during the test.
2. Include step-by-step test procedures for the test, including measurements to be taken.
3. Include a checklist for the Specified post-test examination of all parts.
4. Traction Gear Unit Type Test Report:
5. Include gear tooth mesh and tooth pattern from before and after the test.
6. Include test records of running time and oil temperatures.
7. Include vibration and sound level readings recorded during the test.

18-11 Auxiliary Power Supply (APS) Type Test:

Auxiliary Power Supply Type Test Procedure:

1. Include the following as a minimum:
  - a. Applicable Specified design requirements, environmental ranges, and supply voltages.
  - b. Applicable tests from the Specified standard.
  - c. Details of combined system test demonstrating the capability to start up all ac loads.
  - d. Details of temperature-rise test.
  - e. Details of planned noise measurements.
  - f. If low-voltage power supply (LVPS) and battery charger are part of the APS unit, submit as a combined test procedure under this CDRL.
2. Auxiliary Power Supply Type Test Report:
  - a. Include sufficient test data for each test to demonstrate compliance with the TS.

18-12 Low-Voltage Power Supply and Battery Charger Type Test:

Low-Voltage Power Supply and Battery Charger Type Test Procedure:

1. Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.
2. Include procedures for demonstrating that the battery charger complies with the TS.
3. Low-Voltage Power Supply and Battery Charger Type Test Report:
4. Include sufficient test data for each test to demonstrate compliance with the TS.

18-13 Truck Frame Type Test:

Truck Frame Type Test Procedure:

1. Combine test procedures for all truck tests and submit a minimum of 90 days before the test date.
2. Approval of the test procedure and stress analysis are necessary prerequisites for testing.

3. The test procedure will include, but not be limited to the following:
  - a. A description of the test
  - b. The purpose
  - c. Clear description as to how the test specimen is to be loaded.
  - d. The load increments.
  - e. Description of the equipment to be used to load the specimen.
  - f. Type and location of strain gauges
  - g. Location of deflection gauges
  - h. Complete description of all instruments
  - i. Details of the data acquisition system
  - j. Include the following drawings and sketches:
    - i. Drawings and sketches as needed to clarify the text.
    - ii. Drawings showing the test fixture, the specimen installed in the fixture, and location of load application points.
    - iii. Drawings and sketches showing the location of every strain gauge.
  - k. Include a list of the steps to be performed.
  - l. Include a copy of the current calibration for each instrument and gauge to be used during the test.
  - m. Include the calculation of the accuracy of the test system.
  - n. Include typical logging sheets, printouts, plotting forms, and examples of other data sheets that will be used during the test or in the final report.
  - o. Include the following tables:
    - i. Table showing the maximum allowable gauge reading for each gauge and loading condition.
    - ii. 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.
    - iii. Other tables, showing the acceptable criteria for all other test results, will be included in the test procedure.
  - p. For the fatigue test include the following:
    - i. Critical locations and fatigue allowable selected by the Contractor.
4. Truck Frame Type Test Report:
  - a. Include tables prepared for the test procedure with test results entered for comparison.
  - b. Include copies of original data sheets, data plots, and other means used for gathering data during the test.
  - c. Include a summary of the results indicating whether the truck is compliant with the TS. If not compliant, indicate what corrections will be made and the schedule for the truck retest.
  - d. For the pre-fatigue-test magnetic particle and dye penetrant inspection, if defects are found, include the Specified documentation of defects, and if required, repairs.



18-14 Traction Inverter Type Test:

Traction Inverter Type Test Procedure: Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.

Traction Inverter Type Test Report: Include sufficient test data for each test to demonstrate compliance with the TS.

18-15 OEES Type test

OEES Type Test Procedure: Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.

OEES Type Test Report: Include sufficient test data for each test to demonstrate compliance with the TS.

18-16 Vehicle-Shell Structural Type Tests:

Vehicle-Shell Structural Type Tests Procedure:

1. Combine the test procedures for all vehicle-body structural tests.
2. Submit a minimum of 90 days in advance of the test date.
3. Include the following. Annotated copies of catalog cuts may be used for some of this description:
  4. A description of the test
  5. The purpose
  6. How and with what equipment the specimen is to be loaded and in what load increments.
  7. The type and location of strain gauges
  8. The location of deflection gauges
  9. Complete description of all instruments and gauges
  10. Details of the data acquisition system
  11. An explanation of the accuracy of the instrumentation
12. Include the following drawings and sketches:
  - a. Drawings and sketches to clarify the text.
  - b. Plots of the finite element mesh showing the location of every strain gauge. Dimension the location of each gauge showing the distance from edges, connections, and bends. Note the location on upper or lower, inner, or outer surface.
13. Include step-by-step instructions for the following:
  - a. Description of how load is applied.
  - b. The load at each step
  - c. When to record data
  - d. The place where authorization to proceed is to be obtained from the City's representative.
14. Include a copy of the current certification for every instrument and gauge to be used during the test.
15. Include a calculation of the accuracy of the test system for each test.
16. Include typical logging sheets, printouts, plotting forms, and examples of other data sheets that will be used during the test or in the final report.
17. Include the following tables:
  - a. Tables showing the maximum allowable gauge reading for each gauge and loading condition.
  - b. Tables showing the requirements for all other test criteria.

- c. A table of analytical strain (or stress) values at selected strain gauge locations. This table will list the following:
  - i. Strain gauge number
  - ii. Analytical strain (or stress) from the stress analysis
  - iii. The location of the strain
  - iv. A space to enter the measured strain (or stress)
  - v. A space to enter the calculated percent difference.
  - vi. A space for annotation

**18. Vehicle-Shell Structural Type Tests Report:**

- a. Fill in the comparison table that was included in the test procedure with values for measured strain (or stress) and the calculated percent difference between the analytical and measured values.
- b. Approval of the Test Report will depend, in part, on the adequacy of the analyses of excessive variance between analytical and measured stress values.
- c. Where the percentage difference between the actual and analytical values of stress for the 25% exceeds the Specified values, include the Specified detailed explanation of the reasons for the excessive variance.

**System Type Test CDRLS**

**18-17 Floor Assembly Fire Performance Type Test:**

**Floor Assembly Fire Performance Type Test Procedure:**

1. Include the following as a minimum:
2. Drawing of the section of floor to be tested showing location on vehicle, dimensions, loading, penetrations, and thermocouples.
3. Test facility
4. Include step-by-step procedure that incorporates criteria from the Specified standards.
5. Include minimum fire exposure duration.

**Floor Assembly Fire Performance Type Test Report:**

1. Furnish test report prepared by the test facility, including temperatures, performance, and a test summary indicating pass or fail.

**18-18 Roof Assembly Fire Performance Type Test:**

**Roof Assembly Fire Performance Type Test Procedure:**

1. Include the following as a minimum:
  - a. Drawing of the section of roof to be tested showing dimensions, penetrations, and thermocouples.
  - b. Proposed test facility
  - c. Include step-by-step procedure that incorporates criteria from the Specified standards.
  - d. Include minimum fire exposure duration.

**Roof Assembly Fire Performance Type Test Report:**

1. Furnish test report prepared by the test facility, including temperatures, performance, and a test summary indicating pass or fail.

18-19 Propulsion Combined Type Test:

Propulsion Combined Type Test Procedure: Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.

Propulsion Combined Type Test Report: Include sufficient test data for each test to demonstrate compliance with the TS.

18-20 Friction Brake System Type Test:

Friction Brake System Type Test Procedure: Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.

Friction Brake System Type Test Report: Include sufficient test data for each test to demonstrate compliance with the TS.

18-21 Door System Type Test:

Door System Type Test Procedure: Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.

Door System Type Test Report: Include sufficient test data for each test to demonstrate compliance with the TS.

18-22 Bridgeplate System Type Test:

Bridgeplate System Type Test Procedure: Include step-by-step procedures that demonstrate compliance with the testing requirements of this Section.

Bridgeplate System Type Test Report: Include sufficient test data for each test to demonstrate compliance with the TS.

18-23 Unitized HVAC System Type Test:

Unitized HVAC System Type Test Procedure:

1. Submit one test procedure and include each individual test Specified.
2. Include step-by-step procedures for each individual test.

Unitized HVAC System Type Test Report: Submit as one test report after each individual test is completed.

18-24 Communication Systems Type Test:

Communication Systems Type Test Procedure: Include step-by-step procedures for each subsystem being tested.

Communication Systems Type Test Report: Submit as one test report after each individual test is completed.

**Vehicle Level Type Static CDRLs**

18-25 Vehicle-Level Type Static Tests:

Vehicle-Level Type Static Test Procedures:

1. Include a description of instrumentation and channel assignments.
2. Include step-by-step test procedures for the following tests as a minimum:
3. Horn and bell type test
4. Jacking type test
5. Ducting watertightness type test
6. Air leakage type test
7. Air balance type test

- 1        8. HVAC system type test
- 2        9. Door operation type test
- 3        10. Bridgeplate operation type test
- 4        11. Lighting intensity type test
- 5        12. Communication equipment type tests
- 6        13. Vehicle data network type test
- 7        14. Include each Specified test requirement.
- 8        15. Vehicle-Level Type Static Test Reports:
- 9            a. Submit as one test report after each individual test is completed.
- 10    **Component Routing Test CDRLs**
- 11    18-26 Air Conditioning Unit Routine Test Procedure
- 12    18-27 Motor Routine Test Procedure
- 13    18-28 Traction Gear Unit Routine Test Procedure
- 14    18-29 Traction Inverter Routine Test Procedure
- 15    18-30 OESS Routine Test Procedure
- 16    18-31 AC Auxiliary Power Supply Routine Test Procedure
- 17    18-32 Low-Voltage Power Supply and Battery Charger Routine Test Procedure
- 18    18-33 Battery Routine Test Procedure
- 19    18-34 Friction Brake Routine Test Procedure
- 20    18-35 Communication System Routine Tests Procedure
- 21    18-36 Truck Frame Welds Routine Test Procedure
- 22    18-37 Wheel Back-to-Back Routine Test Procedure
- 23    18-38 Resistance Routine Test Procedure:
- 24        1. Wheel shunt resistance
- 25        2. Vehicle-structure to wheels resistance.
- 26        3. Propulsion system to wheels resistance.
- 27    18-39 TWC System Routine Test Procedure
- 28    **Vehicle Level Routine Test Procedure**
- 29    18-40 Vehicle-Level Systems Routine Functional Tests:
- 30    **Vehicle-Level Systems Routine Functional Tests Procedure:**
- 31        1. Include a list of systems to be tested.
- 32        2. Include step-by-step procedures used for each system.
- 33        3. Include pass/fail criteria for each test.
- 34        4. Vehicle-Level Systems Routine Functional Test Report:
- 35        5. Submit as one test report after each individual test is completed.
- 36    18-41 Vehicle Wiring Routine Tests:
- 37    **Vehicle Wiring Routine Test Procedure:**
- 38        1. Include test methods and voltages applied.

2. Include instruments used with calibration dates.
3. Include step-by-step procedures for each of the following:
  - a. Wiring Continuity Checks
  - b. Insulation Resistance Test
  - c. Dielectric (High Potential) Test
  - d. Vehicle Wiring Routine Test Report

18-42 Watertightness Routine Tests:

Watertightness Routine Tests Procedure:

1. Include details of the spray equipment
2. Include a sketch of the test setup.
3. Include step-by-step procedures for each of the following watertightness tests:
  4. Vehicle
  5. HVAC
  6. Equipment Enclosures
  7. Traction Motor Leads
  8. Watertightness Routine Tests Report

**Vehicle-Level Type Dynamic Test CDRLs (the City's Facilities)**

18-43 Vehicle-Level Type Dynamic Tests:

Vehicle-Level Type Dynamic Test Procedure, include the following:

1. Type Testing Instrument Calibration Certification:
  - a. Include each instrument to be used during vehicle type testing.
  - b. Verify that calibration is current such that recalibration will not be required during the scheduled duration of testing.
2. Step-by-step procedures for the following tests as a minimum:
  - a. Auxiliary inverter type test
  - b. OESS type test
  - c. Propulsion and braking type tests
  - d. Emergency towing type test
  - e. Include each Specified test requirement for each system.
3. Vehicle-Level Type Dynamic Test Report:
4. Auxiliary Inverter: Include representative samples of chart recordings of inverter operating characteristics taken during the auxiliary inverter component type test and the vehicle type tests.
5. Propulsion and Braking:
  - a. Present test results with Specified performance criteria in a clear and organized fashion.
6. Include results of each type of test, including the following as a minimum:
  - a. Each Specified run and series Specified for propulsion and dynamic and friction braking.
  - b. Track brake system test
  - c. Thermal capacity test
  - d. Wheel spin/slide
  - e. Parking brake
  - f. Strip charts and recordings taken during the vehicle level type testing are the property of the City.

18-44 Ride Quality Type Test:

Ride Quality Type Test Procedure:

1. Include a sketch and description of instrumentation.
2. Include a sketch and description of weights used to simulate loading.
3. Ride Quality Type Test Report:
4. Include raw data.
5. Include analysis of data and calculations.

18-45 Noise and Vibration Type Test:

Noise and Vibration Type Test Procedure:

1. Include a sketch and description of instrumentation setups.
2. Include forms for recording data.
3. Indicate section of alignment where measurements will be taken.
4. Noise and Vibration Type Test Report:
5. Include raw data.
6. Include a summary clearly showing whether the Specified levels have been achieved.

18-46 EMI/EMC Type Test:

EMI/EMC Type Test Procedure:

1. Include a sketch and description of instrumentation setups.
2. Include forms for recording data.
3. EMI/EMC Type Test Report:
4. Include raw data.
5. Include a summary clearly showing whether the Specified levels have been achieved.
6. Vehicle-Level Routine Static Tests (the City's Facilities)

18-47 Vehicle-Level Routine Static Tests at the City's Facilities:

Vehicle-Level Routine Static Tests at the City's Facilities Test Procedure:

1. Include step-by-step test procedures for the following tests as a minimum:
  2. Door, Operators and Controls
  3. Bridgeplate, Operators and Controls
  4. Air Conditioning
  5. Heating
  6. Headlight and Stoplight Adjustments
  7. APS/LVPS
  8. OESS
  9. Traction Inverter
  10. Friction Brake
  11. Communication System
  12. Vehicle-Level Routine Static Tests at the City's Facilities Test Report
  13. Vehicle-Level Routine Dynamic Tests (the City's Facilities)

18-48 Vehicle Performance Test on the City Alignment:

Vehicle Performance Test on the City Alignment Test Procedure:

1. Include a description of instrumentation and channel assignments.
2. Include step-by-step test procedures for the following tests as a minimum:
  - a. OESS

- 1                   b. Tractive power system
- 2                   c. Dynamic braking system
- 3                   d. Friction braking system.
- 4                   e. Track braking system
- 5           3. Vehicle Performance Test on the City Alignment Test Report
- 6   18-49 Burn-In Test:
- 7   Burn-In Test Procedure:
- 8           1. Include samples of forms used for recording mileage and equipment failures.
- 9           2. Burn-In Test Report

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## 19.1 General

### 19.1.1 Scope

This Section defines the minimum performance requirements for materials to be used in the construction of the vehicles and establishes minimum guidelines for workmanship. It identifies mandatory government requirements and industry specifications controlling the quality of specific materials and components and the construction methods. Alternatives may be considered for Approval by the City, if proposed.

Inclusion of a material or product in this section does not imply approval of its use in a particular application. Refer to other Sections for detailed requirements for specific vehicle systems.

### 19.1.2 Quality

Ensure that equipment, materials, manufacturing, assembly, and installation processes and practices are in full conformance with the requirements of the TS as well as with proven and recognized industry practices and recommendations.

### 19.1.3 Standards

Materials and workmanship will conform to the appropriate industry standards for use on rail transit equipment:

1. These standards include, Federal, Military specifications or standards, the specifications and standards of the Aluminum Association, AAR, ANSI, ASME, ASNT, ASTM, AWS, FRA, IEEE, IEC, EN, NACE, NFPA, SSPC, or other requirements as Specified in this Section.
2. Foreign or international standards may be proposed as alternatives. Submit proposed standards in English for review by the City. A service history of equipment built to these standards must be included to demonstrate the applicability of the standard.

### 19.1.4 Material Availability in the U.S.

#### *Cleaning Agents*

For each part of the vehicle that is normally cleaned, materials proposed for use in those area must have a manufacturer-recommended cleaning agent available and not prohibited in the U.S.

#### *Maintenance Materials*

Fasteners, paint, lubricants, and other materials required for maintenance of the vehicles must be available and not prohibited in the U.S.

### 19.1.5 Storage of Material

Ship and store equipment and material intended for use in these vehicles such that damage and reduction in life are prevented:

1. These requirements apply to equipment and material at the Contractor's facilities, at the City's facilities, and to capital spare parts.
2. At a minimum, comply with the following:
  - a. Protect stored material subject to corrosion using waterproof covers or coatings. Store materials and equipment within environmentally controlled areas and off the floor or ground.
  - b. Store equipment with ports, covers, and other enclosure openings closed to prevent entrance of dirt or moisture.

- c. Clearly mark dated material with the expiration date; material will not be used beyond this date.
- d. Handle and store material with special handling or storage requirements according to the manufacturer's requirements.
  - i. For equipment with special storage requirements, include storage and handling instructions with the equipment.
  - ii. Clearly mark and store material with appropriate nomenclature to prevent misapplication.
  - iii. Include instructions on how to prepare equipment for use after long periods of storage, where applicable.
- 3. Clearly mark rejected material as such and store it in a separate area specifically designated for that purpose.

#### 19.1.6 Prohibited Materials

The Contractor is prohibited from using the following materials on the vehicle:

- 1. PVC
- 2. Asbestos
- 3. Cadmium
- 4. Lead, all applications, including in paint and coatings, except for electronics solder.
- 5. PCBs
- 6. Carcinogenic materials as listed by current Publication of the American Conference of Governmental Industrial Hygienists (ACGIH)
- 7. CFC and HCFC compounds, including R-22 refrigerant.
- 8. Urethane foam
- 9. Materials in the List of Highly Hazardous Chemicals, Toxics and Reactives, 29 CFR 1910.119, Appendix A

#### 19.1.7 Material Reporting Requirements

Comply with the following:

- 1. Whenever a proposed commercial material is not covered by the Specification or a standard, the material must be submitted for Approval by the City.
- 2. Keep on file Safety Data Sheets (SDSs) for chemical materials (paints, solvents, adhesives, etc.) used in the manufacture of the vehicle, and furnish SDS information as requested by the City for any questionable material. SDSs will comply with 29 CFR Section 1910.1200 (g).
- 3. Maintain records that trace all materials to their manufacturers and production lots, verify compliance with Specified quality standards.

#### 19.1.8 Dissimilar Materials

Dissimilar materials are materials that corrode or otherwise become damaged when in contact with each other.

1. Connection of dissimilar materials is permitted only at permanent connections and with Approved electrochemical isolation.
2. Electrochemical isolation treatments will be permanent and not require maintenance or replacement for the life of the vehicle.
3. Dissimilar materials are not permitted at electrical connections or connections requiring disassembly for maintenance or for removal and replacement of equipment.

### 19.2 Standards of Workmanship

#### 19.2.1 Workers

Comply with the following:

1. Vehicle components will be constructed by workers experienced in the appropriate trades.
2. Comply with worker training and supervision requirements included in the manufacturing control requirements Specified in Section 2.5

#### 19.2.2 Use of Drawings and Procedures

Comply with the following:

1. Design and/or construction drawings and procedures will be readily available where manufacturing is occurring and will be used by workers to accomplish and verify their tasks.
2. Comply with requirements in the Manufacturing section of Section 2.5, to ensure that workers are always using the current revision.
3. Use tooling as defined by the design and/or construction drawings.
4. Work not expressly detailed on the Contractor's drawings, such as internal standards or documents, will conform to the minimum standards of workmanship in this Section, and are subject to the same review and approval standards as the drawings.

#### 19.2.3 Use of Manufacturing Tools and Interchangeability

Comply with the following:

1. Attachment points in the vehicle and on subassemblies will be located by jigs, fixtures, laser levels, and similar methods, unless waived by the City, to ensure accurate placement and per-design tolerances.
2. Components will be constructed to the same dimensions and tolerances, hole and subassembly locations, materials, and finishes, and will be interchangeable in the vehicle and between vehicles without modification.

#### 19.2.4 Prohibited Practices

The following are strictly prohibited:

1. Cut-to-fit, match drilling, filing, and other hand-fitting practices, unless specifically Approved by the City. Where such practices appear necessary in construction, perform a prompt review of design and construction methods, and implement corrections to avoid these practices, in accordance with manufacturing control requirements Specified in Section 2.5.



2. Modification of OEM or subcontractor equipment, including minor modifications such as replacement of wire terminations.
3. Modification of Contractor equipment without following the Approved Modification and Configuration Control Manual procedure, as Specified in Section 2.4.

#### 19.2.5 Metal Fabrication

Comply with the following:

1. In rolled-steel members, camber, and sweep, as received, will not exceed AISC specifications.
2. Flat plates will be sheared or cut using modern metal-cutting technology such as laser cutting or waterjet cutting.
3. Structural shapes, pipe, and tube will be cut to length using band saw or cold cut blade saw. Cutting to length by handheld torch is not permitted.
4. Holes will be drilled or die punched. Bolt holes will not be burned by hand torch. Holes 38 mm (1.5 in) and larger may be cut by modern metal-cutting technology such as laser cutting or waterjet cutting.
5. The spacing of holes on connection plates will have a tolerance of maximum 0.8 mm (1/32 in).

#### 19.2.6 Machining

Comply with the following:

1. Machine fits will adhere to ASME B4.1.
2. Surfaces receiving power machine cutting or profiling will have a surface finish of maximum 0.003 mm (125 microinches) RMS.
3. Shafting will have the ends squared by face off in an engine lathe.
4. Chamfers will be machined on shaft edges and at edge of bore of press on parts.
5. Cut edges will be de-burred.

### 19.3 Fasteners

#### 19.3.1 General

##### *Scope*

Fasteners include threaded fasteners, associated nuts, tapping plates, and washers; quick-release fasteners; rivets; and locking pins.

##### *Design*

Take note of the City's preferences, and comply with requirements:

1. The City's preference is that fasteners conform to ISO metric standards. However, use of inch-standard fasteners may be permitted, as Approved, for U.S. suppliers for which using metric fasteners would require a redesign of products. In the TS, metric units and standards are followed by inch units and standards in parentheses.
2. The City has a strong preference for the following:
  - a. Fasteners used to mount equipment to the vehicle: Metric.
  - b. Fasteners used internal to equipment: Metric.

3. The Contractor will select fastener types, sizes, styles, lengths, materials, grades, and finishes that will satisfy the requirements of the design and meet the requirements of the TS.
4. Minimize the number of different sizes and styles of fasteners used.

*Material*

Comply with the following:

1. Bolts, screws, nuts, washers, and other related fastening devices will be plated steel or stainless steel.
2. Aluminum fasteners are generally prohibited, except when permitted within the TS.
3. Except for fasteners internal to electrical or electronic components, plastic screws, bolts, nuts, or other plastic fastening components will not be used unless specifically Approved.

*Plating*

Comply with the following:

1. Carbon steel, alloy steel, and martensitic stainless-steel fasteners will be plated with zinc, unless specifically waived by the City. Zinc plating will conform to ASTM B633, Type II, and SC2, SC3, or SC4.
2. Plating materials other than zinc, and plating of any type on high strength fasteners, are subject to approval by the City.
3. Cadmium plated fasteners are not permitted.

*Prohibited*

The following are prohibited:

1. Protruding screws, mounting bolts, or similar items on the vehicle interior or exterior, except for those appointments that cannot be built into the structure in any other manner.
2. Self-drilling and self-tapping screws, except where specifically Approved.
3. Tapped holes in structure, brackets, and other vehicle assemblies. Tapping plates will be used when installing fasteners into vehicle structure or subassemblies.
4. Fasteners installed into blind holes, unless specifically Approved.
5. Thread-sealing compounds, except for anti-vibration treatments (such as Loctite) where Approved.
6. Use of elastic stop nuts for electrical connections.

**19.3.2 General Requirements for Threaded Fasteners**

*Head Types*

Comply with the following:

1. General: Hex heads or hex socket-heads.
2. Where Specified: Anti-tamper designs, of the same design throughout.
3. Prohibited: Philips, flat head, or other designs, except in small electronic assemblies or where specifically Approved.

*Identification*

Comply with the following:

1. Metric fasteners: will be identified as required by applicable ISO standards.
2. Inch fasteners: will be identified as required by applicable U.S. standards.

*Maintenance Access*

Provide access for maintenance or replacement of threaded fasteners and nuts. When bolts are used to secure equipment where the bolt head is inaccessible, provide a reusable mechanical locking device to prevent the bolt head from turning when the nut is being turned.

*Thread Projection*

Comply with the following:

1. Minimum projection: 1-1/2 full screw threads beyond the nut, at proper torque.
2. Maximum projection:
  - a. With elastic stop nuts: 6.4 mm (1/4-inch), regardless of bolt diameter.
  - b. Without elastic stop nuts:
    - i. 6.4 mm (1/4 in) diameter or less: 1-1/2 full threads plus 6.4 mm (1/4 in)
    - ii. Greater than 6.4 mm (1/4 in) diameter: Eight full threads, unless otherwise Approved by the City.

*Bolt Hole Size*

Bolt hole clearances will not exceed the recommendations of ISO 273 (or Industrial Fasteners Institute).

*Tapping Plates*

If tapping plates are used, comply with the following requirements:

1. Minimum Thickness: Equal to diameter of the bolt for which the tapping plate is intended.
2. Strength: Same standards as the equivalent nut.
3. Installation:
  - a. Attach to the structure with mechanical fasteners unless otherwise Approved.
  - b. Drill a clearance hole in the structure for the bolt.

**19.3.3 Special Requirements for Structural Fasteners**

*Scope*

This section applies to structural and load carrying bolts:

1. It includes structural bolts for undercar and roof equipment.
2. It includes fasteners used on the side sill to attach heavy equipment brackets (these are considered structural fasteners).

*Material and Property Class (or Grade)*

Comply with the following:

1. Structural or load-carrying bolts will be medium carbon steel.
2. Metric (or inch) bolts and nuts will conform to minimum requirements as indicated in the table below, including markings. Stronger fasteners will be used if required for the application.

3. Nuts will have a material proof strength equal to or greater than the material ultimate tensile strength of the fastener with which it is used. For applications where this is not achievable, submit specific calculations showing that the nut is stronger than the bolt to prevent undetected internal thread stripping.

<b>Structural or Load Carrying Bolts: Minimum Grade</b>		
	<b>Standard</b>	<b>Property Class (Grade)</b>
<b>Bolts</b>	ISO 898-1 (SAE J429 or ASTM A449)	8.8 (5)
<b>Nuts</b>	ISO 898-2 (SAE J995)	According to bolt strength

*Minimum Size*

Bolt diameter will be minimum 10 mm (3/8 in), regardless of design load.

*Required Documentation*

Structural fasteners will have documentation available for examination by the City at the Contractor's QA department:

1. Identification of manufacturer
2. Purchase specifications
3. Fastener material or grade
4. Finish, including plating material and specifications, when applicable

Obtain and hold the documentation for a period not ending before expiration of the last vehicle's warranty period, whether the buyer is a subcontractor, supplier, or the Contractor.

*Additional Requirements for Safety-Related Fasteners*

Comply with the following requirements for safety-related fasteners:

1. Scope:
  - a. Safety-related fasteners include, but are not limited to, those applied to trucks, bolsters, brake equipment, couplers, and power collection devices.
  - b. A fastener is safety related if failures cannot be tolerated; that is, if even a single fastener fails, there is a possibility of brake failure, derailment, or accident.
  - c. In the event of a dispute, the City will make the final determination of which fasteners are safety related.
2. Testing for Conformance to Purchase Specifications:
  - a. 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.
  - b. 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 will be treated as separate lots.
  - c. Testing will be performed using sample quantities as proposed by the Contractor and Approved by the City.

- d. Tests conducted will confirm that fastener material meets Specified chemistry and strength requirements.
  - e. Obtain certified test results from the testing laboratory and hold the documents for a period not ending before expiration of the last vehicle's warranty period.
3. Testing for Hydrogen Embrittlement:
- a. Safety-related fasteners that are plated or chemically cleaned will have certification of hydrogen-embrittlement testing.
  - b. The certification will be based on a representative sample of actual production fasteners that have been tested by the original equipment manufacturer, Contractor, or a supplier for hydrogen embrittlement following SAE USCAR7 procedures. The plating process will be certified to ASTM F519 procedures.
  - c. An ASTM F606/F606M wedge-test sample may be used in place of the ASTM F519 standard samples.
  - d. Test loads will be a minimum of 80% of yield strength or proof load and held for a minimum of 168 hours. Any failures will result in the rejection of the entire lot.
  - e. Obtain certified test results from the testing laboratory and hold the documents for a period not ending before expiration of the last vehicle's warranty period.

#### 19.3.4 Coatings other than Zinc

Comply with the following requirements for alternate fastener coatings (other than zinc):

- 1. Alternate fastener coatings are permissible only if Approved by the City. If Approved, they must be qualified by testing per ASTM B117 with no red rust or visible corrosion products after 96 hours of exposure.
- 2. Test for hydrogen embrittlement in accordance with the Testing for Hydrogen Embrittlement section, above, as Specified below:
  - a. Fasteners less than Property Class 8.8 (or Grade 5): If the coating has the possibility of causing hydrogen embrittlement, each lot will be tested for hydrogen embrittlement.
  - b. Fasteners of Property Class 8.8 (or Grade 5) or higher: Each lot will be tested for hydrogen embrittlement regardless of the coating's propensity for hydrogen embrittlement, including OEM plated zinc or yellow bolts.
- 3. 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 IFI-543, comply with the following:
  - a. Use alternate coating on all fasteners within the LRU.
  - b. Provide an indelible label identifying the coating type used within the LRU and the required torque values for each size fastener used.
  - c. Fasteners internal to a subcomponent within an LRU may use the standard coating system if they are not subject to removal during maintenance activities.

### 19.3.5 Self-Locking Nuts and Washers

#### *Self-Locking Nuts*

##### Self-Locking Nut Requirements:

1. Type: Prevailing-torque, nylon-insert type, regular-height, self-locking ESNA stop nuts, or Approved equal.
2. Alternate type: All-metal; use only where there is insufficient clearance to install ESNA type locknuts, or where the locknut is exposed to temperatures above manufacturer's recommended maximum temperature.
3. Standard: Conform to IFI ISO Standards Handbook (or inch fastener standards found in the IFI Inch Fastener Standards Book) or NASM21044.
4. High Temperature: Nylon insert lock nuts will not be used near heat sources that will exceed the locknut manufacturer's recommended maximum temperature.

##### Use Requirements:

1. Self-locking nuts (locknuts): Use throughout, where appropriate for the application.
2. Non-self-locking nuts with lock washers: Use only in non-structural applications upon approval by the City, or where required by the TS.

#### *Washers*

##### Washer Requirements:

1. Suitable for the application and matched with the property class (or grade) of the bolt with which it is used.
2. Where high-strength fasteners (above Class 8.8/Grade 5) are applied, washers will be hardened.
3. Washers will comply with ISO standards found in the Industrial Fasteners Institute (IFI) ISO Standards Handbook (or inch fastener standards found in the IFI Inch Fastener Standards Book).
4. If used, lock washers will conform to IFI standards.

##### Use Requirements: Provide washers under the heads of bolts and under nuts.

##### Use Restrictions:

1. Split-ring lock washers are prohibited except where specifically Approved.
2. Lock washers will not be used in structural applications or in fatigue applications where the fastener must be torqued and marked. If applicable, prevailing torque nuts will be used for these applications.
3. Other types of washers, including Belleville washers, may be used for special applications with approval by the City.

### 19.3.6 Torquing

##### Comply with the following requirements for torquing:

1. Specify fastener torque value on the Shop Assembly Drawing.
2. Torque threaded fasteners to the value assigned by the designer or to standard torque values recommended by the fastener manufacturer as appropriate to the application.

3. Torque safety-related fasteners, including truck and brake equipment bolts and all fasteners exposed to fatigue loads, to a minimum preload equal to 75% of their proof load and “torque stripe” after torquing by paint or other Approved means.
4. Calculate fastener installation torque for standard oiled or waxed bolts with standard or heavy hex nuts from Industrial Fasteners Institute equations in “Torque Book for Fasteners.” Use the following values for coefficient of friction, “K”, unless another coefficient of friction was established during qualification of an alternate thread plating or coating:
  - a. Unplated threads:  $K = 0.18$
  - b. Plated threads:  $K = 0.15$
5. Torque self-locking nuts in accordance with their manufacturer’s recommendations or conduct tests to determine the proper installation torque.
6. Perform torquing only by torque wrench.

For those nuts or bolts requiring “torque striping,” the City may require bolt torque-tension tests to verify that installed preload is equivalent to 75% of proof loads.

#### 19.3.7 Other Fasteners

##### *Quick-Release Fasteners*

Quick release fasteners may be quarter-turn type or other types, as Approved by the City:

1. Quarter-turn fasteners:
  - a. Shank diameter: Minimum 6.35 mm (1/4 inch)
  - b. Strength: Adequate for the application
  - c. Manufacturer: Southco, or Approved equal
2. Head type: Philips, tamper proof, hex socket, or hex head.

##### *Rivets and Lock Pins*

Rivets and lock pins will meet the following requirements:

1. Exposed to passengers: Austenitic stainless steel or aluminum as appropriate to the materials being joined.
2. Exposed heads: Concentric with the shank and free from rings, fins, pits, and burrs.
3. Structural steel rivets: Conform to ASTM A502.
4. Swage-locking (Huckbolt-type) fasteners: Conform to MIL-P-23469.

Installation:

1. Rivets:
  - a. Driven hot: May be hand driven and will completely fill the rivet holes.
  - b. Driven cold: will be mechanically driven.
  - c. Removed and replaced: Ream holes to the size required such that the next larger rivet may be driven securely.

2. Huckbolt-type fasteners:
  - a. Machine or grind smooth rough surfaces of the collar end where accessible to passengers, crew, or maintenance personnel performing routine maintenance functions.
  - b. The City will make the final determination whether an application is hazardous to maintenance personnel.

#### 19.3.8 Location- and Application-Specific Requirements

##### *Interior – Exposed to Passengers*

Comply with the following requirements:

1. Install such that the fastener head is flush with the mating surface.
2. Match the surfaces being joined using bright or finished fasteners:
  - a. General use: Austenitic or plated martensitic stainless steel.
  - b. For stanchions: Austenitic grade stainless steel.
3. Use screws, bolts, and nuts only if specifically Approved.

##### *Exterior – Exposed to Passengers*

Comply with the following requirements:

1. Stainless steel vehicle body: Austenitic stainless steel.
2. Aluminum vehicle body: Austenitic stainless steel or aluminum alloy fasteners, as appropriate to the design and appearance requirements.

##### *Access Required*

For access panels, equipment box covers, or other areas requiring access, comply with the following:

1. Fasteners will be captive to the panel or cover in which they are used.
2. Where operator or maintenance access is expected more often than every five years, provide quarter-turn fasteners or similar quick-release fastener. Where greater clamping force is required, such as for EMI containment, alternate fasteners may be proposed.
3. Where accessible to passengers, provide tamper-resistant type fasteners of a single style.

##### *Heat Producing Equipment*

When making connections to heat producing equipment, take into consideration the thermal expansion of the components for selection of fastener materials:

1. If the joined components are high-expansion alloys such as copper or austenitic stainless steel, use austenitic stainless-steel fasteners.
2. If the joined components are low-expansion materials such as carbon steel or ferritic stainless steel, use zinc plated carbon steel fasteners of minimum Class 8.8 (or Grade 5).
3. Cadmium plated fasteners are not permitted.
4. Use only fasteners rated by fastener manufacturer for maximum ambient temperatures.



## 19.4 Joining

### 19.4.1 Joint Fitting

Comply with the following:

1. Joints will be properly fitted, whether exposed or concealed.
2. Gaps between joints will be held to a minimum and be uniform in width.
3. The edges of panels will have a smooth, finished appearance.

### 19.4.2 Metal-to-Metal Connections

Comply with the following:

1. Metal riveted or bolted to metal:
  - a. Contact surfaces will be free of dirt, grease, rust, and scale.
  - b. Coat with an epoxy primer as Specified below in the Paints, Graphics, and Coatings section.
2. Aluminum: Metal-to-metal connections will be as Specified below in the Aluminum section.

### 19.4.3 Wood-to-Metal Connections

Comply with the following:

1. Wood and ferrous metal surfaces joined:
  - a. Coat wood with two coats of epoxy paint.
  - b. Coat metal with primer, as Specified below in the Paints, Graphics, and Coatings section.
2. Bolts or rods passing through wood: Coat with primer.
3. Aluminum: Wood-to-metal connections will be as Specified below in the Aluminum section.

### 19.4.4 Wood-to-Wood Connections

Wood and wood joined: Coat both abutting surfaces with two coats of epoxy.

## 19.5 Metal

### 19.5.1 Stainless Steel

#### *Austenitic Stainless Steel*

Comply with the following:

1. General requirements for delivery:
  - a. As required by the Certification Provisions of ASTM A666.
  - b. Structural applications: Test for susceptibility to intergranular corrosion in accordance with ASTM A262:
    - i. Practice A: Use to accept material only.
    - ii. Practice E: Required for final determination of acceptance or rejection of material that is not acceptable by Practice A.

2. Structural components assembled by fusion or resistance welding:
  - a. Specification and composition:
    - i. AISI type 201L, 301L, 301LN or SUS301L (with Nitrogen), 316L
    - ii. Conform to the requirements of ASTM A666 except that the carbon content will not exceed 0.03 percent and type 301LN and SUS301L (with Nitrogen) will not exceed 0.25 percent nitrogen.
  - b. Conform to paragraph (f) from Section 2 of AAR "Specifications for the Construction of New Passenger Equipment Cars."

#### *Ferritic Stainless Steel*

Comply with the following:

1. General requirements: As Specified in ASTM A480/A480M.
2. Used in welded construction:
  - a. May be used only with the specific written approval of the City.
  - b. will contain stabilizing element(s) to prevent sensitization during welding.
  - c. When Specified, ferritic stainless-steel conforming to ASTM A240/A240M may be used for sheeting up to 5 mm (0.2 in) thickness.
  - d. will have a ductile-to-brittle transition temperature (DBTT) or nil-ductility temperature (NDT) below -18 degrees C (0 degrees F).
  - e. Weld heat-affected-zones will also have a DBTT or NDT below -18 degrees C (0 degrees F).
  - f. will have a balanced composition (low carbon and/or suitable titanium content) that will, for all conditions of fabrication and assembly into the vehicle body, inhibit formation of martensite and limit chromium depletion in weld heat-affected-zones, such that material meets ASTM A763 requirements for resistance to inter-granular corrosion.
  - g. Where ferritic stainless steels are welded to other structural steels, the less-noble steel will be painted with weld-through primer.

#### *Other Stainless Steel*

Other stainless steels, non-welded applications: ASTM A666 is acceptable.

#### *Testing*

Before purchasing stainless steel to be used in welded applications, submit a test and inspection plan that verifies that the stainless steel conforms to Specified requirements, as described in the Contract Deliverables Requirements List (CDRL), below.

#### 19.5.2 High-Strength Low-Alloy Steel (HSLA)

Comply with the following:

1. Structural shapes, plates, and bars:
  - a. Minimum standard: ASTM A588/A588M.
  - b. Plate steel: May alternatively conform to ASTM A710, Grade A, Class 1, 2 or 3.
  - c. Delivery: General requirements per ASTM A6/A6M.

2. Cold and hot rolled HSLA sheet and strip:
  - a. Minimum standard: ASTM A606/A606M, Type 4.
  - b. Delivery: General requirements per ASTM A568/A568M.
3. Welded HSLA steel: will develop 27 J (20 ft-lb) Charpy V Notch impact strength in the CGHAZ (Coarse grain heat affected zone 1 mm from fusion area) at -18 degrees C (0 degrees F).
4. Application:
  - a. HSLA steels will be applied according to their specification properties.
  - b. Hot rolled or formed structural shapes conforming to ASTM A36/A36M may be used for non-structural applications, including equipment supports, jack pads, and clip angles.
5. Testing: Before purchasing structural steel, submit a test and inspection plan that verifies that the stainless steel conforms to Specified requirements, as described in the Contract Deliverables Requirements List (CDRL), below.

### 19.5.3 Steel Castings

#### *General*

Comply with the following:

1. Select for composition, heat treatment, and design best suited for the intended application.
2. Marking: Apply pattern and serial numbers in a manner that does not impair their strength.
3. Disposal of Non-Conforming Castings: If castings are found to be non-conforming to requirements determined by the design qualification castings, the material will be repaired, retested, and re-inspected or destroyed at the Contractor's expense.
4. Welding of castings: Permitted, if the casting supplier performs repair welds in accordance with an Approved written procedure and uses welders qualified to ASTM A488/A488M.

#### *Design Qualification*

Comply with the following:

1. Before castings are produced: Select acceptance levels for the design qualification radiographic examinations as appropriate for the service intended, subject to approval by the City.
2. Qualification Test:
  - a. Conduct on one casting, selected by the City from the first lot of production castings, to test the casting design:
    - i. Perform radiographic examination to determine material soundness using reference radiographs to ASTM E446, and mechanical testing, as required.
    - ii. Radiographs will meet the requirements of ASTM E94 and E1030 and the quality level in inspection will be at least 2% (2-2T).
    - iii. Radiographs resulting from the Qualification Test will be made available to the City for review.
  - b. Submit a Qualification Test report as Specified in the Contract Deliverables Requirements List (CDRL) section, below. Obtain approval before production of castings.

3. After Qualification: Once a design is qualified and accepted by the City, no changes will be made in the casting pattern, technique, heat treatment, or material composition without re-qualification in accordance with the requirements of this Section.

*Quality*

Comply with the following:

1. Structural castings: Equal to or better than the design qualification castings in all respects.
2. Test, inspect, and accept castings in accordance with procedures described in AAR M-201.

Perform the inspections below and furnish a test report for each lot of castings produced:

1. Magnetic particle inspections:
  - a. Conduct on all surfaces of each casting according to ASTM E709. Testing personnel will be certified to NAS410.
  - b. Structural castings, including coupler castings: Maximum permissible magnetic particle indications will be 6 mm (1/4 in) in the direction transverse to the usual direction of loading, and 19 mm (3/4 in) in the direction parallel to the usual direction of loading.
2. Radiographic inspection:
  - a. Conduct according to ASTM E94 and ASTM E1030/E1030M, using reference radiographs to ASTM E446.
  - b. Propose a sampling frequency and submit for approval.
3. Radiographic inspection of structural castings:
  - a. will not exceed Severity Level 3 of ASTM E446 in critical areas and will not exceed Severity Level 5 in other areas of the castings.
  - b. During demonstration that the stated severity level requirements of ASTM E446 have been met, re-inspect successively produced castings by radiography in the defective areas shown in the prior radiographic inspection.
  - c. Sampling frequency:
    - i. After severity levels have been proved, 1 casting out of each 10 produced.
    - ii. If no castings are rejected by radiographic inspection, 1 casting in 25.
    - iii. If an unacceptable casting is found during sampling, Contractor will inspect 100% of other castings from the lot/heat, or before and after in sequence (if sequentially cast), until the extent of the unacceptable condition(s) is determined.
    - iv. If the reason for the failure has been isolated, based upon City review, sampling may return to 1 casting in 10, and then, if no failures are found, to 1 in 25.

*Specific Applications*

Comply with the following in the Specified application:

1. Truck and vehicle-body structures:
  - a. Meet AAR M-201, Grade "B", plus 2% nickel, minimum.

- b. Heat-treat castings to develop the following:
  - i. Minimum tensile strength: 517 MPa (75 ksi)
  - ii. Minimum yield strength: 331 MPa (48 ksi)
  - iii. Elongation: Minimum 25% in 50.4 mm (2 in)
  - iv. Reduction of area: Minimum 50%
2. Truck side frames and bolsters:
  - a. Comply with applicable standards:
    - i. Bolsters: AAR M-202
    - ii. Side frames: AAR M-203
3. Coupler, drawbars, and anchors: Meet AAR Specification M-201, Grade "C", quenched and tempered.

#### 19.5.4 Aluminum

##### *General Requirements*

Comply with the following:

1. Aluminum-alloy mill products:
  - a. Identify by designations prescribed by the Aluminum Association.
  - b. Conform to specifications contained in the Aluminum Association's publication "Aluminum Standards and Data."
2. Castings:
  - a. Sand castings: Conform to ASTM B26/B26M.
  - b. Die castings: Conform to ASTM B85/B85M.
  - c. Permanent mold castings: Conform to ASTM B108/B108M.
3. Aluminum alloy forgings: Conform to ASTM B247.

##### *Design Stresses*

Design aluminum structural members such that calculated stresses under the maximum load do not exceed allowable stresses listed in the Aluminum Association's "Aluminum Design Manual."

Make proper allowance for the effects of fatigue, for column and plate stability effects, and for strength reduction at welded regions.

##### *Connections to Aluminum*

Take specific measures, based on a suitable method that can be adapted to the design involved, to prevent the risk of direct metal-to-metal contact that could result in galvanic or electrolytic corrosion. The measures will be Approved by the City. Comply with the following minimum requirements for connections to aluminum unless they conflict with recommendations by the aluminum manufacturer:

1. Provide protection at the contact surfaces of connections to aluminum.
2. Carbon steel and stainless-steel fasteners (including washers and nuts):
  - a. will be zinc plated.

- b. will be coated with zinc chromate paste before installation.
  - c. The head and unthreaded portion of the shank of the bolt will be in contact with the aluminum part when secured in place, where possible. Suitable bushings may be used in place of the zinc-chromate paste.
3. Comply with the follow requirements for connections to aluminum alloy:
- a. Surfaces will not be secured to, nor make direct contact with the surfaces of the following:
    - i. Wood; or
    - ii. The following metals:
      - 1. Copper or copper bearing aluminum alloy
      - 2. Brass or bronze
      - 3. Silver
      - 4. Nickel- and nickel-plated parts or nickel alloys
      - 5. Tin
      - 6. Ferrous materials
  - b. Aluminum alloy to aluminum alloy: Protect surfaces of parts by painting with zinc chromate primer before securing.
  - c. Aluminum alloy to steel:
    - i. Protect with a one-part polysulfide sealant.
    - ii. Alternatively, use an Approved insulation joint material, such as mica, that completely covers the faying surfaces. The material will be non-hygroscopic and, if fibrous, will be impregnated with bitumen or some other Approved water and moisture-repellant substance.
    - iii. Prime and paint fasteners with red oxide or aluminum paint after installation.
    - iv. Rivets driven hot may be considered as covered by a protective oxide coating due to the heating, but the method of riveting will, if possible, always be with the formed rivet head in contact with the aluminum alloy.
  - d. Aluminum alloy with zinc plated stainless or carbon steel fasteners: Protect surfaces as follows:
    - i. Coat with zinc chromate paste or Approved equal before installation.
    - ii. Where possible, only the head and shank of the bolt will be in contact with the aluminum part when secured in place.
    - iii. Suitable bushings Approved by the City may be used in place of the zinc-chromate paste.

## 19.6 Welding and Brazing

### 19.6.1 General

#### *Scope*

This section applies both to welding and brazing performed on vehicle structural elements and on equipment and systems provided for use on the vehicle, unless waived by the City.

#### *Quality*

Comply with the following:

1. Control the quality of welding and brazing, including that performed by subcontractors.
2. Before performing work under this Contract, welders will be tested to confirm their ability to operate the welding equipment and to make the types of welds required by the design or this document.

### 19.6.2 Welding and Brazing Prohibitions

The following weld process and material restrictions will apply in vehicle structure welding:

1. High-iron-powder flux-type rods such as E6024, E7024 and rods known as "jet rod" may not be used.
2. Short-arc MIG welding using hardwire with argon, or argon/CO<sub>2</sub> shielding may be used only on sheet metal, gauges 12 and thinner. Weld sheet steel in accordance with AWS D1.3/D1.3M.
3. Galvanized steel will not be welded to stainless steel.
4. Brazing will not be used to join stainless steel to itself or to other metals unless specifically Approved by the City.

### 19.6.3 Welding

#### *Structural Welding*

Comply with the following:

1. Structural welding practices not specifically covered in other sections of the TS will be in accordance with the following AWS standards. Requirements for cyclically loaded structures will be applied:
  - a. AWS D1.1/D1.1M, for steel 3.2 mm (1/8 in) and thicker
  - b. AWS D1.2/D1.2M
  - c. AWS D1.3/D1.3M, for steel thinner than 3.2 mm (1/8 in)
  - d. AWS D1.6/D1.6M
  - e. AWS D15.1/D15.1M
  - f. AWS Welding Handbook
  - g. AWS D17.2/D17.2M, for resistance welding
2. As an alternate, structural welding may be in accordance with EN ISO 9606-1 for steel and EN ISO 9606-2 for aluminum, except that the City may enforce AWS requirements at its discretion if the alternate standards are more permissive.

3. Structural welding of stainless steel by the fusion-arc process will be governed by the following standards:
  - a. AWS D1.6/D1.6M
  - b. ASME BPVC, Section IX, “Welding and Brazing Qualifications”
  - c. ASME BPVC, Section VIII, “Rules for Construction of Pressure Vessels,” Part UHA, “Requirements for Pressure Vessels Constructed of High Alloy Steel”
4. Other requirements:
  - a. AISI 201L and 301LN stainless steels will be treated as P-No. 8, Group-No. 3 category for reference to ASME BPVC requirements.
  - b. Weld heat-affected zones (HAZ) and weld metal will be limited to maximum allowable stress values in ASME BPVC, 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.
  - c. Ferrite number for welds will be between WRC 4 and WRC 10, or as proposed by the Contractor and Approved by the City.
5. Additional information on definitions, processes or other questions pertaining to welding will be referred to in the AWS Welding Handbook.

*Welding Procedure Qualification*

Comply with the following:

1. Welding procedures (WPSs) will be qualified by the Contractor, accompanied by procedure qualification records (PQRs) containing welding test results, and subject to approval by the City.
2. Use of prequalified WPSs is prohibited unless reviewed and specifically permitted by the City. Welding procedure and qualification will be identified on shop drawings specifically for that purpose.
3. Perform general welding, not Specified elsewhere, in accordance with the standards of AWS D1.1/D1.1M.

*Welder Qualification and Identification*

Comply with the following:

1. Welders will make only those welds for which they have been qualified in accordance with the following:
  - a. Requirements of the AWS or ASME BPVC, Section IX, qualifying procedures.
  - b. As an alternate, the requirements of the applicable standards in the ISO 156xx series, except that the City may enforce AWS or ASME requirements at its discretion if the alternate standards are more permissive.
2. Make available records of welder qualification tests for review upon the City's request.
3. Stamp critical strength welds with an identifying symbol that can be traced to the welder who performed the work.



*Weld Type Requirements*

Comply with the following:

1. Full penetration welds:
  - a. Required for structural welds unless otherwise Approved by the City.
  - b. If made from one side without backup, they will be considered partial penetration welds.
2. Partial penetration welds:
  - a. May be used for structural connections only with approval of a formal detailed proposal:
    - i. Furnish design calculations supporting the penetration required.
    - ii. Conduct tests to prove that production welding achieves this required penetration with a margin of safety suited to the design application.
  - b. Prohibited where subject to alternating tensile or bending loads at the weld root.
3. Fillet welds: May be used only to carry shear loads between statically loaded members.

*Weld Inspection*

Comply with the following:

1. Visually inspect each structural weld in accordance with the applicable AWS requirements:
2. First production welds:
  - a. Inspect visually in accordance with the Specified AWS welding code requirements.
  - b. Inspect by nondestructive surface inspection methods (dye penetrant or magnetic particle, as appropriate), regardless of whether the assembly was presented for First Article Inspection
3. Specify additional nondestructive inspection requirements for subsequent welds.
4. For full penetration welds, comply with the following:
  - a. On the first structure, inspect nondestructively, volumetrically all full penetration welds (ultrasonic or radiographic methods), according to the applicable code or standard.
  - b. For subsequent full penetration welds, propose a random sampling plan for volumetric inspection for approval:
    - i. The minimum acceptable inspection plan will require inspection of one foot of a full penetration weld for every 200 feet of production welds made.
    - ii. The proposed test welds will be selected from among welds that are most critically loaded as decided by calculations or load test results.
    - iii. With approval, destructive sectioning and metallurgical examination may be substituted for some or all the required volumetric inspection requirements for production welding.

*Weld Cleaning Requirements*

All welds, regardless of their location, will be cleaned and free of flux residue, spatter, slag, or other debris that may impair the function or appearance of the welded area.

Heat tint on stainless steel welds not exposed to passenger view need not be removed.

*Welding Rod or Wire*

Comply with the following:

1. Purchase to AWS specifications.
2. Where special materials are required that are not covered by these or other applicable AWS welding material specifications, submit the purchase specifications for approval.
3. Purchase welding filler materials in packages of convenient size, marked with the manufacturer's name and the specification, diameter, and net weight of the material.
4. Store the material in accordance with applicable AWS recommendations to protect it from damage, and so that it can be easily identified.
5. Issue and handle material in such a way as to prevent it from being mixed with that of another filler metal type and specification.

*Special Welding*

Comply with the following:

1. Submit procedures for structural welding of stainless steel to HSLA, or other combinations of metals or conditions not covered by AWS specifications or codes, for approval.
2. Use austenitic stainless-steel electrodes or wire to join carbon or HSLA steels to stainless steels.

*Resistance Welding*

Comply with the following:

1. Weld stainless or carbon steels in accordance with AWS D17.2/D17.2M:
  - a. Structural applications: Class B
  - b. Non-structural applications: Class C
2. Obtain approval for desired exceptions from AWS D17.2/D17.2M including, but not limited to weld nugget diameter, tension shear strength, and minimum spacing, before inclusion in the design or in production procedures.
3. Control current, time, electrode size, shape, and tip force to produce uniform welds of Specified strength that are not subject to intergranular stress-corrosion cracking.
4. Arrange welds to avoid tension or "peeling" forces on the welds under anticipated loading condition.
5. Surface indentation:
  - a. Not exposed to passenger view: Maximum 20% of material thickness (t) or 0.25 mm (0.01 in), whichever is greater.
  - b. Exterior areas exposed to passenger view: Maximum 10% of t or 0.13 mm (0.005 in), whichever is greater.
6. Remove surface burn and discoloration by an Approved method.

*Resistance, Spot Weld and Intermittent Weld Spacing*

Spacing of resistance and spot welds will be appropriate to the design:

1. Spacing will not exceed 50 mm (2 in) plus twice the weld nugget diameter for any structural application, including vehicle-body side sheets.

2. Intermittent weld spacing will not exceed 125 mm (5 in) for 50 mm (2 in) weld length (40% minimum). Exceptions to avoid warping in thin sheets will be considered but must be Approved by the City.

#### *Toughness of Welded Assemblies*

Prove that all safety-related welded structures have adequate toughness for the Specified environmental exposure, including, but not limited to end underframes, fabricated truck frames and bolsters, and welded coupler components:

1. Weld heat affected zone (HAZ), and base metal will resist service impact loads at the lowest Specified operating temperature.
2. Criteria for acceptance will be shown by the Contractor to be adequate.
3. Charpy V-notch specimen impact value: Minimum 20 J (15 ft-lbf) of absorbed energy at the lowest Specified operating temperature, in the absence of prior operating history, and if no analysis requires greater toughness.

#### 19.6.4 Torch Brazing

Comply with the following requirements for brazing (above 450 degrees C (840 degrees F)):

1. Follow the recommendations in AWS Welding Handbook, Volume 2.
2. Qualify procedures and personnel in accordance with AWS B2.2/B2.2M.
3. Brazed joints will present a workmanlike appearance in accordance with AWS C3.4M/C3.4.
4. Protect inner surfaces of air conditioning tubing from oxidizing contaminants during and after brazing operations.

#### 19.6.5 Torch Soldering

Comply with the following requirements for soldering (below 450 degrees C (840 degrees F)):

1. Follow the recommendations in the AWS Welding Handbook, Volume 2.
2. Qualify procedures and personnel through preparation and testing of samples, as follows:
  - a. Copper Piping into Fittings:
    - i. Each worker designated to perform this work will prepare three copper piping connections in the vertical position.
    - ii. The sample joints will present a smooth, workmanlike appearance, without excess solder reinforcement.
    - iii. Each joint will be pressure tested using a water or air system to confirm that it is leak-free.
  - b. Stainless Steel Lap Joints (Trim Seams):
    - i. Each worker designated to perform this work will prepare one typical trim seam sample, using the same stainless-steel materials, finish, and thicknesses as used on the actual vehicle.
    - ii. The seam for evaluation will be minimum 915 mm (36 in) in length and will be set up in the horizontal position during soldering.

- iii. Specimen width will be selected, or the test setup arranged, so that premature overheating of the joint does not occur.
- iv. Finished samples will be saw-cut into four pieces so that eight cross-sections of the joint may be examined.
- v. Exposed solder surfaces will display a uniform, smooth contour and will meet or exceed all applicable AWS quality standards.

## 19.7 Elastomers

### 19.7.1 General

Comply with the following:

- 1. Material: Neoprene unless otherwise Specified or Approved.
- 2. Compound and cure: Suitable for the Project environment Specified in Section 2, Design and Performance Criteria.
- 3. Quality: Free of defects of material and workmanship.
- 4. Performance:
  - a. Highly resistant to ultraviolet, other solar radiation, and vehicle washing fluids.
  - b. Resistant to ozone, oxidation, heat, oil, grease, and acid.
- 5. Design life of resilient parts: Minimum 10 years.

### 19.7.2 Applications

Comply with the following:

- 1. Parts made by vulcanizing an elastomer to metal:
  - a. Premature failure:
    - i. Definition: Failure in less than five years after Final Acceptance of the vehicle.
    - ii. Considered a defect of materials or workmanship when the failure occurs between the metal and elastomer or in the elastomer and the parts are used in normal service and according to the provisions of the TS.
- 2. Metal parts to which neoprene or other such material is cured:
  - a. Material: SAE 1020 or 1045 hot-rolled steel or Approved equal, suitable for brass plating after pickling.
- 3. Door mating edges, door and window seals, and glazing strips:
  - a. Material: Neoprene or ethylene propylene diene (EPDM) rubber.
  - b. Durometer hardness: 70 plus or minus 5 at a temperature between 20 degrees C and 30 degrees C (68 degrees F and 86 degrees F) when measured with a Shore Type "A" durometer.

## 19.8 Piping and Tubing (other than Air Conditioning)

### 19.8.1 General

Comply with the following general requirements for piping and tubing:

1. Furnish, install, and test piping, valves, and fittings in accordance with ASME B31.1.
2. Straight runs of pipe: Continuous and without fittings unless otherwise Approved.
3. Truck piping: will not be run on the bottom of truck side frames, transom, or bolster.
4. Connections to resiliently mounted or moving equipment:
  - a. Via hose or other resilient device, as appropriate.
  - b. Clamp piping within 50 mm (2 in) of the resilient connection.
5. Piping passing through holes in fixed members:
  - a. Rigidly clamp piping to support structure. Cantilevered or other flimsy piping supports are prohibited.
  - b. Clamps will not be welded, brazed, or otherwise permanently fastened to piping.
  - c. Clamps will be insulated with an Approved elastomeric or woven mineral fabric tape to protect and acoustically insulate the piping from structure.
6. After installation:
  - a. Clean piping systems by flushing with an Approved cleaning solution.
  - b. Pressure test in accordance with ASME B31.1
  - c. Repair leaks and retest the system until leak free.

### 19.8.2 Hydraulic Piping, Tubing, Hose, and Fittings

Comply with the following requirements for hydraulic piping, tubing, hose, and fittings:

1. Tubing:
  - a. Type: Seamless cold drawn steel, SAE 1010 or as Approved, designed for hydraulic applications.
  - b. Wall thickness:
    - i. Truck mounted: Schedule 80, and sufficient to maintain a safety factor of 6 at the maximum system pressure.
    - ii. Other locations: Sufficient to maintain a safety factor of 6 at the maximum system pressure.
  - c. Bending: Tubing may be bent using a bending tool designed specifically for bending of the tubing to be used, instead of elbows.
2. Piping:
  - a. Use of tapered pipe threads on fluid carrying system component is prohibited.
  - b. Deburr piping after cutting.
  - c. Clean piping and pipe sub-assemblies.

- d. Cap openings after fabrication. Caps will remain in place until just before incorporation into the final assembly.
- 3. Tubing or Piping Connections:
  - a. Steel or stainless-steel fittings, either JIC 37-degree flare or flareless.
  - b. Piping and tubing connections will use the same type of fitting.
- 4. Hose:
  - a. Rating: will withstand four times the maximum operating pressure without bursting.
  - b. Temperature: Hose will not be used in locations where the temperature may exceed 100 degrees C (212 degrees F).
  - c. Fittings: Permanently fitted to the hose.
  - d. Openings: Cap immediately after fabrication and cleaning.
- 5. Joints: Keep to a minimum; inaccessible joints are not permitted.
- 6. Connections:
  - a. To manifold ports, valve bodies, and other hydraulic system components: Use straight thread fittings with separate O-ring seals, unless otherwise Approved.
  - b. Quick connect couplings:
    - i. Double shutoff with valves built into both mating parts.
    - ii. will conform to MIL-DTL-25427 or be City-Approved commercial couplings providing equivalent performance.
- 7. Cutout cocks: Designed to automatically depressurize the portion of the system that is being isolated by the cutout cock.

## 19.9 Paints, Graphics, and Coatings

### 19.9.1 General

Comply with the following:

- 1. Furnish and apply paint and coatings in accordance with local, state, and federal requirements that apply at the location where paint and coatings are applied.
- 2. Paint, graphics, and coatings will be repairable by the City with materials and processes conforming to local, state, and federal requirements that apply to the Project.
- 3. If paint is applied in California, comply with California Air Resources Board requirements.
- 4. Test paint performance in accordance with Section 18 .

### 19.9.2 Materials Not to be Painted

Equipment or parts of equipment that would be damaged or suffer impaired operation from painting will not be painted, including but not limited to the following:

- 1. Flexible conduit and fittings
- 2. Copper tubing, piping, and fittings
- 3. Wire and cable

4. Power resistors
5. Heat transfer surfaces
6. Electrical insulators
7. Elastomeric devices
8. Grounding pads

### 19.9.3 Paint and Powder Coat Materials

#### *General*

Comply with the following:

1. Paint and powder coat materials will be from a high-quality finishing system, resistant to corrosion, chipping, and fading, and will retain the gloss level as Specified within the TS.
2. Paint and filler materials that are to be superimposed to form a finish system will be mutually compatible and will be warranted for use as a system by the manufacturer of the components.
3. The Contractor and its liquid paint or powder coat supplier will ensure that a continuing supply of touch-up paints in the proper colors used on the vehicle, suitable for touch-up and repair by spray, roller, or brush, will continue to be available in the United States.

#### *Primers*

Where Specified, primers will comply with the following requirements:

1. Wash (etch) primer: A primer with anti-corrosion properties for application as a first coat on metal surfaces, as recommended by the manufacturer of subsequent primer and topcoat.
2. Epoxy primer: Compatible with the polyurethane topcoat.
3. Truck primer: Compatible with truck paint.

#### *Topcoats*

Where Specified, topcoats will comply with the following requirements:

1. Polyurethane: Two-part, high solids, low VOC, polyurethane paint system; gloss or semi-gloss, as Specified within the TS.
2. Anti-skid: For surfaces requiring anti-skid paint, mix a non-skid additive into the paint, such as fine glass or plastic beads.
3. Truck paint: Select truck paint that will not hide structural cracks.

#### *Powder Coat*

Where Specified, powder coat will comply with the following requirements:

1. Interior applications: Thermosetting, resin based, polyester or epoxy powder tailored to the individual application.
2. Exterior applications: Not Approved for use.

#### 19.9.4 Preparation and Paint or Powder Application

##### *General*

Comply with the following:

1. Prepare the substrate surface in accordance with the paint or powder manufacturer's recommendations.
2. Prepare and apply paint and powder materials according to the manufacturer's recommendations, including environmental conditions (clean, dry atmosphere at Specified ambient temperature and humidity).
3. Paint materials will be used at the consistency recommended by the paint manufacturer. If thinners are necessary, they will be Approved by the paint manufacturer and will be used only to the extent recommended.
4. Paint and powder coating will be uniformly applied over all surfaces to be covered and will be free from foreign matter, runs, sags, orange peel, fisheyes, or other application defects.

##### *Applicator Qualifications*

Painting and powder coating will be done by experienced labor, using proper equipment under competent supervision.

##### *Vehicle Body*

After fabricating metal portions of the vehicle body not constructed of stainless steel, prepare and prime by one of the following methods:

1. Grit blast, then immediately after grit blasting, apply epoxy primer.
2. Wash with an alkaline solution and properly rinse; apply a coat of phosphate or a coat of wash primer; and then coat with epoxy primer.
3. As recommended by the manufacturer and Approved by the City, if the manufacturer does not recommend the Specified methods.

In addition, comply with the following requirements for the locations indicated:

1. Enclosed surfaces capable of rusting or oxidation: After cleaning and applying epoxy primer, paint with polyurethane or other Approved coating suitable for the vehicle design life.
2. Arc welds between stainless steel and other materials: De-scale the joint, clean, apply wash primer, apply epoxy primer, and apply polyurethane topcoat.
3. Concealed aluminum: Apply one coat of primer and one coat of an Approved sealer, except to framing structures.

##### *Exterior Not Visible to Passengers*

Surfaces that are on the exterior of the vehicle but not visible to passengers will be prepared as Specified above for the vehicle body, and painted as follows:

1. Under-vehicle:
  - a. Exposed portion of the underframe: Apply epoxy primer and one polyurethane topcoat.
  - b. Metal structures (except stainless steel), including welded brackets and appurtenances: After erecting the framing structure and body sheets, apply epoxy primer and two polyurethane topcoats.



- c. Apparatus and Equipment Enclosures (applies to interior and exterior surfaces):
  - i. Carbon steel: Apply epoxy primer and one polyurethane topcoat.
  - ii. Plastic or fiberglass: Apply epoxy primer and one polyurethane topcoat. Verify that the paint system is compatible with the plastic used.
  - iii. Paint apparatus and enclosures only after metal working activities are completed.
  - iv. Apparatus from suppliers will be painted by the suppliers before installation on the vehicle, under the Contractor's direction and according to the TS and Approved color scheme.
- 2. Roof: Apply one polyurethane topcoat. Use anti-skid paint on roof surfaces on which a person can walk.
- 3. Other parts of the vehicle not exposed to view: Apply one polyurethane topcoat.

#### *Trucks*

Paint truck frames before assembly and complete painting of truck components before installation on the vehicle:

- 1. Before painting, clean trucks by blowing with compressed air and wiping with solvent to remove dirt and grease.
- 2. After cleaning, spray truck components with one coat of primer and one coat of paint and air dry.

#### *Exterior Visible to Passengers*

Comply with the following:

- a. Preparation: Before painting vehicle surface that is exposed to view, rectify dents, gashes, nicks, roughness, and other surface imperfections:
  - i. Remove imperfections so far as possible by straightening.
  - ii. After straightening, wash prime the surface, fill remaining imperfections with an Approved epoxy-based filler, and sand smooth.
    - 1. Filler thickness: Maximum 3 mm (0.125 in); or
    - 2. As recommended by the filler manufacturer for the environment and service to which it is to be exposed, whichever is less.
- b. Painting: Apply epoxy primer and two polyurethane topcoats.
- c. Surface appearance: The finished exterior will present a high-quality appearance free from sags, drips, scratches, variations in gloss, and other imperfections.
  - i. Comply with requirements for gloss and surface as Specified.
  - ii. Test surface appearance as Specified.

#### *Stainless Steel and FRP*

Comply with the following:

- 1. Painted stainless steel: Where required to be painted, the painting procedures will be as recommended by the paint manufacturer for that application.

2. Unpainted exterior stainless steel: Clean with an Approved alkaline cleaning solution that will not damage other painted surfaces.
3. FRP: Where required to be painted, apply one coat of epoxy primer and a topcoat with polyurethane, using the number of coats recommended for the application.

#### 19.9.5 Graphics

Comply with the following requirements for graphics, such as stripes, logos, or vehicle numbers:

1. Material: 3M vinyl graphic film or Approved equivalent.
2. Installation: In accordance with manufacturer's recommendations using manufacturer recommended tools.

#### 19.9.6 Other Coatings

Comply with the following:

1. Apply undercoating's and other coatings, where required, and acoustical insulating materials to cleaned and primed surfaces and members, according to the material manufacturer's recommendations.
2. These materials will be resistant to dilute acids, alcohols, grease, gasoline, aliphatic oils, and vermin.

#### 19.10 Flammability, Smoke Emission, and Toxicity Requirements

Combustible material used in the construction of the vehicle will satisfy the flammability, smoke emission, and toxicity requirements cited in this Section:

1. As a minimum, materials used in the construction of the vehicle will meet the requirements of NFPA 130 Chapter 8, Vehicles.
2. Those materials and products generally recognized to have highly toxic products of combustions will not be used.
3. Material tested in accordance with NFPA 130, Chapter 8, Vehicles, will meet the following toxic gas release limits (ppm) as determined per BSS 7239 or Bombardier SMP 800C:

Carbon Monoxide (CO)	3,500 ppm
Hydrogen Fluoride (HF)	200 ppm
Nitrogen Dioxide (NO <sub>2</sub> )	100 ppm
Hydrogen Chloride (HCl)	500 ppm
Hydrogen Cyanide (HCN)	150 ppm
Sulfur Dioxide (SO <sub>2</sub> )	100 ppm

#### 19.11 Wood and Panels

##### 19.11.1 Lumber

Comply with the following:

1. Lumber will be thoroughly air seasoned, or kiln dried before use and will be dressed on all surfaces to full dimensions.
2. Lumber will be straight grained, free from dry rot, knots, checks, and other defects that may impair its strength and durability or mar its appearance.

3. The use of wood in the vehicle, except where Specified, will be limited to specifically Approved applications.

#### 19.11.2 Plywood

Comply with the following:

1. Type: NIST PS 1, panel grade Structural I.
2. Storage: Store under cover.
3. Plywood panels: Formed from one piece and sealed with two coats of epoxy paint on all edges and cutouts as soon as possible after fabrication.
4. Exposed edges of panels: Treat joints between panels, fastener heads, and openings of panels used in areas accessible to moisture, before installing in the vehicle, as follows:
  - a. Before sealing edges, plug splits showing on edges with wooden wedges dipped in adhesive conforming to Federal Specification MMM-A-181.
  - b. Seal the exposed edges with an Approved epoxy or polyurethane moisture barrier coating.
  - c. Allow minimum 24 hours drying time between each coat.

#### 19.11.3 Plymetal

Comply with the following:

1. Plymetal will be metal-faced plywood conforming to the table below.
2. Plymetal faced with melamine will have the melamine bonded to the metal sheet, and the melamine-faced metal sheet then laminated to the plywood core.

<b>Plymetal Requirements</b>	
<b>Test Conditions</b>	<b>Minimum Metal to Wood Average Shear Value (or 80% Wood Failure)</b>
Dry shear	1.7 MPa (250 lbf/in <sup>2</sup> )
Boil shear, 3-hour boil, tested wet at room temperature	1 MPa (150 lbf/in <sup>2</sup> )
Soak shear, 48-hour soak wet at room temperature	1 MPa (150 lbf/in <sup>2</sup> )
Creep or cold flow, under static load for 48 hours, at room temperature	1.7 MPa (250 lbf/in <sup>2</sup> )

#### 19.11.4 Honeycomb Panels

Honeycomb panels will be an assembly of honeycomb material bonded to melamine-faced metal panels or to metal panels:

1. Honeycomb Core Materials:
  - a. Aluminum: Commercial grade, complying with SAE AMS-C-7438.
  - b. Aramid Fiber Composite: High strength, Kevlar® N636 or equivalent, para-aramid fiber paper impregnated with a heat-resistant phenolic resin, conforming to Specified flammability, smoke emission, and toxicity requirements, for non-structural applications where specifically Approved for use.

2. Panel Skin Materials: Melamine-faced metal or metal.
3. Bonding: Sufficient to develop the full strength of the honeycomb material.

#### 19.11.5 Melamine-Faced Aluminum

Melamine-faced aluminum panels will be constructed by laminating melamine impregnated papers to aluminum sheets using heat and pressure. Use of adhesives for bonding is not permitted:

1. Temperature: Minimum 132 degrees C (270 degrees F)
2. Pressure: Minimum 6.9 MPa (1000 psi)
3. Minimum Thicknesses:
  - a. Melamine and required binder sheets: 0.51 +/- 0.13 mm (0.020 +/- 0.005 in)
  - b. Aluminum sheets, used on plywood substrate: 0.64 mm (0.025 in)
  - c. Aluminum sheets, not laminated to substrate: 2 mm (0.08 in)
4. Flammability, Smoke, and Toxicity: See Flammability, Smoke Emission, and Toxicity Requirements section, above.
5. Preparation: Properly clean aluminum sheets by etching, sanding, or other Approved process to ensure full, permanent, acceptable adhesion.
6. Quality Tests:
  - a. Bond between melamine and aluminum sheets: Meet requirements of the table below.
  - b. Surface characteristics, after manufacture: Comply with NEMA LD 3 type GP (General Purpose).

<b>Melamine to Aluminum Bond Requirements</b>			
<b>Mechanical Properties</b>	<b>ASTM Method</b>	<b>Condition</b>	<b>Value</b>
Internal bond	ASTM D952		17.9 MPa (2,600 lbf/in <sup>2</sup> )
Flexural strength - (S)	ASTM D790	with grain	183 MPa (26,500 lbf/in <sup>2</sup> )
		cross grain	174 MPa (25,300 lbf/in <sup>2</sup> )
Modulus of elasticity - (E)	ASTM D790	with grain	19.3 GPa (2.8 x 10 <sup>6</sup> lbf/in <sup>2</sup> )
		cross grain	21.4 GPa (3.1 x 10 <sup>6</sup> lbf/in <sup>2</sup> )
Tensile strength	ASTM D638	with grain	154 MPa (22,300 lbf/in <sup>2</sup> )
		cross grain	140 MPa (20,300 lbf/in <sup>2</sup> )

#### 19.11.6 Phenolic Composite Floor Panels

##### *Panels*

Phenolic composite floor panels will be a wood core faced on the entire top and bottom surface with a skin consisting of fiberglass fabric impregnated with resin.

1. Wood Core: End-grain balsa.
2. Skin: Bi-axial fiberglass fabric impregnated with phenolic thermosetting resin.
3. Bond: Skin will be permanently bonded to core by a compression molding process, co-curing the wet resin-impregnated skin directly against the core.

4. Minimum Thicknesses:
  - a. Panel: 19 mm (0.75 in)
  - b. Fiberglass fabric:
    - i. Panels supported more than 914 mm (36 in) apart: 2.5 mm (0.1 in)
    - ii. Panels supported minimum 914 mm (36 in) apart: 1.4 mm (0.055 in)
5. Flammability, Smoke, and Toxicity: See Flammability, Smoke Emission, and Toxicity Requirements section, above.

*Physical Test Requirements*

Phenolic composite floor panels will withstand the physical tests in this section with none of the following results:

1. Visible or audible indications of delamination of the panel skin from the core.
2. Puncture or damage to fibers of the top surface.
3. Separation of internal core from the top or bottom skin.
4. Fracture of balsa core.

Phenolic composite floor panels will comply with the following physical test requirements:

1. Static Load Test, Average Loading:
  - a. Test setup: Support a representative sample section of floor panel (without floor covering) on beams spaced at the maximum spacing used on the vehicle, using production bonding and fastening techniques.
  - b. Load: In accordance with crush loading requirements of Section 2, Design and Performance Criteria.
  - c. Test: Apply uniformly distributed load to both sides of joint (butt and/or shiplap).
  - d. Maximum deflection: 2.2 mm (0.088 in).
2. Static Load Test, Maximum Loading:
  - a. Test setup: Same setup used for Average Loading, above.
  - b. Load: 976 kg/m<sup>2</sup> (200 lb./ft<sup>2</sup>).
  - c. Test: Apply uniformly distributed load to both sides of joint (butt or shiplap).
3. Small Area Static Load Test:
  - a. Test setup: Same setup used for Average Loading, above.
  - b. Load: 136 kg (300 lb.)
  - c. Contact device: Footprint 25 mm by 75 mm (1.0 in by 3.0 in), machined flat within 0.25 mm (0.010 in) and edges radiused maximum 3.2 mm (0.125 in).
  - d. Test: Apply load to the contact device located directly over midspan, 150 mm (6 in) from outer vehicle-body sidewall edge.
  - e. Maximum deflection: 5 mm (0.20 in).

4. Indentation Resistance:
  - a. Test setup: Representative sample section of floor panel laid on a level surface.
  - b. Load: Test dowel with the following characteristics:
    - i. Overall surface area: 242 sq mm<sup>2</sup> (0.375-sq in<sup>2</sup>)
    - ii. Radius on bottom edge: 1.6 mm (0.0625-in)
  - c. Test: Apply a concentrated load of 136 kg (300 lbs.) to test dowel.
  - d. Maximum permanent deformation of top surface: 0.25 mm (0.010 in).
5. Small Object Impact Test:
  - a. Test setup: Same setup used for Average Loading, above.
  - b. Load: 7.26 kg (16 lb.) standard bowling ball.
  - c. Test: Drop load from height of 1500 mm (60 in) directly over mid-span, 610 mm (24 in) from edge of panel.
  - d. Maximum permanent deformation of top surface: 1.587 mm (0.0625 in).
6. Large Object Impact Test:
  - a. Test setup: Same setup used for Average Loading, above.
  - b. Load: 68 kg (150 lb.)
  - c. Contact device: Footprint 75 mm by 200 mm (3.0 in by 8.0 in), with rubber pad on the downside surface having the following characteristics:
    - i. Minimum Shore D 70
    - ii. Thickness: 25.4 mm (1 in)
    - iii. Machined flat within 1.524 mm (0.060 in) with edges having a radius of not more than 0.8 mm (0.030 in)
  - d. Test: Drop load from height of 300 mm (12 in) onto contact device located directly over midspan, 610 mm (24 in) from edge of panel.
  - e. Maximum permanent deformation of top surface: 0.8 mm (0.030 in). Some damage to the top phenolic composite skin will be allowed.
7. Rolling Load Test:
  - a. Test setup: Same setup used for Average Loading, above.
  - b. Load: Four-wheeled cart with load of 91 kg (200 lb.) per wheel. Wheels will have the following characteristics:
    - i. Diameter: 75 mm (3 in)
    - ii. Width: 25 mm (1 in)
    - iii. Radius: 3 mm (0.125-in) on each edge
    - iv. Material: Shore A durometer of 80

- c. Test: Roll load onto panels laterally, longitudinally, and in a circular path with radius 610 mm (24 in).
- d. Maximum permanent deformation of top surface: 0.25 mm (0.010 in).

#### 19.11.7 Flatness

Comply with the following:

- 1. Surfaces exposed to passengers may exceed the Specified contour by maximum 2.5 mm (0.1 in) in any 1 m (39 in) distance.
- 2. The slope of any such irregularity will be maximum 2 mm (0.08 in) in 100 mm (4 in).

### 19.12 Fiberglass Reinforced Plastic (FRP)

#### 19.12.1 General

Comply with the following:

- 1. Material: Polymeric-reinforced, laminated material, composed of a gel-coated surface, fiberglass reinforcement, and a polyester, vinyl ester or other Approved resin.
- 2. Chemical resistance: FRP will be resistant to acids, mild alkaline solutions, and those cleaning solutions recommended by the Contractor.
- 3. Environmental resistance: FRP will withstand, without any physical deformation, structural damage, or reduction in life, the environmental conditions in Section 2, Design and Performance Criteria.

#### 19.12.2 Composition

Comply with the following:

- 1. Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors will be added to the resin mixes to obtain finished products with the required physical characteristics below and other requirements of this document.
- 2. Mineral filler will not exceed 28% of finished weight for any preformed matched die molding process.

#### 19.12.3 Gel Coat

Comply with the following:

- 1. The gel coat will be weatherproof, match the Approved color and gloss as Specified and Approved in Section 14, Interior and Exterior Appointments, and contain UV inhibitors to protect the FRP from ultraviolet radiation.
- 2. If a low gloss finish is required, paint the FRP in accordance with this Section.

#### 19.12.4 Manufacturing

Comply with the following:

- 1. Qualifications: FRP suppliers will be experienced with manufacturing FRP structures of similar sizes and complexities, with materials and standards as defined in this Section.
- 2. Manufacturing Techniques:
  - a. FRP will be manufactured by hand-laminated open molding, or as appropriate for the part and Approved by the City.

- b. Production techniques will 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.
- 3. FRP parts:
  - a. Thickness: Minimum 3 mm (0.120 in)
  - b. Thickness at attachment points and edges: Greater than minimum thickness.
  - c. Exposed sharp edges: Not permitted on any parts.
- 4. Quality:
  - a. Inspect FRP materials at the point of manufacture for voids, density variations, and other internal defects, thickness variations, finish, and other defects.
  - b. Except for minor surface defects, repairs to FRP are not permitted.
  - c. Defective material will be discarded.

#### 19.12.5 Strength Requirements

##### *General*

Perform independent laboratory tests as Specified with the TS, to confirm that products comply with the strength requirements below.

##### *Non-Structural (No load)*

Minimum strength requirements are defined below for items that are non-structural or will not be exposed to any loads, such as window masks, destination sign shrouds, ceiling cove panels, and ceiling headers:

<b>Non-Structural (No Load) Strength Requirements</b>		
<b>Mechanical Property</b>	<b>ASTM Test</b>	<b>Required Value</b>
Tensile Strength	D638	69 MPa (10,000 lbf/in <sup>2</sup> )
Compressive Strength	D695	124 MPa (18,000 lbf/in <sup>2</sup> )
Flexural Strength	D790	103 MPa (15,000 lbf/in <sup>2</sup> )
Impact Strength	D256	5.3 J/cm (10 ft-lb/in) of notch
Hardness	D2583	45 Barcol

##### *Structural (Load)*

Minimum strength requirements are defined in the table below for items that are structural or will be exposed to loads from passengers or impacts, such as end bonnets, side skin, under floor equipment enclosures, door pocket panels, wainscot panels, passenger seat back shrouds, and windscreens:

<b>Structural (Load) Strength Requirements</b>		
<b>Mechanical Property</b>	<b>ASTM Test</b>	<b>Required Value</b>
Tensile Strength	D638	124 MPa (18,000 lbf/in <sup>2</sup> )
Compressive Strength	D695	165 MPa (24,000 lbf/in <sup>2</sup> )
Flexural Strength	D790	206 MPa (30,000 lbf/in <sup>2</sup> )
Impact Strength	D256	6.9 J/cm (13 ft-lb/in) of notch
Hardness	D2583	45 Barcol



#### 19.12.6 Shipping and Handling

Perform special handling for any large, complex FRP parts such as the front end, including enclosing parts in custom frames or crates. Conduct a detailed receiving inspection for each such part.

#### 19.12.7 Installation of FRP Front End

Comply with the following installation requirements for FRP vehicle front end:

1. Where FRP is used for the vehicle front end, excessive force will not be used during assembly onto the vehicle structure.
2. Minor trimming to fit will be permitted only at the discretion of the City.
3. After assembly of the front end onto the vehicle, notify the City of any cracks, voids, or defects.
  - a. The defective front end will be removed and replaced unless the City approves a repair.
  - b. The determination to remove and replace or repair the defective part will be solely at the discretion of the City with no additional costs to be borne by the City.

### 19.13 Thermoplastic Sheet

#### 19.13.1 General

Thermoplastic sheet will:

1. Withstand the environmental conditions Specified without physical deformation or structural damage.
2. Be resistant to all recommended cleaning agents.
3. Meet the relevant requirements in the Flammability, Smoke Emission, and Toxicity section, above.

Thermoplastic sheets will be used as extruded or pressure-formed, or as Approved by the City.

#### 19.13.2 Product Requirements

Thermoplastic sheet: Homogeneous and extruded from virgin stock, which will not include any regrind of vacuum formed parts.

Thermoplastic in final form:

1. Surface finish gloss: Level will not vary by more than 5 points, as measured using a 60° glossometer.
2. Surface texture: will not fade out at or near part contours.
3. Color, texture, and gloss: Exposed surface will conform to Section 14, Interior and Exterior Appointments. Only UV stabilized pigments will be used to create the Specified color.
4. Anti-graffiti coating: Provide on exposed surfaces.
5. Quality: Free of waves and quilting on both sides.
6. Defects: Following is cause for rejection of the piece:
  - a. Degraded polymer.
  - b. Voids, lumps, and contamination if the defects are larger than 0.25 mm (0.010 in) and the population is greater than one defect in 0.37 m<sup>2</sup> (4 ft<sup>2</sup>).

### 19.13.3 Strength Requirements

Thermoplastic sheets will comply with the requirements of the standards listed in the table below. Use extruded sheet in the Specified surface finish for testing.

<b>Thermoplastic Sheet Strength Requirements</b>		
<b>Mechanical Properties</b>	<b>ASTM Method</b>	<b>Value</b>
Specific Gravity	D792	1.20 to 1.45
Tensile Strength	D638	48 N/mm <sup>2</sup> (7,000 lbf/in <sup>2</sup> ) minimum
Flexural Strength	D790	69 N/mm <sup>2</sup> (10,000 lbf/in <sup>2</sup> ) minimum
Flexural Modulus	D790	3100 N/mm <sup>2</sup> (4.5 x 10 <sup>5</sup> lbf/in <sup>2</sup> )
Hardness Rockwell	D785	90 to 120 "R" Scale
Heat Shrinkage		10% maximum 15 minutes at 177 degrees C (350 degrees F)
Heat Deflection (annealed)	D648	88 degrees C (190 degrees F) minimum @ 182 N/cm <sup>2</sup> (264 lbf/in <sup>2</sup> )
Impact Strength Gardener Dart Drop, 13 mm (0.5 in) diameter ball:	D5420	
@ 23 degrees C (73 degrees F)		369 kg-cm (320 in-lb.) minimum
@ -29 degrees C (-20 degrees F)		92 kg-cm (80 in-lb.) minimum

## 19.14 Raceways and Junction Boxes

### 19.14.1 Scope

This section applies as follows:

1. Raceways include conduit and wireway, both non-metallic and metallic.
2. Junction boxes are boxes that are part of the raceway system and include both pull boxes and boxes for electrical connections.

### 19.14.2 General Requirements

Comply with the following:

1. Locate raceways and junction boxes to avoid mechanical damage.
2. If the installation of raceways or junction boxes causes the connection of dissimilar materials, the installation will comply with the requirements for dissimilar materials in this Section.

### 19.14.3 Conduit

#### *Permitted Conduit Types*

Comply with the following:

1. Flexible Non-Metallic Conduit:
  - a. Use: May be used where flexibility is required but not where subject to physical damage.
  - b. Conduit: Material meeting the flammability, smoke emission, and toxicity requirements of this Section.
    - i. Interior use: Rated IP64 with fittings

- ii. Exterior use: UV resistant and rated IP66 with fittings
  - c. Terminations: Manufactured by the conduit manufacturer for the conduit selected and suitable for the application.
  - d. Fittings to secure conduit:
    - i. For corrugated-exterior-wall type: Clips manufactured for the purpose by the conduit manufacturer and designed to restrain longitudinal motion.
    - ii. For smooth-exterior-wall type: Two-hole, heavy-duty galvanized steel straps, manufactured for the size of conduit they are used to secure.
- 2. Liquid tight Flexible Metal Conduit:
  - a. Use: May be used in the same locations as flexible non-metallic conduit, except where exposed to accidental impact damage, such as under the vehicle ends.
  - b. Core: Flexible galvanized steel with a continuous copper bonding conductor spiral wound between the convolutions.
  - c. Jacket: Extruded liquid-tight plastic or neoprene meeting the flammability, smoke emission, and toxicity requirements of this Section; moisture- and oil-proof. If used in exterior locations, the jacket will be UV resistant and rated IP66 with fittings.
  - d. Terminations: Zinc-coated steel.
  - e. Fittings to secure conduit: Two-hole, heavy-duty galvanized steel straps, manufactured for the size of conduit they are used to secure.
- 3. Rigid Metal Conduit:
  - a. Use: May be used where flexibility is not required.
  - b. Conduit, elbows, nipples: Steel, hot dip galvanized inside and out after threading, UL listed, complying with ANSI C80.1.
  - c. Couplings and Terminations: Steel, galvanized, threaded type.
  - d. Bushings: Nylon insulated, metallic.
  - e. Fittings to secure conduit: Two-hole, heavy-duty galvanized steel straps, manufactured for the size of conduit they are used to secure.

#### *Conduit Fill*

Conduit fill will not exceed the maximum fill permitted by NFPA 70, Chapter 9, Tables, Table 1, Percent of Cross Section of Conduit and Tubing for Conductors and Cables.

#### *Conduit Installation*

Comply with the following:

- 1. General:
  - a. Install conduit to prevent moisture traps and arrange to gravity-drain toward control boxes or an open end.
  - b. Install conduit such that wire, and cable may be installed after conduit installation without using power equipment and without exceeding the allowed wire or cable pulling tension or sidewall tension.

2. Flexible Non-Metallic Conduit: Install conduit in accordance with the requirements of NFPA 70, Article 356, Liquid tight Flexible Nonmetallic Conduit, including but not limited to the number of bends in one run, bend radii, and securing and supporting conduit.
3. Liquid tight Flexible Metal Conduit: Install conduit in accordance with the requirements of NFPA 70, Article 350, Liquid tight Flexible Metal Conduit, including but not limited to the number of bends in one run, bend radii, and securing and supporting conduit.
4. Rigid Metal Conduit:
  - a. Install conduit in accordance with NFPA 70, Article 344, Rigid Metal Conduit, including but not limited to how bends are made, the number of bends in one run, bend radii, reaming and threading, securing, and supporting conduit, and use of bushings.
  - b. After threading, clean to remove threading oil and protect from corrosion with minimum two coats of brushed on cold galvanizing compound.
  - c. If conduit is terminated at floor level, extend minimum 25 mm (1 in) about the floor to prevent entrance of liquid.
  - d. Clean conduit after installation by pulling through a brush or swab.

#### *Conduit Connections to Boxes and Enclosures*

Comply with the following requirements:

1. Configure conduit connections to boxes and enclosures as follows:
  - a. So that structural, electrical, and environmental integrity is maintained.
  - b. To facilitate removal and replacement of the equipment enclosure. Conduit entries into removable equipment boxes will be secured by means of a bolt-on watertight access panel.
2. Connect conduit to underfloor and roof equipment enclosures using watertight connectors. The entrance of conduit into the top and bottom of equipment boxes is prohibited.

#### *19.14.4 Wireway*

##### *Scope*

A wireway includes wire duct, trough, channel, or other means, not including conduit, used to contain electrical wire, electrical cable, or communications cable.

##### *General Requirements*

Comply with the following:

1. Use restrictions: Use only where it will remain permanently accessible, such as where installed in electrical lockers or behind removable panels.
2. Design and installation: Ensure that wire and cable can be installed without damage:
  - a. Surfaces and edges: Designed to prevent damage to wire and cable insulation.
  - b. Wire entry and exit points: Provide additional wire protection and support.
3. Wire management: Provide means to securely fasten wire and cable within wireways to prevent movement and chafing but allow changes to be made throughout the lifetime of the vehicle.

4. Barriers: If used for conductors of different voltages, provide circuit separation as Specified in the Circuit Separation section, below.

#### *Interior*

Interior wireway may be non-metallic or metallic, as appropriate for the application:

1. Non-metallic wireway:
  - a. Material will be low-smoke, halogen-free, complying with requirements for flammability, smoke emission, and toxicity in this Section.
  - b. The wireway will be designed for the intended purpose and may be solid or slotted.
  - c. Provide a removable cover.
  - d. Attach securely to the vehicle structure using Specified fasteners; adhesive fasteners are not permitted. Secure at intervals complying with NFPA 70, Article 378, Nonmetallic Wireways.
2. Metallic wireway: Meet the requirements for exterior metal wireway.

#### *Exterior*

Exterior wireway will be metallic, unless otherwise Approved, and will comply with the following:

1. Material: Stainless steel, or steel primed and painted in accordance with the requirements of this Section.
2. Drains: Provide to prevent accumulation of water, unless made with perforated material.
3. Covers: Removable.
4. Installation: Attach securely to the vehicle structure using Specified fasteners. Secure at intervals complying with NFPA 70, Article 376, Metal Wireways.

### 19.14.5 Junction Boxes

#### *General*

Comply with the following general requirements for interior and exterior junction boxes:

1. Manufacturer: The Contractor or a regular manufacturer of electrical junction boxes.
2. Interior finish: Primed and painted white.
3. Covers: Gasketed and retained by spring-type latches or captive screws as agreed by the City on a location-by-location basis. Fasteners will be stainless steel.

#### *Exterior Junction Boxes*

Exterior junction boxes will meet the general requirements for junction boxes. In addition, they will be minimum 14-gauge steel and weatherproof.

### 19.14.6 Bonding and Grounding Metallic Raceway and Junction Boxes

Metallic raceway and junction box installations will comply with the following:

1. Provide appropriate fittings such that raceways and connected junction boxes are mechanically and electrically continuous.
2. Provide additional bonding jumpers or internal grounding wires if necessary for electrical continuity.

3. Safety ground raceway and junction boxes to the vehicle structure as Specified within the TS.

## 19.15 Wire and Cable

### 19.15.1 General

Comply with the following general requirements for all wire and cable used on the vehicle:

1. Limit the number of wire types and sizes to the extent possible.
2. Comply with the flammability, smoke emission, and toxicity requirements of this Section, AAR RP-585, and NFPA 130.
3. Provide wire and cable suitable for the application.

### 19.15.2 Wire and Cable Type Requirements

#### *Conductors*

Comply with the following:

1. Material: Soft (annealed) copper.
2. Plating: As indicated in standards referenced for wire types in the Insulation section, below, or if not indicated, in accordance with temperatures below:
  - a. 150 degrees C or less: Tinned; ASTM B33.
  - b. 250 degrees C or less: Silver-plated; ASTM B298.
  - c. 450 degrees C or less: Nickel-plated; ASTM B355.
3. Stranding: Suitable for the application. Provide extra-fine wire stranding for applications subject to repetitive motion, where superior flexibility is necessary for proper installation, or as Specified elsewhere in the Contract Documents.

#### *Insulation*

Comply with the following:

1. Flexibility: For wire sizes No. 6 AWG and larger, the insulation material will be formulated for extra flexibility.
2. Voltage Rating:
  - a. Nominal voltages 300 V or less: Insulation will be rated 600 V, ac, and dc.
  - b. Nominal voltages greater than 300 V: Insulation will be rated 2000 V, ac, and dc.
3. General Vehicle-Body Wiring:
  - a. Sizes No. 12 to No. 28 AWG: Teflon®, mineral-filled, abrasion-resistant insulation; or
  - b. All sizes: Flame retardant, flexible, cross-linked polyolefin complying with ICEA S-95-658, having a continuous temperature rating of 110 degrees C (230 degrees F) or 125 degrees C (257 degrees F), as appropriate for the application.
  - c. Flammability, Smoke Emission, and Toxicity Standards:
    - i. NFPA 130
    - ii. 49 CFR 238
    - iii. ASTM E662 in flaming and non-flaming modes

- iv. BSS 7239 or Bombardier SMP 800C
  - v. IEEE 1202
  - vi. UL 1685
4. High Temperature Applications:
- a. Sizes No. 16 AWG and Larger:
    - i. Abrasion resistant Teflon® polytetrafluorethylene (PTFE) complying with SAE AS 22759/6 or tetrafluorethylene (TFE) complying with SAE AS 22759/10, as appropriate for the voltage level; or
    - ii. Silicone rubber complying with AAR RP-587 and is suitable for the application.
  - b. Sizes No. 18 AWG and Smaller:
    - i. Abrasion resistant Teflon® polytetrafluorethylene (PTFE) complying with SAE AS 22759/6 or tetrafluorethylene (TFE) complying with SAE AS 22759/10, as appropriate for the voltage level.
  - c. Wire used in high-temperature applications for interconnecting will be in bundles with a high-temperature rated, low-smoke generating, insulated protective covering.
5. In Equipment: Wiring within replacement modular units, electronic apparatus such as cards and card racks, and other equipment, as Approved, will be one of the following:
- a. Tefzel® ethylene tetrafluoroethylene (ETFE) per ASTM D3159 (material standard) and insulation construction per SAE AS 22759/16.
  - b. Teflon® polytetrafluoroethylene (PTFE) type EE per NEMA HP 3.
  - c. Cross-linked polyolefin insulated wire, as described for general vehicle-body wiring, above.
6. Crowded Locations (Cab Console or similar locations):
- a. Tefzel® ETFE per ASTM D3159 and insulation construction per SAE AS 22759/16.
  - b. When used for this application, bundle these type wires with a protective covering of cross-linked modified polyolefin or similar high-temperature rated, low-smoke generating insulation.

#### *Multi-Conductor Cables*

Where multi-conductor cable is Approved, comply with the following:

- 1. Conductors and insulation: As described above.
- 2. Fillers: Where required to obtain a circular cross-section, fillers will be made of non-hygroscopic materials compatible with the wire insulation and jacket and will be of the same or of a higher temperature rating than the wire insulation.
- 3. Binder Tape: Non-hygroscopic, of the same (or better) temperature class as the wire insulation, and of a compatible material. Apply if needed to assist in cable manufacture, or as required to permit the cable to function as intended in its application.

4. Shield (if required): Either tin-plated copper braid, concentrically served copper, or aluminum/polyester tape with a drain wire, as appropriate for the application. Tape shields will be permitted for fixed installations only.
5. Overall jacket: Flame-retardant, cross-linked, modified polyolefin, Tefzel® (ETFE), or Teflon® (PTFE), fully compatible with the wire insulation and application.
6. Identification:
  - a. Individual conductors in multi-conductor cables will be color coded or otherwise permanently identified as Approved.
  - b. Overall jacket will be permanently marked at maximum 1 m (3 ft) intervals with the following information, as a minimum:
    - i. Conductor size
    - ii. Number of conductors
    - iii. Voltage rating
    - iv. Jacket type

#### *Ethernet Cable*

For network cabling, provide industrial-grade Ethernet cable designed for reliable performance in a transit environment:

1. Conductors: Tinned copper, solid or stranded as required for the application and Specified performance.
2. Shielding: Provide if required to obtain Specified performance.
3. Jacket: Abrasion-resistant.
4. Construction:
  - a. Suitable for the intended installation method.
  - b. In compliance with flammability, smoke emission, and toxicity requirements of this Section.
  - c. Minimum IP65 rated in accordance with IEC 60529 when mated with Specified connectors.
5. Identification: Cable will be permanently marked at maximum 1 m (3 ft) intervals with the following information, as a minimum:
  - a. Electrical performance rating (e.g., Cat 5e)
  - b. Number of pairs and size (AWG)

#### **19.15.3 Wire and Cable Application and Installation Requirements**

##### *General*

Comply with the following:

1. Wire and cable will be applied and installed as indicated in NFPA 70, Chapter 3, Wiring Methods and Materials, APTA PR-E-RP-002-98, NFPA 130, and IEEE Std 16, except where otherwise Specified in the Contract Documents, in which case that wire will be as Specified.



2. Vehicle wiring will have circuit protection conforming to NFPA 70, Article 240, Overcurrent Protection, or the TS.

#### *Wire Sizes*

Comply with the following:

1. Size wiring for the intended load, voltage drop, application, and installation method.
2. Wire and cable ampacity will comply with NFPA 70, Section 310.15, Ampacities for Conductors Rated 0-2000 Volts. Where the temperature rating of the Approved wire or cable is not included in Section 310.15 tables, manufacturer's ratings may be used, if the rating method is consistent with NFPA 70 Section 310.15.
3. Regardless of load, minimum wire sizes will be as follows:
  - a. Wire pulled through conduit: No. 14 AWG
  - b. Wire on electronic units, cards, and card racks: No. 28 AWG
  - c. Wire laid in, rather than pulled through, wire ducts: No. 16 AWG
4. Wires sizes other than the above will be only as Approved.

#### *Insulation Level*

Wiring within enclosures will be insulated for the highest voltage in the enclosure, unless Approved otherwise.

#### *High-Temperature Wire*

Comply with the following:

1. If used for interconnecting pieces of apparatus, high-temperature wire will be in bundles with a high-temperature rated protective covering.
2. High-temperature insulated wire will not be used in conduit or raceways without specific approval.

#### *Circuit Separation*

Comply with the following:

1. Circuits will be physically separated to reduce the possibility of unsafe conditions, interference, or equipment damage.
2. The following major circuit groups will not be harnessed or bundled together, will not run in the same conduit, and will be physically separated and secured in enclosures, wire ducts, junction boxes, or other wire routing devices:
  - a. High-voltage circuits
  - b. AC circuits
  - c. Communication circuits
  - d. Battery voltage level circuits
  - e. Semiconductor voltage level circuits
3. Wiring operating at potentials differing by 50 V or more will be separated as follows:
  - a. will not be harnessed or cabled together.
  - b. will not be run in conduit together.

- c. In wireway, junction boxes, or other wire routing devices will be separated by a rigid physical barrier.
  - d. Within equipment enclosures will be separated, routed, and secured such that contact between wiring is not possible.
- 4. Provide separation and/or electromagnetic shielding 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.

#### *Spare Wires*

Comply with the following:

- 1. Provide a minimum of 10% spare wires in each harness or group of wires between equipment enclosures, but no fewer than two spares for each wire size.
- 2. Unless specifically Approved by the City, spare wiring will not be used by the Contractor.
- 3. Install spares in connectors on terminal boards or other means as Approved by the City.

#### *Wire Handling*

Comply with the following:

- 1. Wiring will be installed by qualified and experienced wiring personnel:
  - a. Use appropriate tools for work such as stripping insulation, cutting, tinning, soldering, harness making, and attaching terminals.
  - b. Use wiring tools and equipment as recommended by the tool and equipment manufacturer.
- 2. Wire will be protected from damage during all phases of equipment manufacture.
  - a. Wire will not be walked on, dragged across sharp or abrasive objects, kinked, or twisted, or otherwise mishandled.
  - b. The ends of wire will not be permitted to lay on wet floors or other damp areas where moisture may be absorbed into the conductors.
- 3. When removing insulation, wire strands will not be nicked or broken.

#### *Wiring Location Requirements*

Comply with the following restrictions on location:

- 1. Locate wiring such that heat sources, maintenance access, and the City environment do not damage or reduce the life of the wiring.
- 2. Wiring will not pass through or over the battery compartment or overheat-generating equipment such as acceleration and braking resistors.

#### *Wiring Methods*

Comply with the following requirements for wiring methods:

- 1. Wiring Type Requirements:
  - a. Exposed wiring: Keep to a minimum; subject to the City's approval.

- b. Multi-conductor cabling:
    - i. Keep to a minimum, subject to the City's approval.
    - ii. will not be exposed with the following exceptions:
      - 1. Coupler cables with additional jacketing or armor
      - 2. Wiring to standard small devices, such as speed sensors, that cannot accept conduit fittings.
  - c. Under-vehicle and roof wiring: Waterproof, including entrance and exit points from equipment enclosures or wiring devices.
2. Raceway Requirements:
- a. Wire smaller than No. 6 AWG will be installed in conduit or wireway unless it is an integral part of equipment or is contained within an enclosure.
  - b. Wiring to resiliently mounted or moving equipment will be by flexible conduit.
  - c. Wire No. 6 AWG or larger may be cleated in place without conduit or wireway.
3. Securing:
- a. Wiring will be secured and protected against movement, chafing, and contact with conductive, sharp, or abrasive objects and surfaces such that normal equipment motion does not damage or reduce the life of the wiring.
  - b. Wiring will not be secured directly to the vehicle structure, equipment enclosures, or any metallic surface.
  - c. Wire ties: May be used only to secure or bundle wire and cable within wireway, where exiting wireway or entering equipment enclosures, and within equipment enclosures.

#### *Wire and Cable Installation in Conduit*

Install wire and cable in conduit without using power equipment and without exceeding the manufacturer's allowed wire or cable pulling tension or sidewall tension:

1. Clean the conduit just before installation of wire or cable by pulling a brush or swab through.
2. Simultaneously install all cables to be placed in one duct.
3. Use extreme care in installing wire and cables to avoid twisting, kinking, scraping, or injuring the outer sheath.
4. Use continuous lengths of wire and cable between power source and equipment. Splices are prohibited.
5. Wiring within conduit will not be bundled or secured.
6. Pulling compound, if used, will be non-conductive, non-hygroscopic, non-odorous and will not attract vermin.

#### *Wire and Cable Installation in Wireway*

The installation of wire and cable in wireway will comply with the requirements of NFPA 70 Article 376, Metal Wireways, or Article 378, Nonmetallic Wireways, including but not limited to the size of conductors, number of conductors, and ampacity of conductors based on wireway fill.

Comply with the following:

1. Wire and cable will be laid into wireway. If pulling is required, prepare a pulling plan documenting the wire or cable manufacturer's minimum acceptable bend radius and maximum tension during pulling.
2. To the extent possible, install all wire and cable in a wireway at the same time, unless physical separation barriers are provided.
3. The wire and cable will be installed neatly and fastened securely to eliminate movement and chafing.
4. When the wire and cable is in its final position, inspect to ensure that it has sufficient bend radius, and that there is no sagging, pinching, or possibility of chafing that could cause damage over time.

*Wire and Cable Installation by Cleating*

Comply with the following:

1. Cleat Type:
  - a. Split-block cleats of fire-retardant neoprene rubber with a durometer of 50 to 60.
  - b. Neoprene blocks will be clamped together with a minimum of two bolts with a rigid stiffener on each side of the cleat.
  - c. Stiffeners will ensure that clamping pressure is evenly distributed over the full length of the cleat.
2. Cleat opening:
  - a. Molded into the material by an experienced manufacturer.
  - b. Sized only for the intended wire size such that it firmly grips the wire without insulation damage or cold flow. Shimming of oversized openings is not permitted.
  - c. Cutting, drilling, or modification of cleat openings during vehicle construction is prohibited.
3. Installation:
  - a. Route and support wiring such that each individual run of wiring cannot contact other wiring or any other part of the vehicle under any circumstances.
  - b. Cleat spacing: Maximum 0.5 m (18 in).
  - c. Drip loop: Provide on exposed wiring to prevent fluid runoff into connected equipment.

*Wiring Within Enclosures*

Wiring within enclosures will be attached to wire supports rigidly fastened to the enclosure structure. Comply with the following requirements:

1. Wiring will be clear from edges, bolt heads, and similar areas, and will not interfere with or contact enclosure covers.
2. Wiring will be located on the top or sides of the enclosure. Wiring will be a minimum of 25 mm (1 in) above the bottom of the enclosure, including wiring that must connect to the bottom of apparatus.

3. Wiring entering a removable enclosure will be harnessed and secured to facilitate removal of the enclosure. Wires entering an enclosure from different raceways will not be harnessed together or with internal wiring.
4. Wiring will be secured such that there is no strain on wire terminals, multi-pin connector pins, or other wire termination hardware.
5. Wire dress will allow for sufficient slack at terminals to allow for shock and vibration induced movements, equipment shifting, alignment, cover removal, and component replacement.
6. Provide additional wire length for retermination of wires without excess tension or splicing as follows:
  - a. No. 10 AWG and smaller: Four reterminations
  - b. No. 8 AWG and larger: Three reterminations

#### *Identification*

Devise a wire and terminal designation system that will coordinate each electrical circuit in the vehicle into a unified system:

1. The system will identify wiring, including circuit return wiring, and terminals according to their respective circuit function(s), and will accurately correlate with the Integrated Schematic Diagrams.
2. Common designations for return circuits are not permitted.
3. Alternative designations may be used with City approval in small standard assemblies, such as PA amplifiers.

Clearly identify each terminal and identify each wire with both its circuit designation, and, if attached to a terminal, its terminal designation.

1. Mark wires within 75 mm (3 in) of the end of the wire.
2. Provide heat-shrink machine-printed sleeve labels that fit snugly around wire or cable after heat is applied, or continuous wire marking printed on the wire.
  - a. Material: Heat shrinkable, fire retardant, zero halogen, oil, and grease resistant, suitable for the worst-case combinations of ambient and equipment temperatures.
  - b. Printing: Chemical and abrasion resistant.
  - c. Color: White or yellow with black printing.
3. Color coded wires are permitted as an alternative in small standard assemblies such as PA amplifiers.

#### *Wire Ties, Clamps, and Anchors*

Wire ties will be nylon formulated for resistance to ozone and ultraviolet light, rated for outdoor service.

Wire ties:

1. Select width for intended wiring load and minimum insulation indentation.
2. Install with tools with automatic tensioning devices, as supplied by the wire tie manufacturer.
3. Install with sufficient tension to restrain the wiring but without indenting the wire insulation.

4. Install with cut ends flush with the locking mechanism.

Wire clamps:

1. Wire clamps will be either nylon as Specified above for wire ties or stainless steel covered with neoprene or silicon rubber, such as Adel clamps as manufactured by Adel Wiggins.
2. Size for each harness such that minimum 90% of the harness circumference is securely clamped.
3. Fasten clamps with bolts and elastic stop nuts.

Wire tie anchors (if used):

1. Material: Nylon, as Specified above for wire ties.
2. Installation: Fasten to a rigid structure using rivets or screws; adhesive-based wire tie anchors are not permitted.

## 19.16 Wire Terminations

### 19.16.1 General

Wiring will terminate in Approved connectors or on terminal boards:

1. Provide junction boxes or equipment enclosures for all wire terminations or circuit branches.
2. Wire splicing is prohibited.
3. Inline connectors and splice packs are prohibited.

### 19.16.2 Terminal Boards

Definition of Terminal Board: Device commonly called terminal block, terminal strip, terminal stud, or similar, to which wires are connected.

Comply with the following requirements for terminal boards:

1. will be of a series service proven in rail transit.
2. Conducting portion: Plated copper.
3. Insulating portion:
  - a. Strong, high temperature rated, tracking resistant material that is not brittle.
  - b. The material will be either a filled reinforced thermosetting material or a thermoplastic material.
  - c. Use of general purpose phenolic is prohibited.
4. Clamps, screws, or other hardware: May be plated steel.
5. Jumpers between adjacent terminals: Plated brass or copper.
6. Spare terminal requirements:
  - a. Less than 100 terminals: Minimum 10% spare, but no fewer than one unused terminals.
  - b. 100 terminals or more: Minimum 10 spare, plus 2 for every 50 additional terminals above 100.

7. Number of wires permitted:
  - a. Screw compression-clamp terminal boards: Connect a maximum of two terminals to each binding terminal.
  - b. Other terminations: Only one wire per terminal is permitted.
8. Provide adequate space to permit connecting wire terminals with standard tools.

#### 19.16.3 Non-Power Wiring Terminations

Comply with the following:

1. Terminate wires as appropriate for the intended terminal block, as recommended by the terminal block manufacturer.
2. Spring-clamp terminals: Wire may be bare, as recommended by the terminal supplier.
3. Non-spring-clamp terminals: Provide terminations complying with the following requirements:
  - a. Mechanical crimp type terminals such as AMP brand as manufactured by TE Connectivity, or other Approved manufacturers with a comprehensive line of terminals, connector pins and application tools.
  - b. Plated copper.
  - c. Ring-type terminals.
  - d. Prohibited:
    - i. Hook type terminations.
    - ii. Faston-type (receptacle and tab) terminations unless part of OEM components.
    - iii. Fork (spade) type terminations, unless specifically Approved for applications such as relays or other devices with captive screw fasteners.
  - e. Conductor sizes No. 10 AWG or smaller:
    - i. Insulated terminals with metal strain relief device under the insulation that is crimped onto and grips the wire insulation simultaneously with the terminal.
    - ii. The insulation material will be rated for the expected worst-case temperature.
4. Installation:
  - a. Maximum of one wire in each terminal.
  - b. Attach wire terminals and connections to the wiring with crimping tools and dies as recommended by the manufacturer and Approved by the City:
    - i. Crimping tools will be ratcheting types that ensure a complete compression.
    - ii. Maintain these tools in proper calibration and ensure that personnel using them are properly trained.

#### 19.16.4 Power Wiring Terminations

Comply with the following:

1. General Applications: Bolted compression terminals manufactured by TE Connectivity (AMP brand), Thomas & Betts, or Approved equal.

2. Special Applications:
  - a. Locations where rotation of termination could result in contact or unacceptable clearance: Double-bolted terminals.
  - b. Traction motor wire: Terminals will be as recommended by the motor manufacturer, subject to approval.
3. Installation:
  - a. Procedures: As recommended by the terminal manufacturer.
  - b. Crimping tools: Ratcheting type that ensures complete compression, and as recommended by the terminal manufacturer.
  - c. Terminations at heat generating devices: At the terminal, peel back insulation from the conductor a sufficient distance to prevent excessive heat from damaging insulation.

## 19.17 Cable Terminations

### 19.17.1 Multi-Pin Cable Connectors

Provide cable connectors of service proven design by manufacturers such as ITT Veam or Harting. Connectors will comply with the following:

1. Contacts:
  - a. Removable crimp type, with a positive seating mechanism for each contact so it cannot back out of its location in the connector.
  - b. Sized for the wire, as recommended by the manufacturer.
2. Strain relief: Cable clamp at the back of the connector sized for the cable jacket. Clamping on cable wires is prohibited.
3. Extension bodies: Provide where necessary to ensure that there is sufficient room to terminate cable wires while providing the seal and clamp on the cable jacket.

Adjacent connectors will use either different inserts or different insert orientations to prevent erroneous connections.

### 19.17.2 Cable Connectors

Comply with the following:

1. Application:
  - a. Weatherproof interior locations: Non-waterproof or waterproof connectors.
  - b. Under-vehicle and exposed locations: Waterproof connectors.
2. Type: Circular or rectangular metal-shelled, positive-locking, quick disconnect, with the following features:
  - a. Rated for a minimum life of 2,000 couplings before failure.
  - b. Connectors will give audible, visual, and tactile indications of full coupling.
3. Waterproof connectors will have the following additional features:
  - a. Watertight



- b. Furnished with gaskets on the front mating surface and on the back at the cable entry.
4. Installation: Seal unused connector pin positions with either connector contacts or plastic sealing plugs designed for that purpose.

#### 19.17.3 Ethernet Cable Connectors

Connectors will be industrial Ethernet M12 type, complying with IEC 61076-2-101, with the following features:

1. Gold plated contacts.
2. Rated for minimum 500 mating cycles.
3. Connectors and the cable-to-connector attachment IP65 rated per IEC 60529.

#### 19.17.4 Cable Connections to Boxes and Enclosures

Comply with the following:

1. Configure cable connections to boxes and enclosures so that structural, electrical, and environmental integrity is maintained, and to facilitate removal and replacement of the box or enclosure.
2. Cable entry will be by means of watertight sealing glands. Glands and cable terminations will allow for cable replacement without removal of lugs, terminals, or connectors from the wires.
3. Entrance of cables in the top and bottom of equipment boxes is prohibited.

### 19.18 Contract Deliverables Requirements List (CDRL)

#### 19.19 CDRL Detail

Submit the following in accordance with Section 19, Program Control and Quality Assurance:

##### 19-1 Recommended Cleaning Agents:

1. Each material exposed to normal cleaning: Manufacturer's recommended cleaning agent.
2. Each cleaning agent: Safety Data Sheet (SDS).

##### 19-2 Certification of No Prohibited Materials:

1. List of prohibited materials, and certification that none are present on vehicles.

##### 19-3 Proposed Materials Not Covered by Specification or Standard:

1. Material, identified by commercial trademark, name, and address of Supplier.
2. Description and technical data specifications of material composition.

##### 19-4 Safety Data Sheets (SDS):

1. Submit as one complete package including an SDS for each chemical material used in the manufacture of the vehicle.

##### 19-5 Fasteners Design Package:

1. Matrix listing each type of fastener used on the vehicle. Furnish the following information:
  - a. Fastener type
  - b. Manufacturer
  - c. Base material and plating or finish
  - d. Size(s)

- e. Property class, grade, strength
  - f. Indication of application for structural and safety-related fasteners
  - g. Indication of location for fasteners used where there are location-specific requirements.
  - h. Indication of application for fasteners used where there are application-specific requirements.
2. Manufacturer's data for each type of fastener, with sufficient information to demonstrate compliance with the Specifications.
3. Plating type used for high strength fasteners.
4. Alternate plating or coating system (if proposed):
  - a. Qualification data for each process used at each Supplier applying proposed coating, including the following:
    - i. Coating manufacturer's product data including required thickness.
    - ii. ASTM B117 test results from an accredited third-party laboratory
    - iii. Documentation of torque/tension characteristics
    - iv. A statement from the coating manufacturer regarding the propensity for the coating process to cause hydrogen embrittlement of the fastener during coating
5. Structural threaded fasteners: Sufficient information to demonstrate compliance with the requirement for coordination of nut strength with bolt strength to prevent undetected internal thread stripping, including calculations if required.
6. Safety-related fasteners: Proposed sample quantities to be used for production lot testing.

**19-6 Stainless Steel Test and Inspection Plan:**

1. Submit before purchasing stainless steel to be used in welded applications.
2. Purpose: For acceptance of stainless steel.
  - a. Austenitic stainless steels: Include frequency of submittal of certifications in accordance with ASTM A666 and frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A262.
  - b. Ferritic stainless steels: Include frequency of submittal of checks for susceptibility to intergranular corrosion in accordance with ASTM A763.

**19-7 Structural Steel Test and Inspection Plan:**

1. Submit before purchasing structural steel.
2. Include provisions for submission of reports and certification to the City for each shipment in accordance with the applicable requirements of this Section and Specified CGHAZ impact tests.

**19-8 Steel Casting Qualification Test Report:**

1. If the casting selected for qualification fails to qualify, include a plan of action with details of how failed material will be handled.

19-9 Steel Casting Radiographic Inspection Sampling Frequency

19-10 Aluminum Test Reports:

1. Copies of all test reports for sheet, extrusion, and forgings used in the vehicle structure.

19-11 Paints, Graphics, and Coatings Design Package:

1. Manufacturer's data for each type of painting material with the following information:
  - a. Composition
  - b. Recommended application procedures for substrates on which it will be applied.
  - c. Curing characteristics
  - d. Recommended minimum and maximum dry film thickness
  - e. Performance characteristics
2. Detailed paint procedure for all items to be coated.
3. Powder coating:
  - a. Manufacturer's data on powder coating material.
  - b. Powder coat applicator's cleaning and application procedures, including certification that the procedure is Approved by the powder coating material manufacturer.
4. Paint coating and application document containing the following maintenance information:
  - a. Procedures for surface cleaning and preparation, priming, surfacing, and painting for equipment that is painted or powder-coated, whether by itself or by its manufacturers and suppliers.
  - b. Detailed paint schedule showing equipment painted, paint type and manufacturers, recommended thickness, and other pertinent information.
  - c. After approval, include as part of the Maintenance and Servicing.

19-12 Flammability, Smoke Emission, and Toxicity Design Package:

1. Submit a matrix including the following during design review:
  - a. Total weight of all materials
  - b. Where material is used
  - c. Flammability, smoke emission, and toxicity test identity
  - d. Test facility
  - e. Test requirements
  - f. Test results
  - g. Nature and quantity of the products of combustion
  - h. Supplier's name
2. Submit test reports containing the following information for all materials tested:
  - a. Test Performed
  - b. Date Tested

- c. Test Facility
- d. Test Results
- e. Toxicity

19-13 Conduit and Raceways Design Package:

1. Manufacturer's data for each type of proposed conduit.
2. Manufacturer's data for each type of proposed wireway and indicate where it is proposed for use.

19-14 Wire and Cable Design Package:

1. Matrix showing each type of wire and cable proposed for use on the vehicle and indicate the application(s) for which it will be used.
  - a. Manufacturer's data for each type of wire and cable in the matrix.
  - b. Number and name of the standard or standards with which each type of wire or cable complies.
2. Sample of each type of wire and cable proposed, including wire that is part of equipment proposed for use on the vehicle. Samples will be 30 cm (12 in) long.
3. Three copies of certified type test documentation for each size and type of wire and cable proposed.
4. Proposed wire and terminal designation system:
  - a. Manufacturer's data for wire, cable, and terminal markers
  - b. Printed samples of wire, cable, and terminal markers
5. Manufacturer's data for wire ties and clamps
6. Details of proposed spare wires in each harness or group of wires.
  - a. Proposed terminations for spares

19-15 Wire and Cable Connections Design Package:

1. Proposed terminations product line.
2. Manufacturer's data on termination crimping tools
3. Specific application terminations:
  - a. Power wire terminations
  - b. Traction motor wire terminations
  - c. Ethernet terminations
4. Manufacturer's data for each type of cable connector

## **EXHIBIT E: FEDERAL REQUIREMENTS**

### **E.1 PRIVACY ACT.**

Contractor agrees to comply with and assures the compliance of its employees with the information restrictions and other applicable requirements of the Privacy Act of 1974, 5 U.S.C. § 552a. Among other things, Contractor agrees to obtain the express consent of the Federal Government before Contractor or its employees operate a system of records on behalf of the Federal Government. Contractor understands that the requirements of the Privacy Act, including the civil and criminal penalties for violation of that Act, apply to those individuals involved, and that failure to comply with the terms of the Privacy Act may result in termination of the underlying contract.

Contractor also agrees to include these requirements in each subcontract to administer any system records on behalf of the Federal Government financed in whole or in part with Federal assistance provided by FTA.

### **E.2 INCORPORATION OF FEDERAL TRANSIT ADMINISTRATION (FTA) TERMS**

All contractual provisions required by DOT, as set forth in FTA Circular 4220.1G, dated March 20, 2025, and subsequent modifications, clarifications or amendments are hereby incorporated by reference. Anything to the contrary herein notwithstanding, all FTA mandated terms shall be deemed to control in the event of a conflict with other provisions contained in this Agreement. Contractor shall not perform any act, fail to perform any act, or refuse to comply with any the City of Portland requests that would cause the City of Portland to be in violation of the FTA terms and conditions.

### **E.3 SUBSTANCE ABUSE**

The Contractor agrees to establish and implement a drug and alcohol testing program that complies with 49 CFR Part 655, produce any documentation necessary to establish its compliance with Parts 655, and permit any authorized representative of the United States Department of Transportation or its operating administrations, the State Oversight of Oregon, or the City of Portland, to inspect the facilities and records associated with the implementation of the drug and alcohol testing program as required under 49 CFR Part 655 and review the testing process. The Contractor agrees further to certify annually its compliance with Parts 655 and to submit the Management Information System (MIS) reports before March 15 to the City of Portland. To certify compliance the Contractor shall use the "Substance Abuse Certifications" in the "Annual List of Certifications and Assurances for Federal Transit Administration Grants and Cooperative Agreements," which is published annually in the Federal Register.

To the extent applicable, the Recipient agrees to comply with the following Federal regulations: a. Drug-Free Workplace. U.S. DOT regulations, "Government wide Requirements for Drug-Free Workplace (Financial Assistance)," 49 C.F.R. Part 32, that implement the Drug-Free Workplace Act of 1988, 41U.S.C. § 701 et seq.; b. Alcohol Misuse and Prohibited Drug Use. FTA regulations, "Prevention of Alcohol Misuse and Prohibited Drug Use in Transit Operations," 49 C.F.R. Part 655, that implement 49 U.S.C. § 5331.

#### **E.4 AUDIT AND INSPECTION OF RECORDS**

The Contractor shall permit the authorized representative of the United States Department of Transportation and of the Comptroller General of the United States to inspect and audit all data and records of the Contractor relating to its performance and its subcontracts, if any, under this contract with which Federal funds are used from the date of the contract through and until the expiration of three years after completion of the contract. The inspection and audit provided in this section does not include an audit of the manufacturer's cost and/or profit, with the exception of single bid or sole source situations.

#### **E.5 ACCESS TO THIRD PARTY CONTRACT RECORDS**

The following access to records requirements applies to this Contract:

- Where the Purchaser is not a State but a local government and is the FTA Recipient or a subgrantee of the FTA Recipient in accordance with 49 C.F.R. 18.36(i), the Contractor agrees to provide the Purchaser, the FTA Administrator, the Comptroller General of the United States or any of their authorized representatives access to any books, documents, papers and records of the Contractor which are directly pertinent to this contract for the purposes of making audits, examinations, excerpts and transcriptions. Contractor also agrees, pursuant to 49 C.F.R. 633.17 to provide the FTA Administrator or his/her authorized representatives including any PMO Contractor access to Contractor's records and construction sites pertaining to a major capital project, defined at 49 U.S.C. 5302(a)1, which is receiving federal financial assistance through the programs described at 49 U.S.C. 5307, 5309 or 5311.
- The Contractor agrees to permit any of the foregoing parties to reproduce by any means whatsoever or to copy excerpts and transcriptions as reasonably needed.
- The Contractor agrees to maintain all books, records, accounts and reports required under this contract for a period of not less than three years after the date of termination or expiration of this contract, except in the event of litigation or settlement of claims arising from the performance of this contract, in which case Contractor agrees to maintain same until the Purchaser, the FTA Administrator, the Comptroller General, or any of their duly authorized representatives, have disposed of all such litigation, appeals, claims or exceptions related thereto. Reference 49 CFR 18.39(i)(11).

#### **E.6 CLEAN AIR**

The Contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. §§ 7401 et seq. The Contractor agrees to report each violation to the Purchaser and understands and agrees that the Purchaser will, in turn, report each violation as required to assure notification to FTA and the appropriate EPA Regional Office.

The Contractor also agrees to include these requirements in each subcontract exceeding \$100,000 financed in whole or in part with Federal assistance provided by FTA.

#### **E.7 CLEAN WATER**

Contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq. The Contractor agrees to

report each violation to the Purchaser and understands and agrees that the Purchaser will, in turn, report each violation as required to assure notification to FTA and the appropriate EPA Regional Office.

The Contractor also agrees to include these requirements in each subcontract exceeding \$100,000 financed in whole or in part with Federal assistance provided by FTA.

#### **E.8 TRANSIT EMPLOYEE PROTECTIVE ARRANGEMENTS**

The Contractor shall fully cooperate with the City in meeting the legal requirements of the labor protective provisions of 49 U.S.C. 5333(b) and the Labor Agreements and side letters currently in force and certified by the United States Department of Labor DOL guidelines at 29 C.F.R. Part 215, and any amendments thereto. Changes, including changes in service and any other changes that may adversely affect transit employees, shall be made only after due consideration of the impact of such changes on Section 5333(b) protections granted to employees.

It is the City's understanding that 49 U.S.C. 5333(b) requires that Contractor shall provide preference in hiring to all non-management employees providing transit services under the previous Contract.

#### **E.9 CHANGES TO FEDERAL REQUIREMENTS**

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 Purchaser and FTA, as they may be amended or promulgated from time to time during the term of this contract. Contractor's failure to so comply shall constitute a material breach of this contract.

#### **E.10 NO FEDERAL GOVERNMENT OBLIGATIONS TO THIRD PARTIES**

The City and Contractor acknowledge and agree that, notwithstanding any concurrence by the Federal Government in or approval of the solicitation or award of the underlying contract, absent the express written consent by the Federal Government, the Federal Government is not a party to this contract and shall not be subject to any obligations or liabilities to the City, Contractor, or any other party (whether or not a party to that contract) pertaining to any matter resulting from the underlying contract.

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

#### **E.11 FALSE STATEMENTS OR CLAIMS AND CRIMINAL FRAUD**

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 Project. 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 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.

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.

## **E.12 LOBBYING**

Clause and specific language therein are mandated by 49 CFR Part 19, Appendix A. Modifications have been made to the Clause pursuant to Section 10 of the Lobbying Disclosure Act of 1995, P.L. 104-65 [to be codified at 2 U.S.C. § 1601, et seq.].

Lobbying Certification and Disclosure of Lobbying Activities for third party Contractors are mandated by 31 U.S.C. 1352(b)(5), as amended by Section 10 of the Lobbying Disclosure Act of 1995, and DOT implementing regulation, "New Restrictions on Lobbying," at 49 CFR § 20.110(d)

Language in Lobbying Certification is mandated by 49 CFR Part 19, Appendix A, Section 7, which provides that Contractors file the certification required by 49 CFR Part 20, Appendix A.

Use of "Disclosure of Lobbying Activities," Standard Form-LLL set forth in Appendix B of 49 CFR Part 20, as amended by "Government wide Guidance For New Restrictions on Lobbying," 61 Fed. Reg. 1413 (1/19/96) is mandated by 49 CFR Part 20, Appendix A.

Byrd Anti-Lobbying Amendment, 31 U.S.C. 1352, as amended by the Lobbying Disclosure Act of 1995, P.L. 104-65 [to be codified at 2 U.S.C. § 1601, et seq.] - Contractors who apply or bid for an award 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 disclosures are forwarded from tier to tier up to the recipient.

## **E.13 SUSPENSION AND DEBARMENT**

In accordance with the U.S. Office of Management and Budget (OMB) "Guidelines to Agencies on Government-wide Debarment and Suspension (Non-procurement)" 2 C.F.R. Part 180 and U.S. DOT regulations, "Non-procurement Suspension and Debarment," 2 C.F.R. Part 1200, Contractor must provide certification that neither it nor its "principals" are presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by a federal department or agency. Contractor, as a condition of responsiveness, shall complete the certification form located in Attachments Section of the RFP and submit with their proposal.



Contractor shall also include these requirements in each subcontract exceeding \$25,000 financed in whole or part with federal assistance provided by FTA.

## **E.14 CIVIL RIGHTS REQUIREMENTS**

The following requirements apply to the underlying contract:

### **E.14.1 Nondiscrimination**

In accordance with Title VI of the Civil Rights Act, as amended, 42 U.S.C. § 2000d, section 303 of the Age Discrimination Act of 1975, as amended, 42 U.S.C. § 6102, section 202 of the Americans with Disabilities Act of 1990, 42 U.S.C. § 12132, and Federal transit law at Title 49 CFR Transportation

### **E.14.2 U.S.C. § 5332**

The Contractor agrees 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.

### **E.14.3 Equal Employment Opportunity**

The following equal employment opportunity requirements apply to the underlying contract:

- 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.
- 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.

- 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.
- 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.

## **E.15 CARGO PREFERENCE**

The Contractor agrees:

- To use privately owned United States-Flag commercial vessels to ship at least 50 percent of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners, and tankers) involved, whenever shipping any equipment, material, or commodities pursuant to the underlying contract to the extent such vessels are available at fair and reasonable rates for United States-Flag commercial vessels;
- To furnish within 20 working days following the date of loading for shipments originating within the United States or within 30 working days following the date of leading 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 the preceding paragraph to the Division of National Cargo, Office of Market Development, Maritime Administration, Washington, DC 20590 and to the City of Portland (through the Contractor in the case of a subcontractor's bill-of-lading);
- To include these requirements in all subcontracts issued pursuant to this contract when the subcontract may involve the transport of equipment, material, or commodities by ocean vessel.

## **E.16 ENERGY CONSERVATION**

The Contractor agrees to comply with mandatory standards and policies relating to energy efficiency which are contained in the state energy conservation plan issued in compliance with the Energy Policy and Conservation Act.

## **E.17 FLY AMERICAN REQUIREMENTS**

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

#### **E.18 BUY AMERICA REQUIREMENTS**

The Contractor agrees to comply with 49 U.S.C. 5323(j) and 49 C.F.R. Part 661, which provide that Federal funds may not be obligated unless steel, iron, and manufactured products used in FTA- funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. General waivers are listed in 49 C.F.R. 661.7.

Rolling stock must be assembled in the United States and have a 60 percent domestic content (components and subcomponents) applicable at the time of vehicle delivery, and final assembly must occur in the United States. The percent of domestic content contained in the draft guidance issued by the Federal Transit Administration on April 6, 2016 is as follows:

Rail vehicles delivered after Oct 1, 2019 have to meet 70% US content.

For the procurement of rolling stock, the provisions of 49 U.S.C. § 5323(l) and implementing FTA regulations (49 CFR Part 663) pertaining to pre-award and post-delivery audits of rolling stock shall apply. Such audits shall be performed for the purpose of verifying compliance by the Proposer/Contractor with applicable Buy America requirements (49 U.S.C. § 5323(j) and 49 CFR Part 661), relevant Federal Motor Vehicle Safety (FMVS) Standards, and for the purpose of verifying compliance with the City's specification requirements. These audits shall be performed before the award of a contract is effective and again after delivery of the rolling stock, but before title transfer or revenue service begins, whichever occurs first.

The Proposer/Contractor shall provide the City's independent contractor, all such information, records, and data as is reasonably required by the independent contractor to complete the Buy America audit in sufficient detail to enable the City to certify compliance as required under 49 CFR § 663.25. Information provided by the Proposer/Contractor about the actual cost of components and subcomponents (other than costs expressed as a percentage of total vehicle cost) shall be kept confidential to the extent cost data is clearly marked as proprietary by Proposer/Contractor and to the fullest extent permitted under applicable state or federal law.

Before Delivery of the last SCV, the Contractor shall provide cost information of sufficient detail to allow the City's third-party auditor to determine that federal Buy America requirements have been met. The cost information shall be submitted by the Contractor and by the Contractor's sub-contractors directly to an independent auditor selected and engaged by the City.

#### **E.19 FEDERAL FUNDING LIMITATION**

Contractor understands that funds to pay for Contractor's performance under this Contract are anticipated to be made available from the United States Department of Transportation through the Federal Transit Administration (FTA). All funds must be approved and administered by FTA. the City 's obligation hereunder is payable from funds that are appropriated and allocated by FTA for the performance of this Contract. If funds are not allocated, or ultimately are disapproved by FTA, the City

may terminate or suspend Contractor's services without penalty. The City shall notify Contractor promptly in writing of the non-allocation, delay, or disapproval of funding.

## **E.20 CHARTER SERVICE OPERATIONS**

The contractor agrees to comply with 49 U.S.C. 5323(d) and 49 CFR Part 604, which provides that recipients and subrecipients of FTA assistance are prohibited from providing charter service using federally funded equipment or facilities if there is at least one private charter operator willing and able to provide the service, except under one of the exceptions at 49 CFR 604.9. Any charter service provided under one of the exceptions must be "incidental," i.e., it must not interfere with or detract from the provision of mass transportation.

## **E.21 DRUG AND ALCOHOL TESTING**

The Contractor agrees to establish and implement a drug and alcohol testing program that complies with 49 CFR Parts 655, produce any documentation necessary to establish its compliance with Parts 655, and permit any authorized representative of the United States Department of Transportation or its operating administrations, the City of Portland Oregon, to inspect the facilities and records associated with the implementation of the drug and alcohol testing program as required under 49 CFR Parts 655.73 and review the testing process.

Contractor agrees further to certify annually its compliance with Parts 655.72 and to submit the Management Information System (MIS) reports before March 15 to FTA's Office of Safety and Security, or its designated agent.

To certify compliance the Contractor shall use the Management Information System (MIS) form and instructions as required by [49 CFR part 40, § 40.25](#) and appendix H. You may also use the electronic version of the MIS form provided by the DOT. The Administrator may designate means (e.g., electronic program transmitted via the Internet), other than hard-copy, for MIS form submission. For information on where to submit MIS forms and for the electronic version of the form, see: <http://transit-safety.volpe.dot.gov/DAMIS>.

Attachment E  
RFP 00002649 Streetcar Vehicles, Parts and Tools

Sample Contract Exceptions and Deviations Form

Proposers are instructed to request exceptions and deviations to the Sample Contract attached to this RFP using the table below.

Contract Section No.	Current language	Requested exception (in redline)	Reason
<b>EXAMPLE:</b> Section 1.0 Definition - System	" <u>System</u> " means collectively all Products to be provided by Contractor to City and the Third Party Software and equipment specified by Contractor under this Contract.	" <u>System</u> " <b>or "Solution"</b> means collectively all Products to be provided by Contractor to City and the Third Party Software <del>and equipment</del> specified by Contractor under this Contract.	Company requests this change because our SLA and EULA refer to "Solution". No equipment is being provided under this Contract.

Attachment F  
RFP 00002649 Streetcar Vehicles, Parts and Tools  
Pricing Schedules

SCHEDULE A – STREETCAR VEHICLE PRICING					
Schedule	Milestone	Quantity	Item	Unit Price	Extended Price (Quantity * Unit Price)
A - SCV Pricing	A-1	15	Portland Off-wire Streetcar		
SCHEDULE A SUBTOTAL					\$

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SCHEDULE C – SYSTEM SUPPORT PRICING

Schedule	Milestone	Quantity	Item	Unit Price	Extended Price (Quantity * Unit Price)
C - System Support Pricing	C-1	1	Engineering		
C - System Support Pricing	C-2	1	Management		
C - System Support Pricing	C-3	1	Operations and Maintenance Training per Technical Specification Section 3.3		
C - System Support Pricing	C-4	1	Operations and Maintenance Manuals per Technical Specification Section 3.1		
C - System Support Pricing	C-5	1	Field Support per Technical Specification Section 3.5		
C - System Support Pricing	C-6	1	Performance Bond		
C - System Support Pricing	C-7	1	Warranty Bond		
SCHEDULE C SUBTOTAL					\$

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SCHEDULE D – QUALIFICATIONS TESTING					
Schedule	Milestone	Quantity	Item	Unit Price	Extended Price (Quantity * Unit Price)
D - Qualification Testing Pricing	D-1	1	CDRL 18-4 Paint Performance Type Test, TS 18.3.3		
D - Qualification Testing Pricing	D-2	1	CDRL 18-5 FRP Type Test Certificate, TS 18.3.4		
D - Qualification Testing Pricing	D-3	1	CDRL 18-6 EMI/EMC Component Type Tests, TS 18.3.5		
D - Qualification Testing Pricing	D-4	1	CDRL 18-7 Cab and Floor Heater Type Tests, TS 18.3.6		
D - Qualification Testing Pricing	D-5	1	CDRL 18-8 AC Traction Motor Type Test, TS 18.3.7		
D - Qualification Testing Pricing	D-6	1	CDRL 18-9 AC Auxiliary Motor Type Test, TS 18.3.8		
D - Qualification Testing Pricing	D-7	1	CDRL 18-10 Traction Gear Unit Type Test, TS 18.3.9		
D - Qualification Testing Pricing	D-8	1	CDRL 18-11 Auxiliary Power Supply (APS) Type Test, TS 18.3.10		
D - Qualification Testing Pricing	D-9	1	CDRL 18-12 Low-Voltage Power Supply and Battery Charger Type Test, TS 18.3.11		
D - Qualification Testing Pricing	D-10	1	CDRL 18-13 Truck Frame Type Test, TS 18.3.12		
D - Qualification Testing Pricing	D-11	1	CDRL 18-14 Traction Inverter Type Test, TS 18.3.13		
D - Qualification Testing Pricing	D-12	1	CDRL 18-15 OESS Type test, TS 18.3.14		
D - Qualification Testing Pricing	D-13	1	CDRL 18-16 Vehicle-Shell Structural Type Tests, TS 18.4		
D - Qualification Testing Pricing	D-14	1	CDRL 18-17 Floor Assembly Fire Performance Type Test, TS 18.5.2		



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D - Qualification Testing Pricing	D-15	1	CDRL 18-18 Roof Assembly Fire Performance Type Test, TS 18.5.2		
D - Qualification Testing Pricing	D-16	1	CDRL 18-19 Propulsion Combined Type Test, TS 18.5.3		
D - Qualification Testing Pricing	D-17	1	CDRL 18-20 Friction Brake System Type Test, TS 18.5.4		
D - Qualification Testing Pricing	D-18	1	CDRL 18-21 Door System Type Test, TS 18.5.5		
D - Qualification Testing Pricing	D-19	1	CDRL 18-22 Bridgeplate System Type Test, TS 18.5.6		
D - Qualification Testing Pricing	D-20	1	CDRL 18-23 Unitized HVAC System Type Test, TS 18.5.7		
D - Qualification Testing Pricing	D-21	1	CDRL 18-24 Communication Systems Type Test, TS 18.5.8		
D - Qualification Testing Pricing	D-22	1	CDRL 18-25 Vehicle-Level Type Static Tests, TS 18.6		
D - Qualification Testing Pricing	D-23	1	CDRL 18-25.a Horn and Bell, TS 18.6		
D - Qualification Testing Pricing	D-24	1	CDRL 18-25.b Jacking, TS 18.6		
D - Qualification Testing Pricing	D-25	1	CDRL 18-25.c Ducting watertightness, TS 18.6		
D - Qualification Testing Pricing	D-26	1	CDRL 18-25.b Air Leakage, TS 18.6		
D - Qualification Testing Pricing	D-27	1	CDRL 18-25.e Air Balance, TS 18.6		
D - Qualification Testing Pricing	D-28	1	CDRL 18-25.f HVAC system, TS 18.6		
D - Qualification Testing Pricing	D-29	1	CDRL 18-25.g Door operation, TS 18.6		
D - Qualification Testing Pricing	D-30	1	CDRL 18-25.h Bridgeplate operation, TS 18.6		
D - Qualification Testing Pricing	D-31	1	CDRL 18-25.i Lighting intensity, TS 18.6		
D - Qualification Testing Pricing	D-32	1	CDRL 18-25.j Communication equipment, TS 18.6		
D - Qualification Testing Pricing	D-33	1	CDRL 18-25.k Vehicle data networks, TS 18.6		

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D - Qualification Testing Pricing	D-34	1	CDRL 18-43 Vehicle-Level Type Dynamic Tests, TS 18.9.1, 18.9.2, 18.9.3 and 18.9.4		
D - Qualification Testing Pricing	D-35	1	CDRL 18-44 Ride Quality Type Test, TS 18.9.1, 18.9.2, and 18.9.5		
D - Qualification Testing Pricing	D-36	1	CDRL 18-45 Noise and Vibration Type Test, TS 18.9.1, 18.9.2, and 18.9.6		
D - Qualification Testing Pricing	D-37	1	CDRL 18-46 EMI/EMC Type Test, TS 18.9.1, 18.9.2, and 18.9.7		
SCHEDULE D SUBTOTAL					\$

Attachment F  
RFP 00002649 Streetcar Vehicles, Parts and Tools  
Pricing Schedules

SCHEDULE G - SPARE PARTS					
Schedule	Milestone	Quantity	Item	Unit Price	Extended Price (Quantity * Unit Price)
G – Spare Parts	G.1	1	Articulation diaphragm or bellow	\$	\$
G – Spare Parts	G.2	1	Articulation diaphragm or bellow repair kit	\$	\$
G – Spare Parts	G.3	1	Articulation bushing/rebuild kit, complete	\$	\$
G – Spare Parts	G.4	1	Coupler & draft gear assembly, complete	\$	\$
G – Spare Parts	G.5	1	Master controller, complete	\$	\$
G – Spare Parts	G.6	1	Master controller, Microswitches, keys	\$	\$
G – Spare Parts	G.7	1	Wiper motor	\$	\$
G – Spare Parts	G.8	1	Wiper motor arm	\$	\$
G – Spare Parts	G.9	1 vehicle set	Wiper blades	\$	\$
G – Spare Parts	G.10	1	Horn assembly	\$	\$
G – Spare Parts	G.11	1	Bell assembly	\$	\$
G – Spare Parts	G.12	1	Windshield washer pump	\$	\$
G – Spare Parts	G.13	1	Windshield washer spray nozzle	\$	\$
G – Spare Parts	G.14	1	Speedometer/ADU	\$	\$
G – Spare Parts	G.15	1 vehicle set	Operator console switches/buttons	\$	\$
G – Spare Parts	G.16	1	Door panel (RH) , complete including window, seats, sensitive edges, and push button switches	\$	\$

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G – Spare Parts	G.17	1	Door panel (LH) , complete, including window, seats, sensitive edges, and push button switches	\$	\$
G – Spare Parts	G.18	1	Door operator linkages and mechanism, complete	\$	\$
G – Spare Parts	G.19	1	Door controller assemblies or modules	\$	\$
G – Spare Parts	G.20	1	Crew switch	\$	\$
G – Spare Parts	G.21	1	Internal door manual release mechanism	\$	\$
G – Spare Parts	G.22	1	External door manual release mechanism	\$	\$
G – Spare Parts	G.23	1	Pushbutton switches (interior and exterior)	\$	\$
G – Spare Parts	G.24	1	Complete Bridgeplate	\$	\$
G – Spare Parts	G.17	1	Air flow switches (all)	\$	\$
G – Spare Parts	G.18	1	Thermostats and temperature sensors (all)	\$	\$
G – Spare Parts	G.19	1	Air conditioning unit, complete	\$	\$
G – Spare Parts	G.20	1	Fresh air and return air filters	\$	\$
G – Spare Parts	G.21	1	Operator’s heater and window defroster systems, including controls, excluding cab windshield	\$	\$
G – Spare Parts	G.18	1	Head lights (exclusive of fixture)	\$	\$
G – Spare Parts	G.19	1	Pantograph assembly, complete	\$	\$
G – Spare Parts	G.20	1	Pantograph head, complete, with suspension devices	\$	\$
G – Spare Parts	G.21	1	Pantograph shoe carbon insert set	\$	\$
G – Spare Parts	G.22	1	Pantograph raise/lower actuator assembly, complete, including limit switches	\$	\$
G – Spare Parts	G.23	1	Lightning arrester	\$	\$

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G – Spare Parts	G.24	1 each	High speed circuit breaker (s), complete	\$	\$
G – Spare Parts	G.25	1 each	High-voltage fuses	\$	\$
G – Spare Parts	G.26	1	Battery box assembly including sliding tray, if applicable	\$	\$
G – Spare Parts	G.27	1	OESS box assembly	\$	\$
G – Spare Parts	G.28	1	OESS BTMS complete	\$	\$
G – Spare Parts	G.29	1	OESS complete	\$	\$
G – Spare Parts	G.30	1	OESS energy storage elements	\$	\$
G – Spare Parts	G.31	1	Emergency battery cut out switch	\$	\$
G – Spare Parts	G.32	1	Auxiliary inverters, complete	\$	\$
G – Spare Parts	G.33	1	Aux power stack	\$	\$
G – Spare Parts	G.34	1	Auxiliary inverter printed circuit cards/control unit, all	\$	\$
G – Spare Parts	G.35	1 each	Fans	\$	\$
G – Spare Parts	G.36	1 each	Ventilation replaceable air filters (if applicable)	\$	\$
G – Spare Parts	G.37	1	LVPS, complete (if separate)	\$	\$
G – Spare Parts	G.38	1	LVPS power stack	\$	\$
G – Spare Parts	G.39	1 each	Ground brush assembly, complete	\$	\$
G – Spare Parts	G.40	1	Ground brushes, sets per assembly	\$	\$
G – Spare Parts	G.41	1	Ground brush springs, sets per assembly	\$	\$
G – Spare Parts	G.42	1	Vehicle mounted shop power plug assembly, complete	\$	\$
G – Spare Parts	G.43	1	Traction motor couplings	\$	\$

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G – Spare Parts	G.44	1	Propulsion/dynamic brake resistors assembly, complete	\$	\$
G – Spare Parts	G.45	1	Propulsion AC inverter, complete, in enclosures	\$	\$
G – Spare Parts	G.46	1	Control relays and sensors, all	\$	\$
G – Spare Parts	G.47	1	Speed sensor, all	\$	\$
G – Spare Parts	G.48	1	Electronic control each, complete (1 each, if included in item 4)	\$	\$
G – Spare Parts	G.49	1	Printed circuit cards, all	\$	\$
G – Spare Parts	G.50	1 each	Inverter ventilation motors (if applicable)	\$	\$
G – Spare Parts	G.51	1	Propulsion gearbox with axle coupling, complete	\$	\$
G – Spare Parts	G.52	1	Power semiconductor assemblies	\$	\$
G – Spare Parts	G.53	1	Ventilation replaceable air filters (if applicable)	\$	\$
G – Spare Parts	G.54	1	End truck, complete (ready to install under vehicle)	\$	\$
G – Spare Parts	G.55	1	Dummy trucks	\$	\$
G – Spare Parts	G.56	1	Motor truck wheel and axle set with gear box, brake disc, motor couplings, and journal bearings	\$	\$
G – Spare Parts	G.57	1	Wheel tire, each type	\$	\$
G – Spare Parts	G.58	1	Rubber wheel blocks or rings, each type	\$	\$
G – Spare Parts	G.59	1	Height adjustment shims, if applicable	\$	\$
G – Spare Parts	G.60	1	All truck parts other than axle-mounted parts (including stops, hangers, linkages, tie bars, stabilizers, radius rods, load sensors, safety bars, etc.)	\$	\$
G – Spare Parts	G.61	1	Sanding nozzle and brackets	\$	\$

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G – Spare Parts	G.62	1	All friction brake equipment (except connecting hoses, fittings, inter-unit wiring, electronic control unit, and hydraulic pressure control unit)	\$	\$
G – Spare Parts	G.63	1	Brake pads with backing plates (in addition to Item 1)	\$	\$
G – Spare Parts	G.64	1	Hydraulic emergency release pump, complete	\$	\$
G – Spare Parts	G.65	1	Hydraulic pressure control unit (HPCU), complete	\$	\$
G – Spare Parts	G.66	1	Hydraulic accumulator	\$	\$
G – Spare Parts	G.67	1	Sanding assembly, complete (with dedicated air compressor if applicable)	\$	\$
G – Spare Parts	G.68	1	Friction brake, electronic control logic, complete	\$	\$
G – Spare Parts	G.69	1	Printed circuit cards	\$	\$
G – Spare Parts	G.70	1	All manually controlled valves and cocks for brake equipment	\$	\$
G – Spare Parts	G.71	1	Brake system magnet valves and pressure switches, all (in addition to Item 1)	\$	\$
G – Spare Parts	G.72	1	Track brake assembly, complete (including cables)	\$	\$
G – Spare Parts	G.73	1	Track brake suspension springs , elastomeric elements, and hardware, complete	\$	\$
G – Spare Parts	G.74	1	Sand box heater	\$	\$
G – Spare Parts	G.75	1	Communications pre-amplifiers, mixer amplifiers, and power amplifiers	\$	\$
G – Spare Parts	G.76	1	Audio system control head, complete	\$	\$
G – Spare Parts	G.77	1	Microphone	\$	\$
G – Spare Parts	G.78	1 each	Interior and exterior P.A. speakers, complete with transformers	\$	\$

Attachment F  
RFP 00002649 Streetcar Vehicles, Parts and Tools  
Pricing Schedules

G – Spare Parts	G.79	1 each	Passenger intercom stations	\$	\$
G – Spare Parts	G.80	1	Automatic passenger information system control panel, if applicable	\$	\$
G – Spare Parts	G.81	1 vehicle set	Automatic passenger information system interior and exterior signs	\$	\$
G – Spare Parts	G.82	1	Automatic passenger information system controllers	\$	\$
G – Spare Parts	G.83	1 vehicle set	CCTV cameras/monitors	\$	\$
G – Spare Parts	G.84	1	CCTV NVR	\$	\$
G – Spare Parts	G.85	1	GPS Receiver	\$	\$
G – Spare Parts	G.86	1	Wi-Fi IP Router	\$	\$
G – Spare Parts	G.87	1	Event recorder assembly, complete	\$	\$
G – Spare Parts	G.88	1	APC system, complete	\$	\$
G – Spare Parts	G.89	1	ATS system, complete	\$	\$
G – Spare Parts	G.90	1	ATS control rack, complete	\$	\$
G – Spare Parts	G.91	1	ATS cards	\$	\$
G – Spare Parts	G.92	1	Windshield	\$	\$
G – Spare Parts	G.93	1	Cab side window LH & RH	\$	\$
G – Spare Parts	G.94	1	Cab side window LH & RH glass	\$	\$
G – Spare Parts	G.95	1	Side windows	\$	\$
G – Spare Parts	G.96	1	Door windows	\$	\$
G – Spare Parts	G.97	1	Glazing strip, windshield	\$	\$



Attachment F  
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Pricing Schedules

G – Spare Parts	G.98	1	Glazing strip, cab window	\$	\$
G – Spare Parts	G.99	1	Glazing strip, side windows, if applicable	\$	\$
G – Spare Parts	G.100	1	Glazing strip, door windows	\$	\$
G – Spare Parts	G.101	1	Windscreens	\$	\$
G – Spare Parts	G.102	1	Seat bottom insert	\$	\$
G – Spare Parts	G.103	1	Seat back insert	\$	\$
G – Spare Parts	G.104	1	Single seat, complete, if applicable	\$	\$
G – Spare Parts	G.105	1	Double seat, complete, if applicable	\$	\$
G – Spare Parts	G.106	1	Flip-up seat, complete, if applicable	\$	\$
G – Spare Parts	G.107	1	Multiple seat, complete, if applicable	\$	\$
G – Spare Parts	G.108	1	Exterior air intake and exhaust grills	\$	\$
G – Spare Parts	G.109	1	Floor covering (equivalent amount in rolls)	\$	\$
G – Spare Parts	G.110	1	Skirts	\$	\$
G – Spare Parts	G.111	1	Cab shades	\$	\$
G – Spare Parts	G.112	1	Cab seat, complete	\$	\$
G – Spare Parts	G.113	1	Cab seat parts (suspension, arm rest, controls, etc.)	\$	\$
G – Spare Parts	G.114	1	Master controller key	\$	\$
G – Spare Parts	G.115	1	Master controller tubler	\$	\$
G – Spare Parts	G.116	1	Crew key	\$	\$
G – Spare Parts	G.117	1	Maintenance key	\$	\$

Attachment F  
RFP 00002649 Streetcar Vehicles, Parts and Tools  
Pricing Schedules

G – Spare Parts	G.118	1	Interior and exterior locks assemblies not part of other spare parts	\$	\$
G – Spare Parts	G.119	1	All seals and gaskets not included in specific subsystems spares	\$	\$
G – Spare Parts	G.120	1	All air and hydraulic filters not included within specific subsystem spares	\$	\$
G – Spare Parts	G.121	1	All fuses not included in specific subsystems spars	\$	\$
G – Spare Parts	G.122	1	All fuse holders not included in specific subsystems spares	\$	\$
G – Spare Parts	G.123	1	All refrigerant hoses and lines (including fittings) not included within specific subsystem spares	\$	\$
G – Spare Parts	G.124	1	Wire and cable of all types used on the vehicle, in lengths equal to total amount on vehicle	\$	\$
G – Spare Parts	G.125	1	All vehicle control high voltage contactors, control modules, and low voltage relays not included in specific subsystems spares	\$	\$
G – Spare Parts	G.126	1	All special fasteners not commercially available	\$	\$
G – Spare Parts	G.127	1	All special and commercially available terminals and connectors for wire and cable	\$	\$
G – Spare Parts	G.128	1	All lubricants (oil and greases) necessary to maintain the vehicles per the O&M Manual (1 year supply)	\$	\$
G – Spare Parts	G.129	1	Monitoring and diagnostics logic units and assemblies	\$	\$
G – Spare Parts	G.130	1	Spare parts necessary to maintain all diagnostic test equipment for a period of 2 years	\$	\$
SCHEDULE G SUBTOTAL					\$

Attachment F  
RFP 00002649 Streetcar Vehicles, Parts and Tools  
Pricing Schedules

SCHEDULE H – SPECIAL TOOLS					
Schedule	Milestone	Quantity	Item	Unit Price	Extended Price (Quantity * Unit Price)
H – Special Tools	H.1	1	Portable hydraulic Rerailing equipment	\$	\$
H – Special Tools	H.2	1	dummy bogies	\$	\$
H – Special Tools	H.3	1	Locked axle dollies	\$	\$
H – Special Tools	H.4	1	Portable car jacks	\$	\$
H – Special Tools	H.5	1	Vehicle lifting adapters	\$	\$
H – Special Tools	H.6	1	Articulation locking bars	\$	\$
H – Special Tools	H.7	1	Flush cart (w/ adapters, fittings, particulate analyzer)	\$	\$
H – Special Tools	H.8	1	Brake special tools	\$	\$
H – Special Tools	H.9	1	Brake testing equipment (pad force, pressure testing, etc.)	\$	\$
H – Special Tools	H.10	1	OESS special tools	\$	\$
H – Special Tools	H.11	1	OESS test equipment	\$	\$
H – Special Tools	H.12	1	fiberglass molds, front skirts, partial end cap (300 mm above windshield and down)	\$	\$
H – Special Tools	H.13	1	Roof equipment lifting apparatus (including interior components)	\$	\$
H – Special Tools	H.14	1	ATS test equipment	\$	\$
H – Special Tools	H.15	1	TWC test equipment	\$	\$

Attachment F  
RFP 00002649 Streetcar Vehicles, Parts and Tools  
Pricing Schedules

H – Special Tools	H.16	1	Pantograph test equipment	\$	\$
H – Special Tools	H.17	1	Tire installation equipment	\$	\$
H – Special Tools	H.18	1	Wheel pressing adapters	\$	\$
H – Special Tools	H.19	1	Hegenschiedt hold downs (wheel tru)	\$	\$
H – Special Tools	H.20	1	Coupler adapter(s)	\$	\$
H – Special Tools	H.21	1	Forklift to vehicle coupler towbar	\$	\$
H – Special Tools	H.22	1	Forklift to bogie towbar	\$	\$
H – Special Tools	H.23	1	Oscilloscope	\$	\$
H – Special Tools	H.24	1	Network tester (Canbus, Ethernet, etc.)	\$	\$
H – Special Tools	H.25	1	Full set of Crimpers	\$	\$
H – Special Tools	H.26	1	Door force gauge	\$	\$
SCHEDULE H SUBTOTAL					\$

### Buy America Certification Form

Proposer must check the appropriate box, provide the information requested, and sign this certificate.

- ☐ The Proposer hereby certifies, to the best of its knowledge and belief, that it is currently in compliance with the requirements of Section 165(a)(165(b)(3) for rolling stock) of the Surface Transportation Assistance Act of 1982 and the applicable regulations in 49 CFR Part 661 (Part 661.11 for rolling stock).
- ☐ The Proposer hereby certifies, to the best of its knowledge and belief, that it will soon be compliance with the requirements of Section 165(a)(165(b)(3) for rolling stock) of the Surface Transportation Assistance Act of 1982 and the applicable regulations in 49 CFR Part 661 (Part 661.11 for rolling stock).
- ☐ The Proposer hereby certifies, to the best of its knowledge and belief, that it cannot comply with the requirements of Section 165(a) (165(b)(3) for rolling stock) of the Surface Transportation Assistance Act of 1982, but that it may qualify for an exception to the requirements pursuant to Section 165(b)(2) or (b)(4) of the Surface Transportation Assistance Act and regulations in 49 CFR Part 661.7.

\_\_\_\_\_  
Signature of Authorized Official

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name and Title

### Transit Vehicle Manufacturer (TVM) Certification Form

This procurement is subject to the provisions of 49 CFR Section 26.49. Accordingly, the following certification must be completed and submitted with the proposal. A proposal that does not include this TVM Certification Form will not be considered.

- ☐ The Proposer, if a transit vehicle manufacturer, hereby certifies that it has complied with the requirements of 49 CFR Section 26.49 by submitting an annual DBE goal to the Federal Transit Administration (FTA). The goal has either been approved or not disapproved by FTA.
- ☐ The Proposer, if a non-manufacturer supplier, hereby certifies that the manufacturer of the transit vehicle to be supplied has complied with the above-referenced requirement of 49 CFR Section 26.49

\_\_\_\_\_  
Signature of Authorized Official

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name and Title

Attachment I  
RFP 00002649 Streetcar Vehicles, Parts and Tools

## Specification Functional and Technical Requirements Form

General Detail		Description of Item	Proposed Value	Unit
Vehicle Details				
1	Total Length	Total length of the vehicle body.		m
2	AW0 Weight	The weight of the vehicle, excluding occupants and baggage.		kg
3	AW3 Weight	Maximum recommended operating weight of the vehicle.		Kg
4	Seating Capacity	The maximum number of passengers sitting inside the vehicle. This number should include the driver.		#
5	Floor Area for Standees	The floor area that is available for standing passengers.		m^2
Battery ESS Detail				
6	Battery Chemistry	Name of battery chemistry.		
7	Battery Pack Voltage	Nominal voltage of the battery pack.		V
8	Capacity of Battery Pack	Coulometric capacity of the battery pack.		Ah
9	Max Cont. Discharge Rate	Maximum rate of charge at which the battery pack can be discharged continuously.		C-rate
10	Max Discharge Pulse	Maximum current at which the battery can be discharged for pulses of up to 10 seconds.		C-rate
11	Discharge/Charge Profile	Maximum continuous discharge and charge power over SOC range.		plot
12	Max Allowable SOC	The maximum SOC that the batteries will be allowed to reach during routine charging. The onboard BMS or charger controller typically limits this value.		%
13	Min Allowable SOC	The minimum SOC that the batteries will be allowed to reach during routine operation. This value is typically limited by the onboard BMS.		%
14	Cells in Series	Number of cells connected in series to form a battery string.		#
15	Strings in Parallel	Number of strings wired in parallel.		#
16	Max Capacity of String	Maximum Capacity of each battery string.		Ah

Attachment I  
RFP 00002649 Streetcar Vehicles, Parts and Tools

General Detail		Description of Item	Proposed Value	Unit
17	Nominal Cell Voltage	Nominal voltage of each battery cell.		Vdc
18	Minimum Cell Voltage	Minimum voltage of each battery cell.		Vdc
19	Maximum Cell Voltage	Maximum voltage of each battery cell.		Vdc
20	Total Pack Weight	Weight of battery pack (including cells, packaging, and cooling systems).		kg
21	Additional Description (configuration details, cycle life, estimated calendar life, etc.):	Please provide the additional information on a separate page(s) with a reference to this table and line item.		
Electrical Accessory Detail				
22	Max Heating HVAC Load	Maximum possible electrical load of the HVAC system while heating the vehicle during transit service.		kW
23	Max Heat Output	Maximum BTU output of the HVAC system.		BTU
24	Max Cooling HVAC Load	Maximum possible electrical load of the HVAC system while cooling the vehicle during transit service.		kW
25	Max Cooling Capacity	Maximum BTU cooling capacity of HVAC system.		BTU
26	Auxiliary Load	Nominal electrical load of auxiliary components and accessories (excluding HVAC).		kW
Power Electronics Detail				
27	Propulsion Inverter Efficiency	Nominal efficiency of propulsion inverters.		%
28	Aux Inverter / LVPS Efficiency	Nominal efficiency aux inverter and LVPS		%
29	OESS Converter Efficiency	Efficiency of OESS charge/discharge converter		%



Attachment I  
RFP 00002649 Streetcar Vehicles, Parts and Tools

General Detail		Description of Item	Proposed Value	Unit
Pantograph Detail				
31	Current Rating (stationary)	Electric current the device is designed to carry while the vehicle is stationary and connected to the OCS.		A
32	Current Rating (in motion)	Electric current the device is designed to carry while the vehicle is in motion and operating on the OCS.		A

Attachment J  
RFP00002649 Streetcar Vehicles, Parts and Tools  
Civil Rights Data Collection Form

The information provided in this section will be retained separately and will not be used for purposes of evaluating and scoring proposals.

Proposer Information	
Is your firm COBID Certified?	<input type="checkbox"/> Yes <input type="checkbox"/> No, and my firm does not qualify.
Describe your firm's workforce demographics	

Subconsultant Information (please identify all subconsultants to be used)			
Subconsultant 1 Information		COBID Certified?	Scope and percent of work allocated
Firm's legal name		<input type="checkbox"/> Yes Certification #:  <input type="checkbox"/> No	
Email			
Phone number			
BuySpeed Vendor #, if applicable			
Subconsultant 2 Information		COBID Certified?	Scope and percent of work allocated
Firm's legal name		<input type="checkbox"/> Yes Certification #:  <input type="checkbox"/> No	
Email			
Phone number			
BuySpeed Vendor #, if applicable			
Subconsultant 3 Information		COBID Certified?	Scope and percent of work allocated
Firm's legal name		<input type="checkbox"/> Yes Certification #:  <input type="checkbox"/> No	
Email			
Phone number			
BuySpeed Vendor #, if applicable			
Add additional rows for additional Subconsultants as needed			

RFP00002649 Streetcar Vehicles, Parts and Tools

Debarment Certification Form

The Proposer (applicant for an FTA grant or cooperative agreement, or potential contractor for a major third party contract) certifies to the best of its knowledge and belief, that it and its principals:

1. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
2. Have not within a three-year period preceding this proposal 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;
3. 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 (2) of this certification; and
4. Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default. If the Proposer (applicant for an FTA grant, or cooperative agreement, or potential third party contractor) is unable to certify to any of the statements in this certification, the participant shall attach an explanation to this certification.

THE PROPOSER (APPLICANT FOR AN FTA GRANT OR COOPERATIVE AGREEMENT, OR POTENTIAL CONTRACTOR FOR A MAJOR THIRD PARTY CONTRACT) CERTIFIES OR AFFIRMS THE TRUTHFULNESS AND ACCURACY OF THE CONTENTS OF THE STATEMENTS SUBMITTED ON OR WITH THIS CERTIFICATION AND UNDERSTANDS THAT THE PROVISIONS OF 31 U.S.C. SECTIONS 3801 ET SEQ. ARE APPLICABLE THERETO.

\_\_\_\_\_  
Signature of Authorized Official

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name and Title

CHECK THE APPROPRIATE BOX:

- ☐ The undersigned chief legal counsel for the Proposer hereby certifies that they have authority under State and local law to comply with the subject assurances and that the certification above has been legally made.

\_\_\_\_\_  
Signature of Proposer's attorney

\_\_\_\_\_  
Date

- ☐ Proposer does not have a "chief legal counsel"

### **Lobbying Certification Form**

The undersigned certifies, to the best of his or her knowledge and 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, 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 or 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 Form to Report Lobbying," in accordance with its instructions.
3. The undersigned shall require that the language of this certification be included in the award documents for all sub-awards at all tiers (including subcontracts, sub-grants, and contracts under grants, loans, and cooperative agreements) and that all sub-recipients shall certify and disclose accordingly.

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 section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure

\_\_\_\_\_  
Signature of Authorized Official

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name and Title:

**NOTE:**

CONTRACTORS ARE REQUIRED, PURSUANT TO FEDERAL LAW, TO INCLUDE THE ABOVE LANGUAGE IN SUBCONTRACTS OVER \$100,000 AND TO OBTAIN THIS LOBBYING CERTIFICATE FROM EACH SUBCONTRACTOR BEING PAID \$100,000 OR MORE UNDER THIS CONTRACT.